THE TRANSPORTATION EXPERIENCE

POLICY, PLANNING, AND DEPLOYMENT

WILLIAM L. GARRISON

DAVID M. LEVINSON

THE TRANSPORTATION EXPERIENCE

This page intentionally left blank

The Transportation Experience
Policy, Planning, and Deployment

William L. Garrison
David M. Levinson

OXFORD
UNIVERSITY PRESS

2006

OXFORD
UNIVERSITY PRESS

Oxford University Press, Inc., publishes works that further
Oxford University's objective of excellence
in research, scholarship, and education.

Oxford New York
Auckland Cape Town Dar es Salaam Hong Kong Karachi
Kuala Lumpur Madrid Melbourne Mexico City Nairobi
New Delhi Shanghai Taipei Toronto

With offices in
Argentina Austria Brazil Chile Czech Republic France Greece
Guatemala Hungary Italy Japan Poland Portugal Singapore
South Korea Switzerland Thailand Turkey Ukraine Vietnam

Published by Oxford University Press, Inc.
198 Madison Avenue, New York, New York 10016

Oxford is a registered trademark of Oxford University Press

www.oup.com

Library of Congress Cataloging-in-Publication Data
Garrison, William Louis [date]
The transportation experience: policy, planning, and deployment / William L.
Garrison and David M. Levinson.
p. cm.
Includes bibliographical references and index.
ISBN-13 978-0-19-517250-8; 978-0-19-517251-5 (pbk.)
ISBN 0-19-517250-7; ISBN 0-19-517251-5 (pbk.)
1. Transportation and state—United States—History. 2. Transportation and
state—Great Britain—History. I. Levinson, David M. [date] II. Title.
HE203.G37 2004
388′.0973—dc22 2003028117

9 8 7 6 5 4 3 2 1

Printed in the United States of America
on acid-free paper

Dedication

Marcia S. Garrison
Trinh Ann Carpenter

This page intentionally left blank

Preface

A preface provides a place to alert the reader to the authors' point of departure and the decisions made about topical emphasis, inclusion, and exclusion.

As would be expected, there will be emphasis on topics the authors give high priority and have special knowledge of, either through experience or research. Such topics include the effects of transportation improvements on economic and social development, how transportation organizations and technologies function as systems, and research and development policies that might improve technologies. There will be emphasis on the growth dynamics of systems—their innovation, development, deployment, and ultimate stagnation. Our emphasis on growth dynamics, systems, and learning is unconventional.

Why dance to a different drummer? It takes conviction and hard work to proceed in an unconventional way. Why hard work? Much of the policy literature is not relevant, so one has to dig hard. Why conviction? We think we need to do better and can do better. Our experiences tell us that we need new approaches.

Garrison began work in transportation policy and planning in the 1950s in the State of Washington. The issue for the State was the development and funding of a freeway program. Studies emphasized both rural and urban development needs, capacity and other design features of facilities, and schemes for funding. Funding was to be tied to tolls and what is now termed value capture, and some valuable insights were obtained on the development impacts of transportation investment.

Emerging program decisions in Washington State were mooted by the passage of the 1956 Interstate Act, and the stage for the work shifted to Washington, D.C. That was during the late Eisenhower years and the focus remained on highways, mainly cost allocation. With the Kennedy years, activities extended to other modes, yielding about a forty-year experience in national planning and policy debates and studies, enriched somewhat by experiences in other nations and work with service providers, as well as work on regional economic development and science and engineering policy topics. State and local government experiences have been limited.

The context for work included congressional boards and commissions, agency advisory committees, and studies performed for the Congress or for agencies by nonprofit organizations, augmented by informal discussions. Sometimes experiences responded to opportunities, but most responded to issues or problems. In transportation these included safety, interstate funding, decline of passenger railroads, airport investment needs, reversal of transit's fortunes, deregulation, maritime subsidies, congestion, roles of rate bureaus, tolls on inland waterways, state and local roles, and so on. To manage these issues, recommendations were sometimes informed by studies, but what may be termed conventional wisdom was often the major force shaping recommendations.

Levinson's career has been shorter; he entered the professional world in the late 1980s in Maryland as a transportation planner and modeler. His experiences ranged from the technical aspects of model development, the policy world of growth management, the planning of new networks (none of which has been built), and the economic and engineering analysis of intercity transportation and ITS technologies, along with research into traveler and institutional behavior.

While over the past two decades the Internet and other communications technologies have radically reshaped how we conduct our activities, nothing similar has emerged in transportation. The view of the transportation world in the past two decades has been shaped not by its growth but by its maturity, and the seeming inability of society to build significant infrastructure, to implement important policies, or to develop and deploy new technologies. That which is pitched as important is really minor; that which is posited as novel is often a rehash of nineteenth-century technology at twenty-first-century prices.

Much was learned from those experiences. We can claim a few accomplishments and doing no harm. At the same time, we lament opportunities not grasped and progress not made. At best, we came away from experiences with the feeling that the paths of existing programs had been mildly pushed in new directions and that programs had been polished a little. Sometimes new initiatives were suggested, but their implementation was rare.

One important thing we did learn was not to think of ourselves as transportation geographers, or transportation engineers, or transportation planners, or transportation policy analysts, or transportation economists, but rather, to coin a term, *transportationists*. The study of transportation is sufficiently interdisciplinary to warrant a discipline of its own. The movement of people and goods across networks over time and space is the unifying object of study. The central research questions in transportation concern what moves, why and how people and goods move, how networks operate, how the interaction of travelers and shippers and carriers and networks shapes behaviors, how networks are (or should be) built and paid for, and so on.

Conviction leading to an unconventional approach followed from optimism. Surely we can do better. It also followed from a sense of urgency. The transportation modes in the developed world are well deployed. Their technological and organizational formats are mature. Consequently, productivity gains come hard and the modes have limited capabilities to further energize social and economic development. We need to think harder. We need to do better.

William L. Garrison
David M. Levinson

Acknowledgments

My transportation experience began as a user and sometimes operator of trains, planes, trucks, ships, and automobiles. Traveling a bit more than the one hour per day the average person does, that's about four years worth. I learned some things, but not nearly as much as I learned from when visiting places and people involved in providing facilities, building equipment, and providing services.

Places included laboratories and test facilities and people included independent truckers, labor union leaders, and train crews. Managers have included all kinds of people ranging from owners of tankship fleets and railroad executives to public agency managers. Robert Pfeiffer of Matson Navigation, Downing Jenks of the Missouri Pacific Railroad, James Forman of United Parcel, G. Plowman of the U.S. Steel Company and onetime Deputy Secretary of Commerce for Transportation, and G. P. St. Clair of the Bureau of Public Roads were a few of my great tutors. On quick review I count about twenty tutors, and I am sure that number would double and redouble with more recollection.

I was learning about the transportation modes and about the ways actors viewed their worlds, where they were coming from so to speak. What to make of the messages I was receiving? Living a university life, I am used to sensing the ways career selection and academic fields affect where my colleagues are coming from. A similar understanding extends to actors in the transportation world. Actors' values and sense of role, the institutions they create, and the rules that guide their actions are shaped by experiences. There is more. Ideas are light baggage, and the transportation experience has traveled and impacted widely, sometimes in a surprising fashion. Robert's Rules of Order, used in the United States to guide meetings, had its roots in public meetings on inland waterway improvements.

Several decades ago I began to use the transportation experience as an organizing theme in my courses. This book grew from notes originally developed by me with the modest objective of supporting classroom discussions and independent work by students. They were intended as a complement to classroom discussions and were much less than a book. Even so, a book emerged. The notes and this book are fragments—the experience is much larger and richer. Even so, I hope they give the reader a way to reason about why systems, people, and institutions do what they do.

In addition to the transportation people and academic colleagues who have tutored me, I have many to thank, especially authors whose works I have read and students and team teachers in classrooms. Special thanks go to David Jones with whom I taught graduate engineering and planning students for several years and from whom I learned much. Special thanks also go to David Levinson who added many ideas of his own and took the time and exerted the effort to revise and extend rough classroom notes into book form. Because of his effort, this book is much richer than its parent.

William Garrison

The book began life as course notes for two courses taught by William Garrison, one of which (CE250) I took as a graduate student at the University of California at Berkeley. The ideas within were different from everything else I had read as a student of transportation policy and economics, and suggested a deeper and longer thought-out consideration of the structure of transportation. When I had the opportunity to teach a similar course, I reached for those notes to start.

Students at the University of Minnesota have reviewed this book as part of CE5212: Urban Transportation Planning, where an earlier version was used as a text. The author would particularly like to thank Kathy Carlson, who assisted with formatting and research on several case studies; Wei Chen, who helped create some of the maps and figures; and Heidi Hamilton and Kasia Winiarczyk for careful review of the text. John Viner and Glenn Orlin reminded me of some of the history of growth management and modeling in Montgomery County, Maryland.

My thinking on these topics has been shaped by many others: professors in addition to Garrison (Everett Carter, Gang-Len Chang, Carlos Daganzo, Betty Deakin, Erik Ferguson, David Gillen, Mark Hansen, Adib Kanafani, Michael Meyer, Marty Wachs, Richard Walker) and professionals including Ajay Kumar, Michael Replogle, and Bob Winick.

David Levinson

Contents

Part I

Overview: Looking Around

The chapters to follow introduce what we shall be looking for as this book unfolds, and they also introduce the worlds of policy making, planning, system deployment, and management. The emphasis is on actors and institutions, as well as the process at work. There is a cross-section view—how things are today. Subsequent parts of the book address why things are as they are.

When describing how things are we emphasize the United States and its federal government. Readers are challenged to look around their neighborhood for similarities at international, local government, and agency levels. Similarities are there, just under different names.

We shall begin looking back in part II, where we will tell the railroad story, and in part III we shall look back and around while visiting the other modes. Part IV will consider the interaction of transportation and complementary experiences, those that form the inputs to transportation. Part V will ask how innovation and other actions aid in creating experiences, and in part VI we ask the reader to engage in speculations about the present and the future.

This page intentionally left blank

1

Introduction

We still . . . [ask students in college] . . . to think, but we seldom tell them what thinking means; we seldom tell them it's just putting this and that together; it's just saying one thing in terms of another. To tell them to set their feet on the first rung of a ladder the top of which sticks through the sky.
—Robert Frost, *Education by Poetry*

The Transportation Experience explores the genesis of transportation systems; the roles that policy plays as systems are planned, innovated, deployed, and reach maturity; and how policies might be improved. While the territory to traverse is vast, underlying themes that characterize policy development and implementation facilitate our journey. In a sense, policy matters are simple. They just seem complex because policy games are played on diverse stages, with many actors, and with issues that appear under different names. Policy themes have much in common across modes, from time to time, and from situation to situation. Their complexity is more apparent than real.

The first concentration of the book will be on policy. Planning enters when it is triggered by policy decisions. Moreover, planning experiences may inform policy, though this seems infrequent. Our third focus emerges as much policy aims to aid deployment and to respond to problems encountered as systems grow. Finally, management issues manifest as modes mature.

A neat sequence of policy followed by planning, deployment, and operations? The sequence gives a nice but incorrect image of an orderly step-by-step unfolding of processes. It is misleading because things may happen out of sequence and often in parallel—for instance, deployment may begin with policy racing to catch up. In addition, the forces of experience and tradition hold across the board, so to speak. So when we say, for instance, "X affected planning" or "Y affected policy," the reader should have in mind "and other things." It is not a neat world with compartmentalized causes and effects.

Emphasis is on the American and British experiences since the beginning of the industrial revolution. The reader will find, however, that the American or British experiences are hardly unique. They have roots in Western Europe, and each country is but one stage for the playing out of themes common to all places. And while much of the transportation system in Europe and North America is mature (if not senescent), the rest of the world is still planning, developing, and deploying. The accomplishments and mistakes of the more developed countries generate lessons that may be applied to places where networks remain nascent or adolescent.

To begin at an arbitrary point in time and place leaves unanswered the question of how experiences before that point in time shaped beginnings. Sometimes Western Europe is considered the locus for the emergence of what we call "the modern world." We know that there were beginnings, or the resources for beginnings, in many places. China, in particular, demonstrated the capability to organize knowledge, resources, and technologies for large-scale public works and transportation activities. It developed navigation instruments, defense walls, great canals, roads, and bridges. In the fourteenth century, China was a major maritime power, using large ships and considerable organizational capability. China imposed its will in Southeast Asia and as far away as Africa. The advantages to be had from transportation and trade were there. Additionally, the development of knowledge was well advanced in China compared to Europe. Yet in the following centuries, Europe came to dominate technology and progress.

However, it is unclear to what extent precursor experiences in and outside of Europe affected the developments that were born in Western Europe. Ideas are light baggage, and through contacts during the Crusades and through travel and trade, Western Europe might well have borrowed ideas.

Quest

There are a number of ways of organizing the text. It could be based modally, telling the story of each mode in turn. Building on Bruno (1993), it could be a giant timeline, giving the history of transportation from when humans first walked on two legs to the present. It could use the "life cycle" paradigm of birth, growth, maturity, and senility, and describe the modes in parallel (but out of chronological sequence) by this paradigm. It could order by "structure," considering infrastructure, equipment, and operations as our basic organizing scheme. It could distinguish between urban, rural, and intercity transportation, and passenger and freight transportation, giving us a 3×2 matrix. It could distinguish between nodes (ports, airports, terminals, intersections) and links (roads, rails). It could be organized by "supply chain," considering inputs, process, and outputs. We have selected a hybrid, organized thematically (figure 1.1).

In spite of our emphasis on themes, generic topics, or theory, the book begins with an overview of current and recent policy activities. The taxonomy enables us to obtain a first-cut answer to the question "What is it we wish to explain?"

The text then tackles planning themes, beginning with the emergence of transportation planning as a discipline from a variety of sources, not simply the urban transportation planning that is today most widely known. The topics of deployment and the life cycle of technologies are addressed. This is followed by the issues of management of mature systems.

We then turn to the search for the systematic ideas that thread policy debates and policy-making activities. We review the development of the railroads and the policies bearing on their birth and deployment. An important finding emerges quickly. It will be

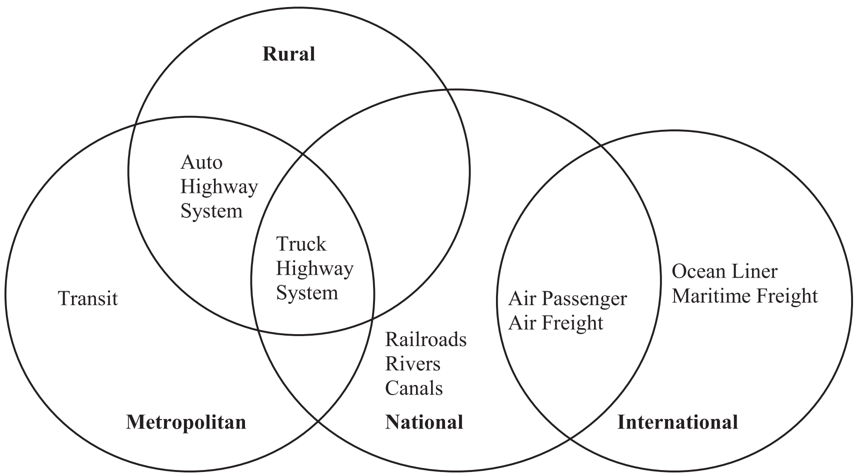


Figure 1.1. Framework for classifying modes.

seen that the railroads borrowed or learned from previous experiences, especially road and canal building and operations. To aid in seeing the influence of precursor experiences, the relations between rail and road and canal experiences will be traced. With only minor modifications, railroads elsewhere copied the precursor experiences embedded in English railroads. Policies for roads and canals were augmented and revised to enable railroad construction and operations.

As deployment proceeded, the railroads developed policies to cope with problems and to aid in grasping opportunities. Some of these policies were embedded in rail institutions; some were imposed by government; and some were developed jointly. The discussion will examine the pattern of embedded versus government policies in some detail because much policy in later modes borrowed from the rail experience. That is especially true for rail transit.

In addition to illustrating the policy development pattern, the railroad discussion will illustrate a paradigm for the analysis of a system as it is born and deployed, and later, as maintenance of service and market shares become central matters. As is true of policy, system structure and behavior tend to be frozen by early events and the embedded policies developed to aid deployment.

The pattern is not a simple one, however. This is because a system's behavior and performance are a function of structure, the system's life-stage and changes in its environment, including the development of competitive modes.

The overview of policy, planning, deployment, and management activities constitute the first part of the book. The search for systematics using the railroad life cycle is the second part of the book. The third part of the text will examine the situation in other modes. Extended discussions will be given to the maritime and inland waterway modes, for they challenge readers to apply knowledge to situations they may not know well. Readers may be more familiar with the highway, transit, and air situations.

The fourth part of the book cuts across modes and looks at complementary experiences that might be considered "inputs and outcomes." We examine some of the things necessary to produce transportation (communications, energy, money, information, time, land), as well as the outcomes of transportation (environmental effects—which can be transformed, for instance, by saying that clean air is an input).

The fifth part of the book examines creating experiences, innovation, technology, imagination, and measuring the real benefits transportation provides. In this part we move beyond examining what is and consider what might have been and what might be. This permits thinking outside the existing modes and operating strategies, to consider alternative paths of development. The text concludes with key points and speculations.

These discussions will counter some conventional wisdom. Most think of each mode as having a unique history and status, and each is regarded as the private playground of experts and agencies holding unique knowledge. However, we argue that while modes have an appearance of uniqueness, patterns repeat and repeat: system policies, structures, and behaviors are a generic design on varying modal cloth. The illusion of uniqueness will prove no more than myopic.

As our discussion proceeds, themes such as these will emerge:

- Policies are built from experiences. At the dawn of a system, experiences are mainly transferred from other, older modes.
- Policies mirror the intrinsic characteristics of systems and the interplay of those characteristics with deployment problems. This theme overlaps with the previous theme. The words “intrinsic characteristics” refer to the structure, behavior, and performance of systems, and this theme notes that these characteristics affect policy.
- Policies may be strictly embedded in system organizations and protocols or, at another extreme, in governments. The question of appropriate loci and shared power is long-standing, and it has mainly been answered on pragmatic grounds.

There are of course, interrelations, for policy affects and constrains experiences and the intrinsic characteristics of systems.

Objectives

The Transportation Experience strives for two objectives:

1. It seeks to inform readers of the experiences and logics underlying transportation activities and the ways they are thought about. These are collected in models and techniques that are the essence of the field. As used by the authors, the words “model” and “technique” have quite different meanings. *Model* refers to conceptual schemes used to impute cause and effect; it is a process-oriented word. A *technique* is a device for measuring, optimization, and so on.
2. It seeks to expand the readers’ understandings of the boundaries of current knowledge. It notes that knowledge has accumulated from past experiences. The ways things are thought about and analyzed have been honed on past experiences and that gives us confidence about our approaches. At the same time, the heavy hand of past experiences places boundaries on current knowledge, especially on the ways professionals define problems and think about processes.

Achievement of the first objective takes time, but is quite doable. A first approximation of the content of the field is easy to acquire. Much of what we know about transportation has been reduced to “textbook knowledge,” and there are a number of books to cover elements of the field.

Difficulties arise as we strive to reach beyond textbook-level knowledge. Not many years ago one could command the field by investing time in a library and using a little taste about what is important. Today, however, the literature is much too vast for that approach. There are numerous planning-related journals that would need to be reviewed; for instance, David Banister and Laurie Pickup (1989) remark that they examined some 10,000 references before selecting the 660 used in their book.

The second objective has to do with understanding the boundaries of present knowledge. As stated, knowledge has accumulated from experiences, and we can gain insights about boundaries by understanding past policy formation and planning tasks and how they were managed. The answers to the questions "Why do planners (engineers, policy makers) think the way they do and do what they do?," "How well does what they do work?," and "What needs to be done to make what they do work better?" turn in large part on understanding previous experiences.

The Transportation Experience strives to enrich the reader's grasp on all types of transportation. At first glance, this may appear much too vast a task for a single book. Our goal says that we should treat each of the modes—rail, air, highway, pipeline, inland water, transit, maritime, and so on. It says that we should consider transportation at different scales and in different environments—national, regional, state, metropolitan, municipal; urban, rural—as well as in different social and economic situations. It says that we should consider multiple goals and purposes: congestion relief, energy conservation, and provision of a mix of modal services, for example. It says, too, that we should consider analysis of subsystems, such as those posed by railroad fixed facilities, maritime fleet planning, and trucking operations.

Achieving the goal of completeness is not much helped by the literature. At the textbook level, where technical materials and experiences have been digested for classroom presentation and study, books apply mainly to urban transportation planning. The professional literature is also dominated by urban transportation concerns, in recent years emphasizing transit. Some of this material is very demanding from a technical point of view, and its treatment takes time.

The topics we strive to cover are vast, and the reader should be alert to omissions. Some modes, such as short sea (ferry-like) services and pipelines, are hardly mentioned. Many regulatory, pricing, and political theory topics are passed over lightly. However, the signposts in this book should help readers find roads to and through omitted topics.

The imprint of the transportation experience on urban and regional settlement patterns and related topics in another vast topic that we mention only briefly. But those matters are well treated elsewhere. Our extensions to these subjects are limited and signposts will have to do.

Structure

A transportation system can be usefully viewed as having a triad structure:

- There are *fixed facilities* such as airports and airway navigation facilities or railroads and terminals. On the soft side, there are institutions that match these.
- There are *operations* involving many kinds of institutions and protocols, as well as hard technologies, such as traffic lights.

- There is *equipment* and its production, care, and feeding: locomotives, airplanes, liners, shipping firms, automobile dealers, repair shops, insurance companies, and so on.

Each of these system components has associated institutions, as stated. There are governmental and private institutions, as well as professional associations. Each has specialized financing, management, and fiscal arrangements. To a large extent, policy, planning, and management have their scope determined by their component elements.

Taking railroads as an example, at a first glance there are interacting locomotives and cars (equipment component), routes and yards (fixed facility component), and control systems (operations component). Looking with somewhat wider scope, we see firms producing equipment, constructing and maintaining routes and terminals, and providing services. Expanding still further, we see suppliers to those activities, professional organizations, the Association of American Railroads, federal and state government activities, the operating officers association, and so on.

We may also remark that the triad structure has a *unitary* character, that is, observing its "same everywhere" character. Transportation systems are unitary systems mainly because operations over networks require standardization. There are other reasons that will be noted later. This unitary structure affects behavior. Standards enforce highly predictable behavior, and standards are valued as an instrument of control.

A second feature of behavior is its reactive *disjointness*. Actors in each component of the triad monitor the states of other components and adjust their affairs to fit. For instance, a topic of concern today is how to adjust highway facilities to fit increasing use and consequent congestion. We seek to strengthen pavements to accommodate larger and heavier trucks. The air traffic control system is being improved to accommodate larger aircraft and growing traffic.

The unitary character of transportation together with the disjoint nature of system structure place sharp limits on images of what planning should be and what it can do. Often, planning is component constrained, and its system impact may be limited; it may also be limited because unitary standards limit degrees of freedom. Planning strives to catch up with and adjust to developments elsewhere. Broadly, a system gets started and the predominant hard and soft technologies are frozen. From the point of view of *steerability*, the die is cast. System development moves along a predetermined path.

Gabriel Bouladon (1967) has provided a notion of inherent service capability and compared service capability to demand, shown in figure 1.2. Bouladon suggests gap filling as a role for planning. This notion has been adopted in Japan (figure 1.3).

In figure 1.2, the left scale is a log scale, and the optimum utilization line indicates how the demand for trips decreases with distance. The *x*-axis is also a log scale. Plotting the service a mode can provide, one sees some combinations of distances and demand volumes where there are gaps. For instance, the "too far to walk and too close to drive" market is only partially served. Most commuters don't have horses available, and bicycles don't work well for many individuals and in certain climates and terrains. The Segway, for instance, seeks to fill this gap and uses the idea in marketing.[1] The "too close to fly, too far to drive" gap is the target for high-speed rail planning.

Figure 1.4 shows a similar idea for freight. The freight scheme doesn't show gaps as the Bouladon scheme does. Gaps are to be imagined in the vicinity of the lines separating zones of modal dominance. Truck trailers on freight cars (TOFC), for example, are carving out mode shares at the truck–rail long-distance interfaces.

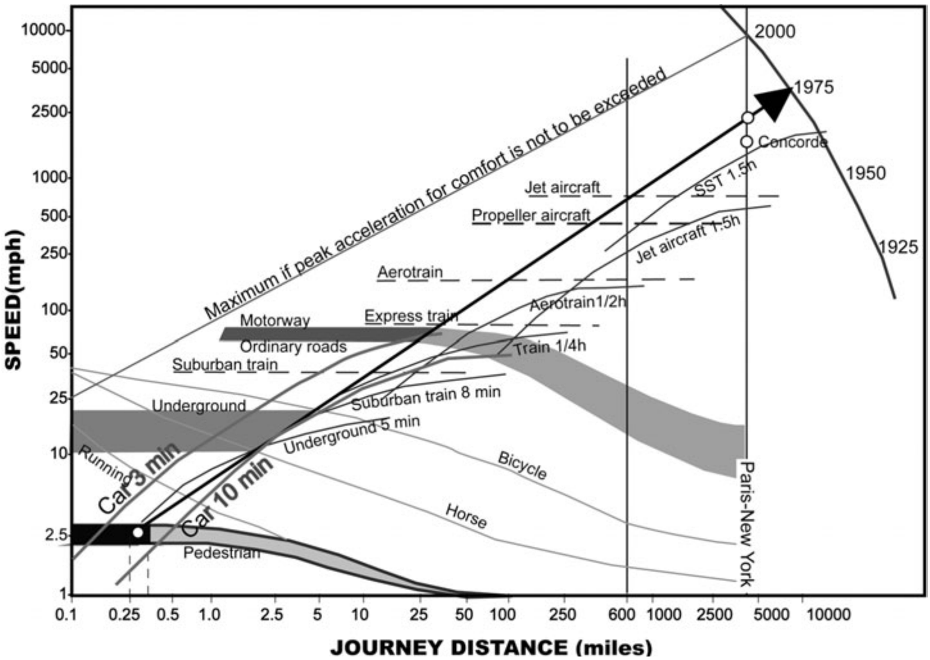


Figure 1.2. Transport gaps: density vs. distance. (Source: adapted from Bouladon, 1967.)

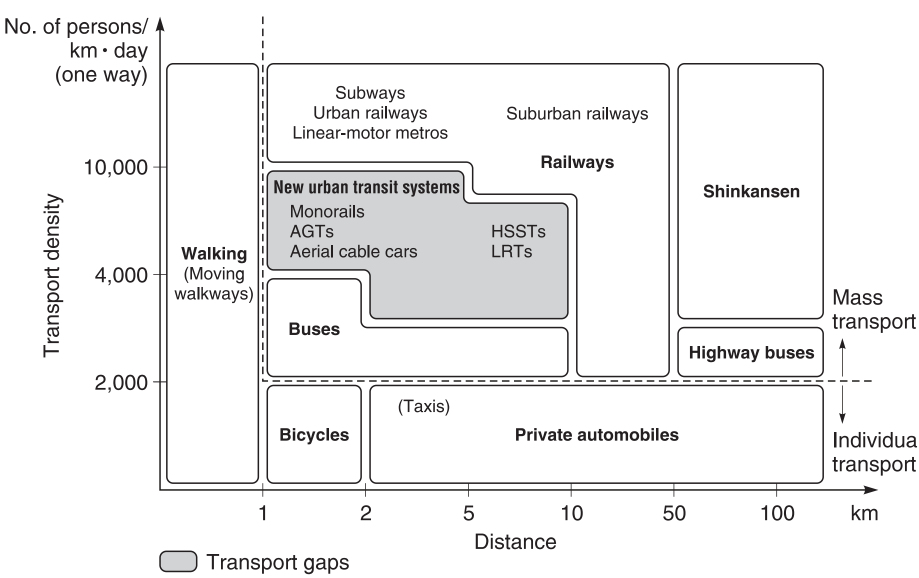


Figure 1.3. Adaptation of transport gaps to Japan. (Source: adapted from Nehashi, 1998.)

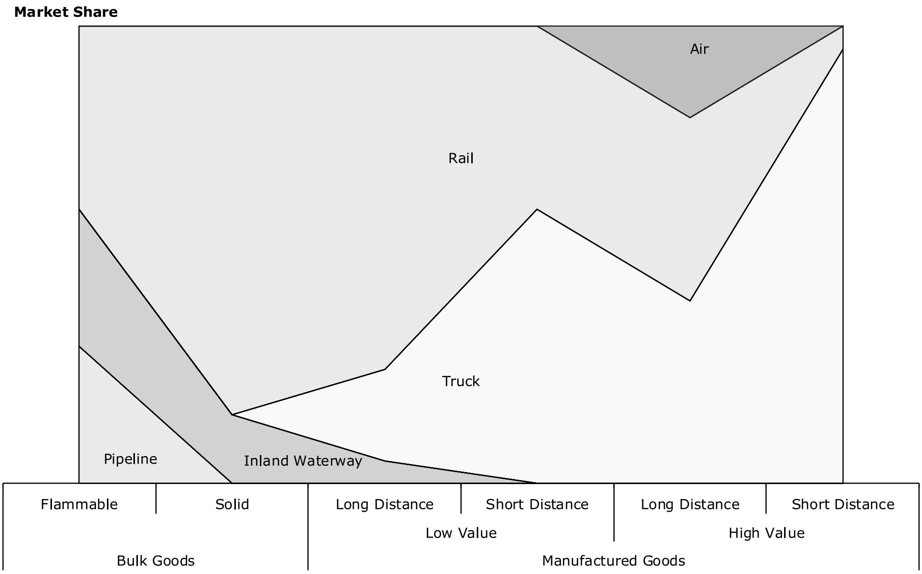


Figure 1.4. Transportation analysis of freight.

We think of the unitary, disjoint, and lack of steerability attributes of systems as dysfunctions. They suggest three roles for planning:

1. Accept the dysfunctions and work within the constraints they set.
2. Seek ways to truly steer systems by working around or breaking the tyranny of the dysfunctions.
3. Identify and fill transportation gaps.

Performance

There is another generic consideration bearing on transportation. It is what we like to refer to as the intrinsic character of transportation systems: how systems behave and how they perform.

Figure 1.5 displays an S-shaped curve, the realization of the railroad system in the United States. Such curves characterize many features of transportation systems and other systems as well. Early on, the planning task was to determine what the rail system should be like. Through much of the history of the rail system, planning tasks had to do with deployment: network arrangements, capacity needs, sequenced deployment, and so on. When deployment approached saturation, the task changed. Nowadays, planning has the task of managing a mature (senile?) system. The point is that there are different planning tasks as a system develops: acts in play, so to speak.

Two words, stable and linear, characterize the process that yielded the realization shown in the figure. The process is stable because observed points fit the development path closely. If for some reason the path diverges as the mileage path did during 1890s when there was little track laid, the path returns to its stable trajectory. It is a linear path: convert the y-axis to logs, and a nearly straight line results.

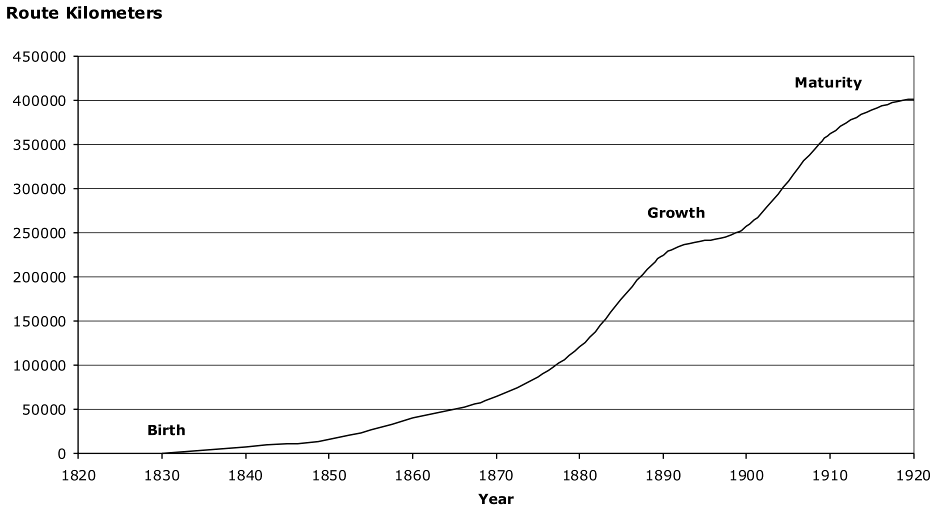


Figure 1.5. Railroad route kilometers in the United States, 1830–1920.

Figure 1.5 shows one component of one system. The S-shaped temporal realization of behavior applies to other components of the rail system (vehicles and operations) and its performance. (Performance has to do with what a system does that is worthwhile.) In general, S-shaped realizations of behavior are found for all transportation systems.

This introduction is not the place to further explore the implications of system behavior. We shall only note that most of the planning experience has been with stable, linear processes. Yet planning addresses changes, and for change to occur we must create and manage unstable, nonlinear processes. A system is unstable if a small perturbation from its past track sends it off in a changed direction. It is nonlinear if there are branch points or discontinuities.

We now assert that the planning (and control) of nonlinear, unstable processes is today's central transportation problem. *The Transportation Experience* will discuss that assertion; it will permeate our discussion.

Conduct

Transportation policy is an attractive topic for study because of the strong interrelations between policy and the nature of transportation systems. The policy story tells us what transportation is, does, and can or might do.

Policy may be defined as sets of formal and informal rules that control the innovation, construction, operation, financing, service provision, and other attributes of transportation systems. That is a vast subject area. There are policies for the testing of concrete pavements, for land taking, the funding of airports, the domain or scope of agency concerns and powers, controlling the range of products offered by equipment manufacturers, safety inspections, the subsidy of liner operators, and so on. Further, the limits on the subject area are not well defined. Policy and planning overlap, for in many ways planning is the application of policy.

This breadth is of concern because transportation professionals are expected to know the rules that apply to their environments. Knowing requires more than an ability to list policy rules to which work should adhere and where those rules are to be applied. Even so, policy courses historically have had a "What is it?" thrust. Business schools offered policy courses dealing with the regulation (and deregulation) of commercial transportation. Where policy was treated in civil engineering departments, it emphasized highway funding and construction protocols. The results of such courses are but a limited snapshot of a descriptive sort.

The Transportation Experience seeks to provide deeper "knowing." It strives to help the reader understand how and why policies (rules) are developed and how to assist in forging policies to improve the functioning of systems.

The earlier discussion of topics to be emphasized indicated one of the ways *The Transportation Experience* will seek to manage the vast breadth and strive for depth. The insights gained will cut through vastness. It will be seen how learning in one situation is applied to another (policy is a result of experience and exchange), how policies mirror the intrinsic characteristics of systems, and how policies may be embedded or shared with governments. For example, transportation systems are networks, and there are policies, similar across the modes, that result from networking. Network integration policies are critical in all modes.

On a larger scale, the study of policy says how society has learned to create, deliver, and operate large, complicated systems that serve specific tasks very well. The insights extend beyond transportation because there are a number of large, complicated systems that share the structure of transportation systems. Transportation policy has lessons for all public facility systems.

In spite of those nice words about the bright side of the study of transportation policy, there is an overwhelming dark side. As a result of that dark side, some regard policy work as trivial, foolish, or counterproductive. It is often treated as a second-class subject, at best.

There are some quite perceptibly troublesome things. It is true that poor analysis gets published by claiming values for policy. Policy often results in using resources in unproductive ways. Often policy yields large cross-subsidies, and the ethical and social values of these are unclear. Policy often yields stasis rather than development.

One summary statement about the dark side compares policy making to sausage making, an activity that fastidious persons should avoid. Another is that the debate is at best petty and unseemly squabbles over marginalia. Howard Darling (1980), the dean of Canadian policy analysts, had this to say:

> [The policy debate is] . . . swamped by a flood of ingenious rationalizations equating one's self-interest with other people's responsibilities (p. 186) . . . confusion extends to those who suppose that some new and elaborate recasting of tranportation legislation is going to work like a tranquillizer (p. 235).

Such statements often apply. Although Darling mainly had railroads in mind, his remark certainly applies to the debates about urban transportation. In the United States there is a geographical organization of political power that affects the forging of policy and the distribution of gains and losses from policy actions. There is *the many against the few* consideration in decision making (and its reverse: *the well-organized few against the many*). These features of the political scene affect transportation.

Transportation systems have complex social and economic interrelations, and individuals and organizations have limited abilities to perceive their structure and performance. The general public's perceptions stem mainly from subjective user experience; newspaper and TV coverage has scant depth. Policy needs are seen in response to the evil things that happened yesterday, and policy becomes, in Darling's (1980) words, "a series of ritualistic poses" (p. 5) and "witchcraft" (p. 178). We would not fault the public for wanting corrections for the problems it senses, and that is not the intent of these comments. Rather, it is to point out that professionals too often fail to respond to the signals the public sends. The public identifies an undesirable symptom (or states a goal), yet the professional is unable to provide an appropriate diagnosis and suggest a cure. Professionals lack effectiveness when they fail to perceive the nature of system processes and the relation of policy to those processes. There are lots of excuses for this.

One excuse is the disjoint structure of transportation systems—they divide into fixed facilities, equipment, and operations. The typical professional is a member of a component, and has limited system understanding. Cognition, need to know, and loyalty are component bound. There are highway experts, vehicle experts, traffic experts, transit experts, airport experts, logistics experts, and others, but few transportation experts. Division of labor is a virtue, of course, and not everyone can or should hold deep knowledge across transportation. Even so, all should know enough to contribute to development or at least know enough to do no harm. There are also specialists from nontransportation fields who wish to have their say on policy. Regardless of the elegance of the home discipline, such experts have limited cognition.

Another excuse is the large time-span that characterizes the behavior of systems. Processes work out over decades, and the professional is informed by only that part of the process experienced. Altshuler (1965) remarked that highway and transit answers are preselected solutions to the urban transportation problem, and that is a comment on the experiences of those offering solutions. So even the professional engages in petty squabbles over marginalia. Marginal because the debate is over whether to do a bit more or less of what went before, and petty because of narrow scope and thus consequence. Darling also used the word "unseemly." It is simply unseemly for the professional to debate from limited knowledge.

Reference in the paragraphs above has been to excuses. There are no reasons why the transportationist cannot command policy, enact plans, and deploy systems. All that is needed is to broaden our cognition in a full, methodical way, and that is the essence of *The Transportation Experience*.

2

Policy

Every discussion of duty has two parts. One part deals with the question of the supreme good. The other with the rules that should guide our ordinary behavior.
—Cicero, *On Moral Duty*

Introduction

The transportation experience shapes the nature of policy making. Planning, deployment, and management follow. This reshapes experience, and the process continues. We visualize this process in figure 2.1. As we shall see, the experience in one mode may frame policy making for other modes.

Our view says that understanding the transportation experience is the key to understanding policy, planning, deployment, and management. An operative word is learning: we have learned from the transportation experience, and learning has yielded rules (guidelines, regulations, etc.) that tell us how to create, deploy, and operate systems. We take those rules to be policies. What is their origin, who enforces them, how well do they work, and how are they changed, are some of the questions to be addressed.

The unfolding of the transportation experience provides an organizing theme for our discussions; it tells us how policy protocols are modeled on experience. We shall spend a good amount of time on railroads because they provide a *mother logic* that applies to other modes. But railroads are not the only mother logic; the maritime experience affected other modes, as surely the automobile/highway system will affect future modes. Each mode has its own "logic," as well as that it has adopted from other modes.

Our investigation of transportation policy begins with a survey of alternative policy models. We then examine today's policy activities with a U.S. focus. Such a survey is a rather awesome task and is subject to omissions. Our aim is for the reader to obtain a sense of the scope and variety of policy activities and an appreciation of the need for the development of systematic, cross-cutting ideas.

The discussion turns to interpretations of what we have seen. We seek to highlight the content of policy debates and policy making. The easy conclusion to reach is that policy is issue-responsive, it tends to be single issue oriented, and it incorporates simple

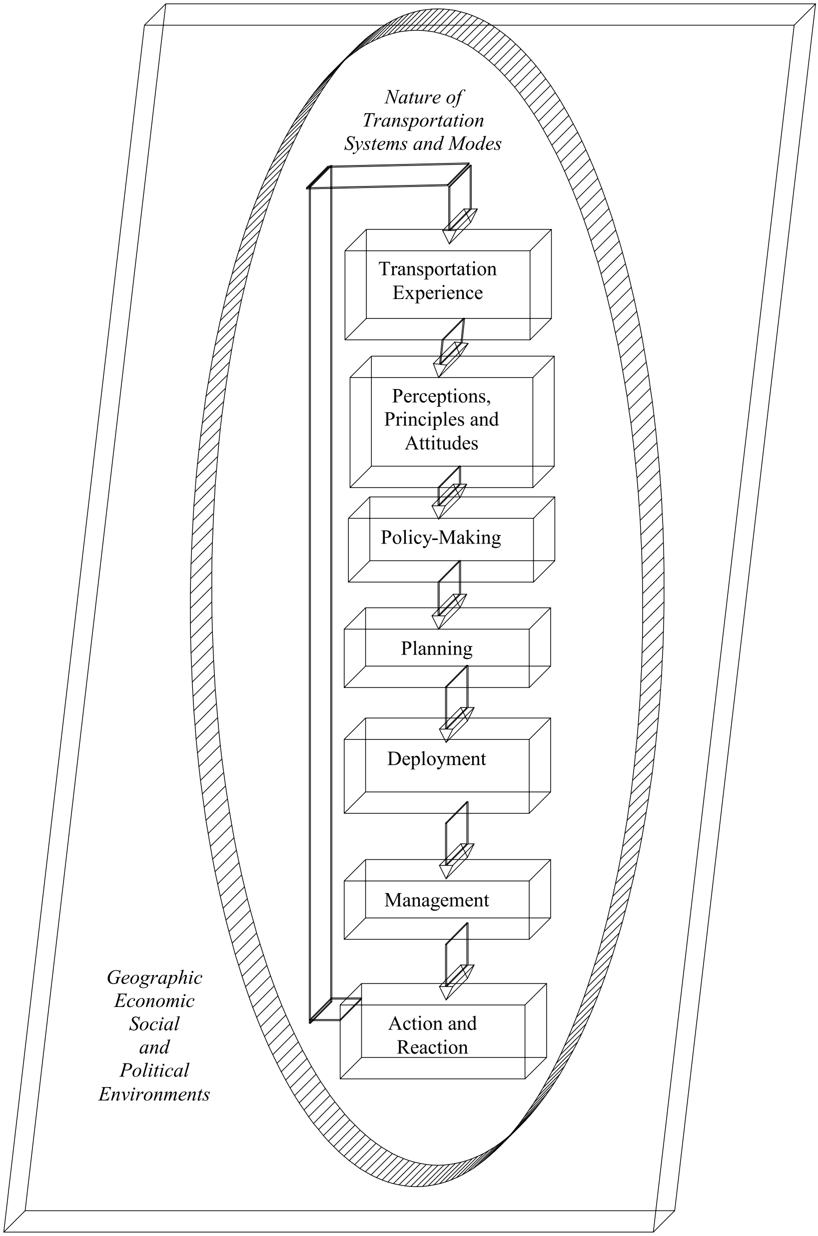


Figure 2.1. Experiential policy model.

control protocols. Even when policy work addresses a laundry list of issues and is thought of as "comprehensive," issues are treated pretty much one by one.

For one reason or another, issues become topical. Governmental and nongovernmental interested parties, such as those characterized as forming iron triangles, debate them. Using calculi involving coalition formation, tradeoffs, and side payments, policy gets made and implemented.

The conclusion that issues drive policy work begs the questions "How do issues get on the table?," "What is a transportation issue, what is a non-issue?," and "How are issues framed and perceived?"

Policy Models

The introduction to this chapter gave a terse statement of the authors' point of departure. We have not yet said how this point of departure differs from others. Think of figure 2.1 as the *experiential policy model*. The transportation experience is embedded not only in geographic, economic, social, and political environments; it is also corralled by the limits of technological structure and the nature of specific modes. The nature of transportation and the greater environment, collated with the transportation experience, gives rise to perceptions, principles, and attitudes. Those beliefs generate a layer of policies (both government and private) that translate into actions. Action and reaction indicates that the modes adjust performance to cope with problems. Those actions shape and reshape the transportation experience.

Our view may be contrasted with the *conventional policy model*, which has behind it the worldview that we (in a gross oversimplification) attribute to economists, policy analysts, lawyers, and others in the policy arena (figure 2.2). There are two major

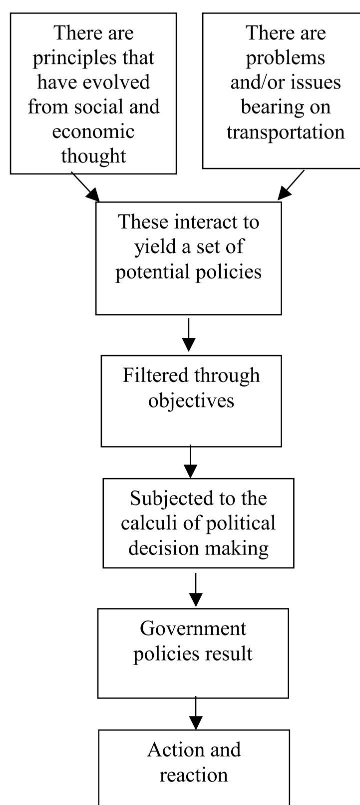


Figure 2.2. Conventional policy model.

differences between this conventional policy model and the experiential policy model. The experiential policy model says that perceptions, principles, and attitudes are forged from experience interacting with the nature of transportation systems. For example, principles bearing on the organization of systems, as well as public and private sector roles, stem from experiences when systems were deployed. Policies relating transportation investment to economic development result from past development experiences. In contrast, the conventional policy model emphasizes “outside system” (or exogenous) principles.

Our experiential policy model does not emphasize such outside principles, and rather considers the formation of principles from the transportation experience as part of the system (or endogenous). It is subject to the objection that experiences other than transportation ones are bound to bear on transportation experiences and attitudes. That is a valid objection and must be true, yet we have a strong response to it.

One aspect of the response is that the transportation experience has so permeated all social and economic experience that we should not think of purely “outside transportation” experiences. The deep and economy-wide impacts of the railroad experience on institutional forms, financing, government activities, regional economic organization, and so on, illustrate the impacts as well as the transfer of transportation experiences. As we point out later in the book, national industrial policies have roots in transportation experiences. The explicit recognition of embedded policies is another important way the experiential model differs from the conventional model.

We also deemphasize outside experiences because of the ways one may position our experiential model and the conventional models. The experiential model explains the structure and performance characteristics of systems to which the policy is applied. The characteristics of systems create the need for policy studies and conditions their results. The characteristics may be thought of as providing stages for daily and annual debates about regulatory, funding, pricing, and investment legislation.

Many major organizations affecting policy are listed in table 2.1. Box 2.1 describes the roles of some of these important public-sector organizations.

Government’s Proactive, Normative Rule

An issue often arises when it is recognized that some activity is dysfunctional—something isn’t working correctly. One litmus test for dysfunctional activities is the logic of what governments do. Among other things, governments are expected to manage things that are regarded as wrong. If something is going on that is counter to the way governments are supposed to manage things, there is an issue.

The logic of what governments do has grown out of long experience. Transportation roles in the United States are seen for governments when there are Constitution-based responsibilities: the economic integration of the states (interstate trade), safety (health), and provision of services (welfare). The presence of market failure, limits on expertise, control of illegal activities, nontransportation goals affecting transportation, and many other considerations over the years have broadened the bases from which roles are argued.

We have attempted to make a list of the reasons why governments have regulated (or nationalized) transportation systems, as shown in box 2.2. The list of rationales shown

Table 2.1 An Alphabet Soup of U.S. Agencies and Organizations

Acronym	Organization
AAA	Automobile Association of America
AAAS	American Association for the Advancement of Science
AASHO	American Association of State Highway Officials (became AASHTO)
AASHTO	American Association of State Highway and Transportation Officials
AREA	American Railway Engineering Association
ASTM	American Society for Testing Materials
BPR	Bureau of Public Roads (became the FHWA)
BTS	Bureau of Transportation Statistics (DOT)
CBO	Congressional Budget Office
CEOs	Chief Executive Officers
COSPUP	Committee on Science and Public Policy (of the NRC)
DOC	U.S. Department of Commerce
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration (DOT)
FHWA	Federal Highway Administration (DOT)
FMCSA	Federal Motor Carrier Safety Administration (DOT)
FRA	Federal Railroad Administration (DOT)
FTA	Federal Transit Administration (DOT)
GAO	General Accounting Office (of the Congress)
HRB	Highway Research Board (of the NRC, name changed to TRB)
HUFSAM	Highway Users Federation for Safety and Mobility
ICC	Interstate Commerce Commission
ITE	Institute of Transportation Engineers
ITSA	Intelligent Transportation Systems America (public/private partnership)
MARAD	Maritime Transportation Administration (DOT)
NAECOT	National Academy of Engineering Committee on Transportation (NRC)
NASA	National Aeronautics and Space Agency
NHTSA	National Highway Traffic Safety Administration
NRC	National Research Council
NSF	National Science Foundation
NTPSC	National Transportation Policy Commission (of Congress)
OMB	Office of Management and Budget (Executive Office of the President)
OST	Office of the Secretary of Transportation (DOT)
OTA	Office of Technology Assessment (Congress)
PPMs	Policy and Procedure Memoranda (FHWA)
RAND	Research and Development (Corporation)
SAE	Society of Automotive Engineers
STB	Surface Transportation Board
STPP	Surface Transportation Policy Project
TRB	Transportation Research Board (NRC, was the HRB)
TSA	Transportation Security Administration
UMTA	Urban Mass Transportation Administration (DOT) (now FTA)
WTS	Women's Transportation Seminar

in box 2.2 is rough, and we would not argue its perfection. Indeed, each time we use it we think of needed revisions. The point of the list is that it helps identify the nature of issues and their origins. As we see it, an issue arises when something is wrong. Wrong with respect to what? Air service to small communities is seen as a fairness issue, for example; the airlines are not providing services to everyone.

BOX 2.1 U.S. Public Sector Transportation Institutions

Many federal, state, and local agencies have transportation responsibilities. The Surface Transportation Board and state public utility commissions are the major ones not mentioned in this discussion.

The United States Department of Transportation (U.S. DOT) was created in 1967. The Office of the Secretary manages policy, overall administration, and international affairs. It is divided into modal administrations, the major ones being:

- *Federal Aviation Administration* (*FAA*). Promotes safety by issuing and enforcing regulations, and certifying aircraft machinery and pilots. It operates the airspace system (traffic control centers and instrument landing systems). The Airport and Airway Trust Fund was created in 1970. The FAA makes grants to over 3,000 airports for capital improvements. The fund also is used for capital investment in the air traffic control system and to defray a portion of its operating costs.
- *Federal Highway Administration* (*FHWA*). Administers the federal-aid highway program. The Highway Trust Fund (primarily from gas taxes) provides financing to states for the pay-as-you-go system.
- *Federal Railroad Administration* (*FRA*). Charged with ensuring that the nation has a safe, efficient railroad system. It is now mainly involved in safety regulation.
- *National Highway Traffic Safety Administration* (*NHTSA*). Seeks to improve the safety of motor vehicles by creating and enforcing safety standards, and administers highway safety programs in cooperation with the states and local communities.
- *Federal Transit Administration* (*FTA*). Provides planning and financial assistance to transit systems under the Urban Mass Transit Act of 1964. It assists in the development of improved equipment, operation techniques, and methods; encourages planning and establishment of area-wide systems; and provides assistance to state and local governments for the operation of systems. Funds are now available for both capital and operating projects.
- *Maritime Administration* (*MARAD*). Charged to develop a strong merchant marine system, it is involved in training, ship construction and operating subsidy programs, and bilateral maritime agreements.
- *Federal Motor Carrier Safety Administration* (*FMCSA*). Created in 1999, it regulates truck safety.
- *Surface Transportation Board* (*STB*). Adjudicates disputes and regulates interstate surface transportation through various laws pertaining to the different modes of surface transportation. It is the successor to the Interstate Commerce Commission.

The U.S. Army Corps of Engineers administers navigable waterways. Inland waterway projects are about 50 percent funded by the Inland Waterway Trust Fund (user fuel impost) while since 1986 the Harbor Maintenance Trust Fund (surcharge on cargo value) provides for 40 percent of harbor maintenance costs. The remainder of funding is from general revenues.

States have roles dating from the early canal and railroad days. State highway departments were formed in about 1910 and were largely concerned with the federal-aid system. Now most states have transportation departments involved with several modes, the situation varying from state to state. State regulatory activities may or may not be lodged in the transportation departments. The states play a major funding role. They expend state

(continued)

BOX 2.1 U.S. Public Sector Transportation Institutions—cont'd

and federal funds on state systems and often assist local governments. AASHTO (the organization of state DOT leaders) is a major player in the development of state and federal policies and programs and sets standards, goals, and so on.

Cities and counties traditionally have funded projects from user fees and general revenues. Now they depend more on federal and state funding for transit, highways, and airports.

Regional agencies have mainly planning and coordinating activities. Regional planning commissions (RPCs) and regional planning agencies (RPAs) were created as a result of the Housing Act of 1954. The metropolitan planning organizations (MPOs) were created as a result of the 1962 Highway Act, which required states to form agencies to undertake planning. Planning and coordination now extend to FHWA, FAA airport, and FTA projects. Regional agencies prepare plans to serve as a guide for future projects, prepare transportation improvement programs (TIPs), and are encouraged to engage in transportation system management (TSM). TIPs and TSM documents identify projects scheduled for the current year, and the next two- and five-year periods.

Special districts are formed by local initiative to provide special projects or services. They often have taxing authority.

BOX 2.2 Rationales for Government Intervention in Transportation

Fairness

- Service is not available everywhere. Early on in the development of a system, intervention is needed to ensure that service is available everywhere. Later, reductions in service may require intervention.
- Those served are not treated in the same way. Intervention is required in the name of equity. This is closely related to the above statement, but extends to small and large shippers.
- Transportation (or location) rents ought to be shared between service providers and service users or between capital and labor. Governments should referee.
- Government should do something so that transportation providers are treated fairly. Not all providers make adequate profits. Also, providers may be at the mercy of large service purchasers.

Competition

- Dysfunctional market organization is a market failure needing repair. Only governments can make the deep system interventions required.
- Monopoly transportation providers abuse their economic power. Intervention is needed to control abuses.
- Intervention will improve the optimal use of resources. The systems are unable to implement marginal cost prices because marginal costs are less than average costs. Marginal cost pricing is socially desirable and ought to be implemented. To achieve this goal, social decisions have to be made about the additional resources required to cover system costs, that is, the funds over and above those obtained by charging marginal cost prices.

BOX 2.2 Rationales for Government Intervention in Transportation—cont'd

Progress

- Infant industries need assistance. A variation on this is the notion that social overhead capital requires up-front investment.
- Processes of innovation and technology development are not working in viable ways; government should do something.
- Government should do something about decreasing (or diminishing improvements in) off-system and on-system productivity.
- Technology change may require new arrangements that only governments can implement.

Stability

- Government control of between- or within-system competition is necessary in order to achieve some desired result. Desired results are in the minds of beholders, and they range all over the map.
- Stability is a good thing, and governments ought to provide for it. Transportation development (or deterioration) may upset an existing equilibrium.
- When a social contract begins to fail, government must step in to glue it together.

Off System

- Transportation may need to be limited, expanded, or coordinated to achieve some off-system goal. Government may be called on to assist in providing the service.
- The health and safety of the public and/or labor requires intervention.
- The effective workings of governments, national economic systems, or defense systems require government intervention.

Interaction with the Transportation Experience

The statements in the list are general, so how do they generate specific issues? We think that the transportation experience interacts with general ideas to yield specific issues. How does that work? We have just remarked that subsidized air service to small communities is an issue because it is needed to cure dysfunctions identified by the list. But why was the question raised? How much subsidized service is warranted? It is the transportation experience that answers those questions. Small communities experienced services at one time, and the experience hardens the issue about what is needed.

The "experience yields policy" part of figure 2.3 suggests a closed system moving along a trajectory. But the environment changes, and it is the transportation experience plus the changed environment that trigger issues. These become policy issues if the situation is in conflict with one or more of the items on the list.

We should recognize that government involvement in transportation is large and longstanding. Also, there has been feedback from the transportation experience to the general functions of governments. The transportation experience has thus affected governments and ideas of what governments should do in a rather broad fashion.

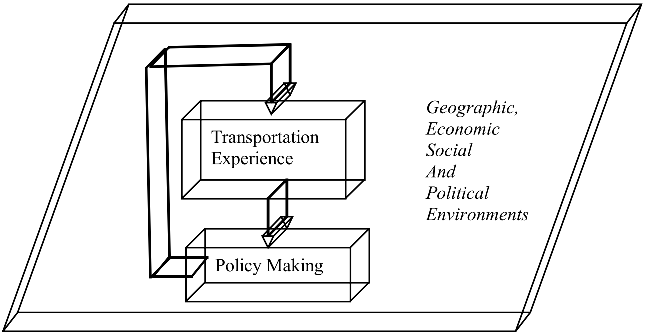


Figure 2.3. Feedback between the transportation experience and policy making.

The relation is not one-way: transportation has affected the development of government roles; government roles have affected transportation.

Also, we should keep in mind that the transportation experience is not broadly known. Individuals know fragments of it, depending on how they are positioned within a mode. The recent experience is better known than historical experience. The longer experience extends to many of today's topics: toll roads, defense, value capture, subsidy for maritime transportation, transportation and land use relations, deregulation, network rationalization, and so on. However, since that experience is not widely known, it is sometimes ignored when framing policy.

Identifying the Subjects of Policy

We have referred to dysfunctional government structures, and have used some ideas about that to aid in recognizing issues and policy responses. A scheme that we have used looks like figure 2.4. Using that classification device, issues may be divided into two classes, on- and off-diagonal. The problems of dealing with off-diagonal issues are much discussed in the literature, especially by persons engaged in intergovernmental relations. The figure and its implications are transparent and will not be further remarked on at this point.

		Loci of Issues		
		National	Regional	Local
Loci of Authority	National			
	Regional			
	Local			

Figure 2.4. Loci of authority versus loci of issues.

Another way to approach issues is to classify them by their associations with inputs to systems, systems per se, or outputs from systems. Consider the list below, which is from the NTPSC's *Special Report No. 1* (NTPSC, 1978, pp. 6–7):

1. Federal Economic Regulatory Reform
2. Air Carrier Regulation
3. Motor Carrier Entry
4. Rail Abandonment
5. Standard Highway Rules and Regulations
6. Public versus Private Ownership of Transportation
7. Proliferation of Government Agencies in Transportation
8. Consolidation of Transportation Regulation Agencies
9. Federal Transportation Planning Assistance
10. Federal Subsidies
11. Modal/Intermodal Trust Funds
12. Block Grants to State and Local Governments
13. Maritime Trade Support
14. Waterway User Charges
15. Financing Urban Mass Transportation
16. Maintenance, Repair, and Upgrading of Highway Facilities
17. Transportation Industry Capital Formation
18. Coal Slurry Pipelines
19. Energy Conservation
20. Transportation and the Environment
21. Highway Accident Reduction
22. Labor–Management Relations
23. Stimulation of Employment Through Transportation Facility Construction
24. Regional and Community Development Through Transportation Policy
25. Mobility Rights

About ten of the items belong to the input and output classes, and the remaining issues deal with the running or operation of the systems. Many of the systems operation issues bear on intergovernmental relations. Another group has to do with efficiency to be obtained through deregulation and/or assurance of a "level playing field" for competition.

On reviewing this list (and considering the many issues into which they divide), we note (1) narrow definitions and (2) lack of attention to outputs. Issue 24 does have an output orientation. It refers to development. But by and large the social and economic purposes that transportation serves are not stressed. It is implicit that making transportation efficient and controlling ills is all that is needed. Agreeing with Dupuit (1844), who said "The ultimate aim of a means of communication must be to reduce not the costs of transport, but the costs of production" (p. 63), we think policy ought to pay more attention to outputs. His insight, stated conventionally that transportation is a derived demand, is too often lost in transportation debates.

Control

Policy is a rule or set of rules for control. How do policy analysts think about control? For one thing, control is usually applied to a system part rather than to the system. The term *cybernetics* (which is the study of feedback and automated control) comes from

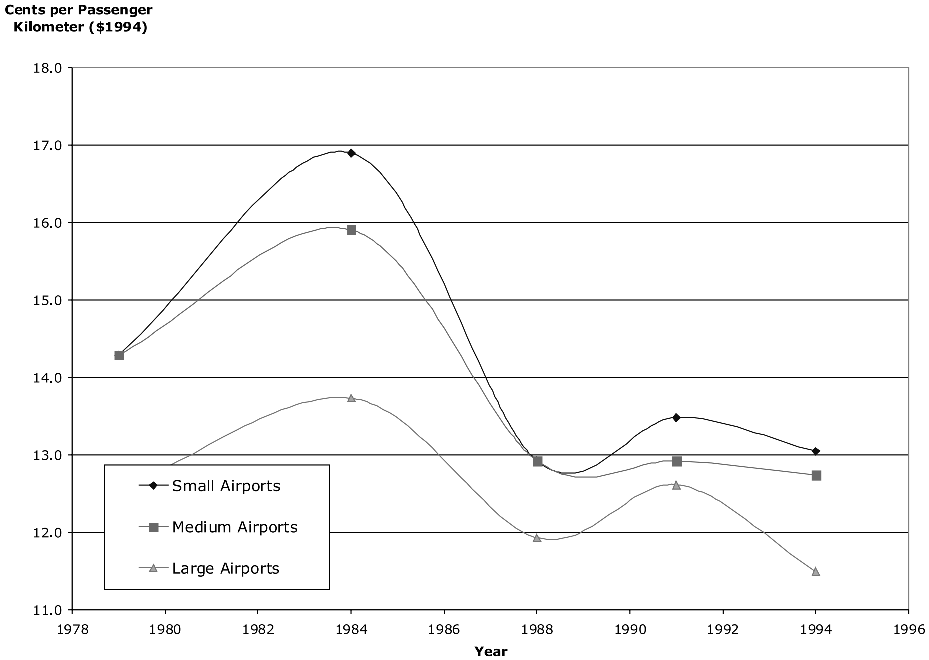


Figure 2.5. Airfares since deregulation: small, medium, and large airports. (Source: U.S. GAO, 1996.)

the Greek word *cubernetes*, meaning pilot or steering or control. The word *government* comes from that same word's Latin translation *gubernator*.

Consider, for example, the deregulation of air transportation. While the firms have been deregulated, there are other components of the system that have not been deregulated. So it is not proper to say that air transportation as a whole has been deregulated. Deregulation was intended to unleash competition and improve efficiency and service quality. To what extent can that be done through partial deregulation? Although many statements have been made about large consumer savings as a result of deregulation, consultation of data gives fuzzy results.

The data are only a fragment, and they require some interpretation. Figure 2.5 shows an upturn just after deregulation in 1978, though a general airfare drop followed over the next decade, and figure 2.6 compares airfares to the costs of other modes. However, it fails to show the long drop in prices from 1950 to 1978 (approximately a halving), leaving the question of whether deregulation lowered prices, or if the price drop was just a continuation of previous trends and efficiencies in the airline industry. That drop largely reflected improved equipment and economies of scale on routes. There has been the fitting of equipment and services to market niches. As a result there have been long-term price decreases for services. The introduction of deregulation seems to have mildly accelerated a long-term trend. Clearly, the airports most hurt were the smaller markets, while large competitive markets benefited the most.

A second matter for discussion is how to select control instruments, and how those instruments control. Control is often considered in a classic way. The system to be

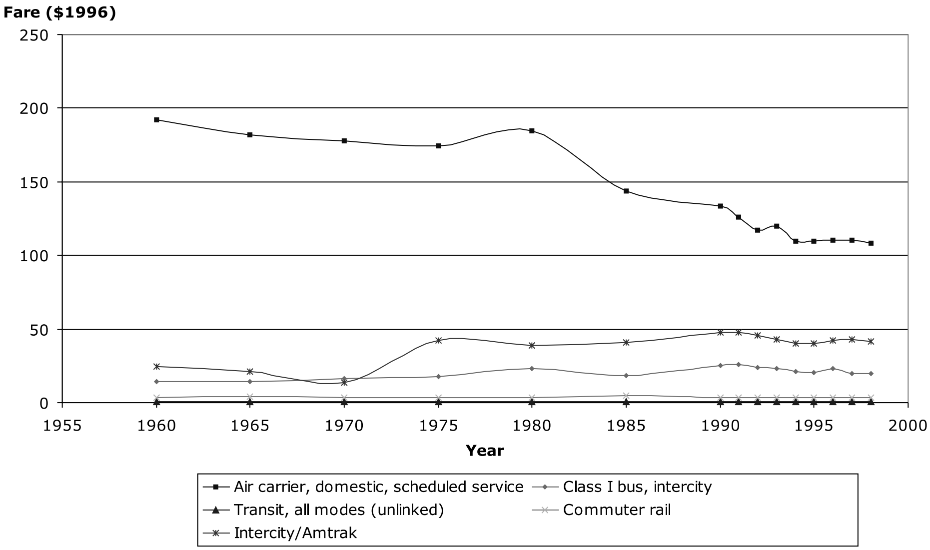


Figure 2.6. Airfares since deregulation: air versus other modes. (Source: Bureau of Transportation Statistics, 2000a.)

controlled is seen as moving along a development trajectory, and policy is to accelerate or steer the trajectory (steer if there has been a perturbation pushing the system off its optimal trajectory). That is a control problem very similar to the "man on the moon" problem, and the Newtonian model applies (from *ca.* 1686 and Newton's *Principia*). We agree with the interpretation that policy makers and analysts tend to be Newtonian (Foley, 1990), but we have never tried to explain that to a policy analyst, and would not dare to try.

An object has attributes of velocity (v), position (r), and acceleration (a). We can move it along its trajectory, $r(t)$, in any direction we want to. A point on the trajectory is a state, and the objective of policy is to move from one state to another. That thinking underlies the way policy is discussed. The debates concern desired states and ways to move things. Time's arrow has no meaning; a dynamic object is controlled by initial conditions. So we accelerate transit development by pumping money into it.

The reader may react that ours is an outrageous and unneeded abstraction. We do not think it is. A large proportion of the policy work we have experienced involves thinking that the problem is to tweak the direction in which things are going (steer within a narrow lane) or to accelerate by subsidies or decelerate by taxes. The change of structure and behavior in fundamental ways is not considered.

We have also observed another way of thinking. It comes up in debates about transportation and energy and the inevitability of congestion. Carbon fuels are limited in supply, and they are being exhausted. A new facility is provided, and there is more travel and we have not eliminated congestion. In these cases, the problem to be controlled is that of managing a bleak future. The future is bleak because technologies are inherently self-limiting. It is inevitable that things will get worse, and we must adjust expectations downward.

Although we may be pushing the abstraction too far, perhaps the implicit model is an entropy one, dating from Clausius in 1850. In particular, the second law of

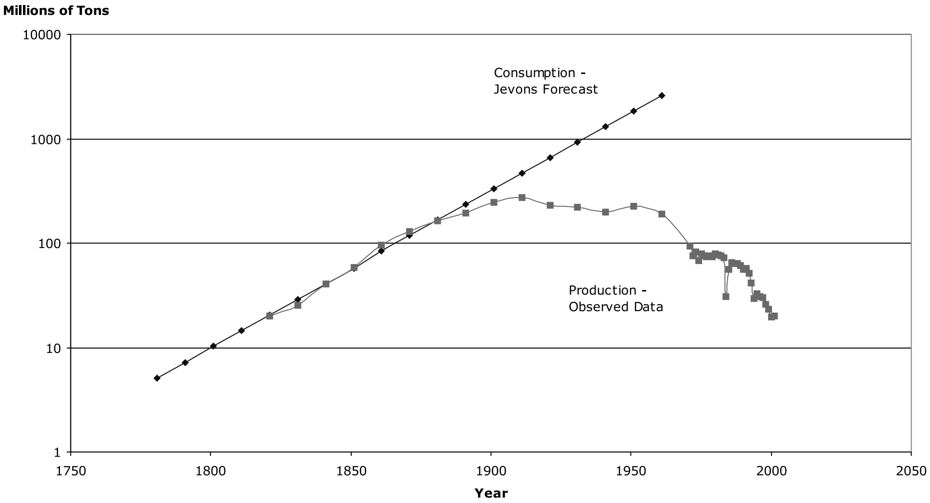


Figure 2.7. Coal consumption and production in the United Kingdom: forecast and actual use. (Source: Jevons, 1866; Cipolla, 1973; Pollard, 1980; Munro, 2000.)

thermodynamics influences thinking, roughly: any physical system left to itself distributes its energy in a manner so that entropy increases; the available energy of the system diminishes. Things run to homogeneity and death.

The theory of Malthus (1766–1834) on the inevitability of overpopulation and the work of Jevons (1835–1882) on the effect of sustained growth in English coal consumption represent the independent development of ideas that yield end-states similar to those entropy-think yields. Jevons's book, *The Coal Question* (1866), had wide influence. Jevons was highly regarded in academic circles, and government policy makers paid much attention to his point that the growth of coal production driven by industrialization would soon exhaust English supplies. His broader point was that technologies are inherently self-limiting. His was a theory of technology that continues to remain valuable for many. He posed the policy issue: "we have to make the choice between brief greatness and longer continued mediocrity" (p. 376).

Figure 2.7 is adapted from Jevons's book and more recent data. It is presented here because of its similarity to population, energy (e.g., figure 2.8), land use, and other many other projections we have seen. The local coal consumption data track the production data, although some coal is sent overseas. The magnitude of the forecasting error is huge (observe the log scale on the *y*-axis). Similarly, as can be seen in oil price forecasts, even when conducted by experts in the field, they tend to be extrapolations of recent trends. Every forecast (from Delphi I to Delphi IX) expects prices to rise in the long term despite 20 years of largely falling prices. This is not to say prices won't rise, just that the forecasts have been consistently pessimistic.

How is this pattern of thinking reflected in policy? We hear debates about how we are running out of petroleum (energy available for the system is diminishing), it is assumed that the highway system is fully deployed (things run to homogeneity and run out of steam). The only thing that can be done is to control boundary conditions (for that is the way thermodynamic objects can be controlled) and accept mediocrity. So we

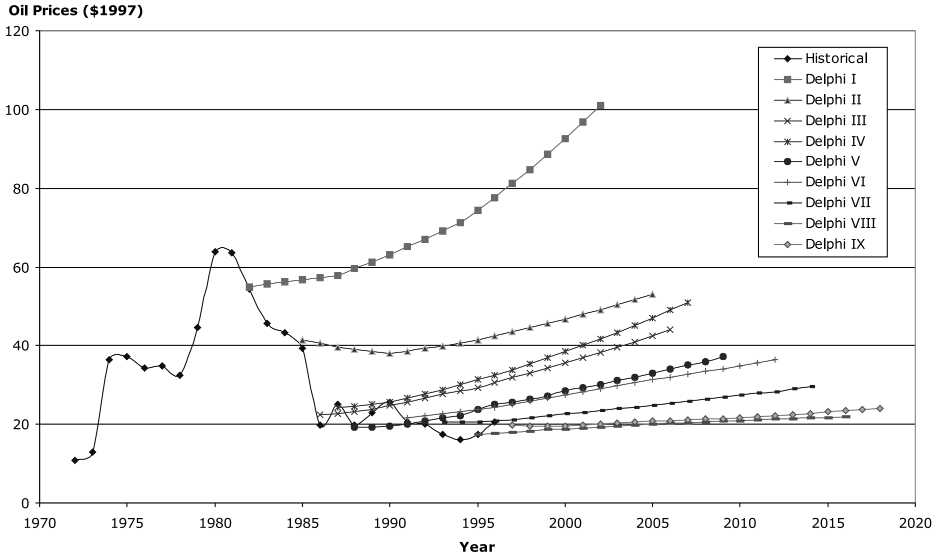


Figure 2.8. Comparison of historical oil prices and Delphi forecasts. (Source: Nelson, 1997.)

control energy use in automobiles by seeking improved use of propulsion energy and accept the mediocre service of congested transportation facilities.

This discussion is not saying that policy analysts should ignore resource matters, for certainly resource questions drive important parts of policy agendas. We are discussing self-limitations and inevitability. Again, the reader may think that our abstraction is outrageous and unneeded. The authors would turn that thought around and say: It is outrageous that we think about policy in physical system terms. We do indeed do that, even though transportation systems are sociotechnological systems.

The broad point of this discussion of control is that people accept things as they are and limit the consideration of policy instruments to those that can shift states and/or change boundary conditions. Movement is along an equilibrium path. Those ways of thinking are not wrong; they are just too limited. We can do much better!

Doing Better

The many social programs created or expanded in the 1960s provided windows for the uses of social science knowledge. What was known could be used to cure housing problems, improve education, solve urban problems, and do many other things. But for many reasons, not all of which were related to adequacy of knowledge, applications of the social sciences did not solve problems, and a considerable disenchantment set in. Daniel Moynihan (1975) pressed for a change of view; his notion of "benign neglect" became a working rule. As a result of perceived failures, researchers have drawn back from claiming values for applications. In addition, current published work gives short shrift to applications, and methodological contributions are emphasized.

The 1960s rush to apply social science knowledge through policy did not affect transportation very much. However, economics-based policy has long found an applications window in transportation, and was not rejected in the 1970s. Work by researchers pressing for deregulation was well received and led to the transportation deregulation movement of the late 1970s and early 1980s. In Western Europe and elsewhere, policy that recommended privatization of government transportation assets was implemented in the 1980s and 1990s. Today, congestion pricing represents an application of knowledge directly to policy.

There is a long tradition of the study of government structure and behavior, in political science and law in particular. One result is that policy problems are thought to result from poor government structure, and their cure is to change its configuration. For example, it was felt that the regulation of the airlines was dysfunctional, and the disbanding of the Civil Aeronautics Board (CAB) was the result, a radical change in structure.

The dysfunctional government structure view has much currency in Washington. Indeed, the curing of government structural dysfunctions is often a motive for national transportation policy studies. It is a motive for the reorganizations that occur frequently in agencies.

The work of the Buchanan School has introduced economic reasoning into structural/behavioral work (Buchanan and Tullock, 1962). It employs the well-known "free rider" insight that economists use in discussing the structure of markets and market failures. In political situations, the rational individual would not exert effort toward an end desired by a large political group because that individual would share in the end even if no personal action were taken. In a large group, the action of one individual is inconsequential. This reasoning helps explain why special interest groups are so powerful. The intensity concept used by political scientists is similar to the free rider notion, and political scientists emphasize how the geographical organization of political power in the United States aggravates the intensity problem.

Iron Triangles and Aluminum Rectangles

In the United States, the national government structure comprises three branches: the legislature (Congress), the executive (President and administrators), and the judiciary (courts). Informed by the executive and in other ways, the Congress makes policy. Policy implementation takes place within independent regulatory agencies or executive branch departments. The courts interpret the intent of Congress, the relations among branches of government, and government powers. That is the way textbooks put it.

Actually, policy is made by negotiation between those who are affected and those who affect. The playgrounds for the formation and implementation of transportation policy are regulatory agencies or units of departments, a subcommittee of the Congress, and those who are regulated, for example, the railroads. The structure is so tight that the words "iron triangle" have been used to describe it. It is a government within and partly outside of government.

This iron triangle substructure provides the context for many studies of the interrelations of structure and behavior. That model of a tight substructure worked well in previous decades for the trucking, maritime, air, intercity bus, and rail modes.

However, things are now a little fuzzier. That is partly because the United States Department of Transportation (U.S. DOT) has gained strength and has begun to advocate policy. Also, the U.S. DOT has picked up safety regulation tasks, though the situation differs by mode. Moreover, independent environmental and consumer groups now keep a closer tab on transportation policy and try to influence it, moving us from an iron triangle to what we might call an aluminum rectangle. As more players involve themselves in transportation policy, the rigid policy structure becomes far less rigid. This has become most pronounced in highway and transit policy since the 1991 Intermodal Surface Transportation Efficiency Act opened up transportation policy making to many more players.

The Federal Highway Administration (FHWA) has worked hard to define its turf, and it works hard to keep and expand what it has. Although the FHWA is only one component of the truck–highway–user system and it must adhere to system rules, it can take considerable independent action. It is a powerful creator and implementer of policy. On the matter of turf, the Surface Transportation Board (STB) has no difficulty interrelating with railroad fixed facility topics, such as route abandonment. It has not said a word about the FHWA's debate with truckers over facilities suitable for large trucks. It would not dare to, for highways are not part of the STB turf.

The FHWA and the truck situation is an example of an iron triangle (few outside groups have involved themselves effectively in truck regulation, causing us to keep only three corners). Other cases include the Army Corps of Engineers and its waterways and wetlands and the Federal Aviation Administration and its airways and airport systems. The Federal Transit Administration situation is a little different because of scale. Transit regulation triangles historically have been local ones, with local public utility commissions or similar agencies having regulatory functions. Recent changes have reduced the strength of these arrangements, and have created national sets of relations.

One trend in the United States is increased interest of the DOT in policy making and implementation. The DOT and the OMB more and more exert their influence on policy and regulation, with varying results. The DOT had considerable influence on the Interstate Commerce Commission (ICC) de facto deregulation of the railroads.

Structure plays out differently in other nations, of course. Even so, other nations usually have a regulatory organization, and special interest groups (such as highway lobbies) have their say (Hamer, 1987). In some, there is the "white paper" style of policy analysis. In many other nations, systems are (or were) nationalized, especially railroads. The iron triangle concept does not have the inside government/outside government split found in the United States, that is, government is regulating inside-government railroads. Is there more "government versus those who are governed" conflict in the United States than in the nationalized system case? It would be hard to show that there is.

Discussion

We have suggested above some models used to guide policy thinking. Just before that, we discussed the purposes of policy: why do we create and implement rules to control systems? If there are dysfunctions something is wrong, and policies seek to manage or correct wrongs. Our brief remark on improving what systems do that is worth doing introduced another aspect of the purposes of policies. They seek improvements going beyond correcting wrongs.

This section will not rehash those remarks. It seeks to emphasize the ways equity and efficiency issues are seen in the minds of beholders and the roles they play in debates.

Imagine being at a conference table or in a public meeting where policy is at issue. You wish to understand what is being said and why. What we have said thus far is helpful. People do come from a vision of what is wrong, and they apply their calculi of how things work to make suggestions. People operate with their own mythologies and systems of metaphors (described in box 2.3). They work toward the "supreme good." They also frame their suggestions (or countersuggestions to what others have said) in

BOX 2.3 Symbolic Systems

Moving from the way the world works to the way it is represented, symbolic systems and images provide the tools used to simplify the complex world; the tools translate complexity into "common sense" and then provide a common-sense basis for actions. What is wrong and what to do becomes simple and transparent. Richmond (1989) applies the extensive literature in semiotics and linguistics to transportation.

Richmond provides concise discussions of symbols, images, and metaphors. In brief, symbols are instruments of thought. They are partial information that can provide a gateway to a larger pattern or may be part of that larger pattern. For instance, a symbol on a map provides a gateway to the reader's knowing that, say, a park or a freeway is present; such a symbol may also be part of the larger pattern. It may show the extent of the freeway network or of a park. The point is that symbols allow one to conceive objects, so once we see the symbol for a freeway we see beyond the symbol to the larger object.

A sign acts as an announcer, for example, ENTER FREEWAY, CURVE AHEAD, RAILROAD CROSSING. It does not always lead the reader to conceive the subject. It is quite different from a symbol, although a sign may introduce a symbol. An image is intertwined with a symbol, it is how a symbol is understood. One abstracts from the pattern brought to mind by the symbol using a calculus of images to make sense out of the complexity a symbol represents. A symbol on a map brings forward the pattern of a freeway. One then understands that pattern using images that abstract from the larger whole. The image held by a pavement expert might differ from that held by a traffic engineer or an ordinary user. The Transportation Security Administration symbol (figure 2.9), a stylization of their uniform, brings the military object to mind. The hope is, of course, that images of heroic officers will encourage airline passengers to cooperate.

One tool we use is a metaphor, one thing standing in place of another. A metaphor permits our drawing on a variety of experiences and applying them to a new situation. We might say, for example, that Brunel did a Stephenson (the developer of the first railroad, whom we will meet in chapter 6) when he developed steamships for the packet trade. That is very useful. It is a heuristic fiction that names, frames, and connects what Brunel did. The birth, growth and development, and maturity metaphor is useful.

Schon (1963) uses the notion of "generative metaphor" to describe the development of social policy. Participants in the policy process tell stories about what is wrong and how things can be fixed. These stories are metaphor based, and the naming, framing, and fixing of problems reflect the metaphors behind the stories. In policy discussions, metaphors serve to cut through and organize complexity; they also execute a normative leap. They pinpoint what is obviously wrong, and they make what to do also seem obvious.

BOX 2.3 Symbolic Systems—cont'd

Richmond (1989) also addresses the myth that rail transit can alleviate the transportation problems of Western cities, Los Angeles in particular. What is a myth? Symbols direct us to particular conceptions of objects, images form the impressions we draw about the objects, and metaphors frame and structure these. The result is a myth. Richmond's study involved interviews with political actors in Los Angeles, and he uses extensive quotes to show the images of trains: "powerful," go "whoosh," "straight through." He presents an aside on the sexual potency of the technological power of a train. A train is interesting because it is imaged as a "she" as well as a penis symbol. Inquiring into the way symbols and images are organized in metaphors, Richmond refers to the organic metaphors so often used in transportation (e.g., arterials, free flow). He stresses the metaphor of the body in balance. The body and its transportation system is not in balance or equilibrium because the circulation is congested. Trains are needed to get circulation in balance.

We think that it is helpful to consider metonymies because they may serve as a building block for images. A metonymy is the use of the name of one thing for the name of another, and that is not the same as a metaphor. It is contiguity/association based. For a simple example, we might refer to America's land resources, although the land is actually owned by many people. Metonymies shape images. The rugged cowboy grins, sits on a horse in a beautiful western landscape, and smokes a cigarette. The cigarette takes on the name of the landscape and all that. Automobile advertisements show sport cars going fast on California rural roads; family cars are shown in the driveways of expensive houses. Sport cars have the meaning of going fast on rural roads, and family cars are the good suburban life. We think metonymies play a major role in shaping transportation images. Have photographs of BART with the Bay Area landscape in the background shaped mass transit policy? We think yes, just as photographs of Shinkansen (new train) bullet trains with Mount Fuji in the background and flowers in the foreground have shaped interest in high-speed rail proposals.

We think that there are differences in the metonymies typically associated with the modes. A bus runs in a grubby place, streetcars and trains run (are imaged to run) in the country or in beautiful suburbs and malls connecting to vibrant, but not too crowded, downtowns.

Why do attitudes change? For example, cars used to be good things, now they are bad. Perhaps that is because the metonymies change. In the early days cars were much used for touring, they were associated with the countryside and were imaged as carefree exploration of the countryside. Cars were viewed as much superior to the train for touring. Today, cars and congested freeways go together, at least in the debate on transportation problems of large cities. Some now argue that to be carefree you must be car-free.

Symbols direct us to particular conceptions of objects, images form the impressions we draw about the objects, and metaphors frame and structure these. Richmond (2003) says the result is a myth, but many political leaders and voters in Los Angeles say the contrary.

When Darling (1980) said that policy had been transformed into a kind of "witchcraft," it seems that he was commenting on processes involving Schon's generative metaphors, the metaphors used to name and frame policy problems. Darling saw naming and framing as witchcraft.

(continued)

BOX 2.3 Symbolic Systems—cont'd

Because reasoning involves naming and framing, and that naming and framing is based on symbols, metaphors, and so on, the results of all reasoning must be myths. The results of reasoning are artificial constructs. That reasoning leads to the conclusion that all transportation knowledge and policy is steered by myth. While that conclusion must be true, it is destructive and immobilizing. If everything is a myth, why bother? Surely some myths are superior to others; while not generally agreed to, Richmond's and Darling's myths are superior to the wisdom generally held. Why? The obvious answer is the analytic content of Richmond's and Darling's knowledge. Analytic knowledge lets us see many myths, such as railroad management tried to discourage passenger ridership, regulation was forced on the railroads, expansion of transit would be energy efficient, and so on.

Who generates myths? Who is using metonymies, constructing metaphors, and engaging in the policy debate? Who is debating policy? White-collar urban planners and politicians engage in service activities and commute to congested office districts. The nature of their transportation problems and their solutions thus follow (Hillman, 1979).

Politicians adjudicate the interest of differing publics so the balance metaphor may be especially appealing to them. Urban planners also have balance upfront; they are attracted to certain metonymies and images, such as the "right" kind of urban landscape. Nowadays, urban transportation planners use the Urban Transportation Planning (or UTP) process; process and equilibrium metaphors are valued. If trained in engineering, transportation planners have a classical, Newtonian physical science worldview. Nature is orderly and exact; it doesn't change by leaps and bounds. Aristotle said in about the year 300 B.C.: "Nature does nothing in vain."

Because nonengineers engage in the policy process and their experiences are different, we suppose that there are classes of myths: economists' myths, urban planners' myths, environmentalists' myths, traffic engineers' myths, politicians' myths, transportation analysts' myths, and so on, because there are different modes and these operate in different situations. We sense that these suppositions are true, but have explored their content only in a casual fashion.

An important point is that it seems that some actors' myths have more authority than myths held by other actors, with authority varying from situation to situation. This speculation contradicts the statement above that authority is gained from the analytic content of myths. The contradiction is easy to explain. Analytic content appeals to some, such as the authors. Others give authority on other grounds.

light of their fragment of the transportation experience. If they are working, say, on airport design in response to congestion, that experience frames their views of the air transportation system and of transportation in general.

But it seems that there is something more, something beyond the "supreme good" suggested by Cicero in this chapter's opening, and the influence of experience. Some rules are telling them exactly what to say.

By and large, we would reject the implication that personal or institutional interest, greed, or something like that is shaping remarks. Rather we think that they are making equity and efficiency tradeoffs (see figure 2.10). Those tradeoffs guide "ordinary behavior."

Figure 2.9. U.S. Transportation Security Administration: security procedure image. (Source: Transportation Security Administration website, accessed in 2003.)

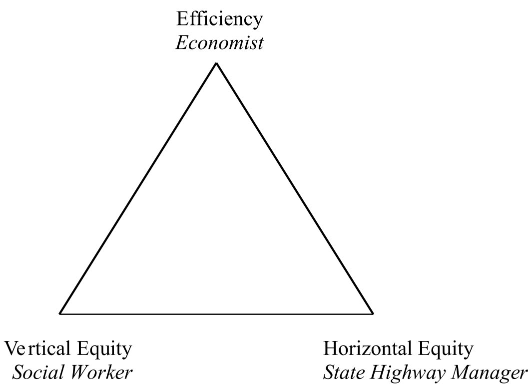


Figure 2.10. Efficiency and equity space.

Horizontal equity has a spatial or among-places content; vertical equity has an interpersonal or among-actors of different classes context. Efficiency at either micro or macro levels has to be traded off against equity of different types.

Returning to our imaginary conference table or public hearing, we hear an owner-operator trucker demanding that policies be imposed to reduce the cost of short-term chassis rentals or a small airport operator demanding facility investment subsidies. In our experience, greed is not the reason for such demands, although at first glance it may seem to be; rather it is rules about equity and efficiency.

3

Planning

Make no little plans. They have no magic to stir men's blood and probably themselves will not be realized. Make big plans; aim high in hope and work, remembering that a noble, logical diagram once recorded will never die, but long after we are gone will be a living thing, asserting itself with ever-growing insistency. Remember that our sons and grandsons are going to do things that would stagger us. Let your watchword be order and your beacon beauty. Think big.
—Daniel Burnham, Chicago architect (1864–1912)

Introduction

This chapter treats the planning aspects of the transportation experience. By way of example, it concentrates on the urban experience. Our objective centers on methods for planning today's and tomorrow's transportation systems. However, the characteristics of systems, their problems, and protocols for management of their problems have ancient beginnings. For example, the analyst setting out to improve international transportation would find that traditions affecting credit and money transfers, legal responsibilities, and liability can be traced to Greek and Roman legal and commercial practices and even earlier. The modal histories are given in later chapters, which will describe the emergence of planning in each specific mode.

What comprises planning and what comprises policy are not always clear. To be brief, we think of policies as rules for behaving, and plans as the schematic of the desired outcome. Thus policies focus on the process and plans on the product. Obviously, process affects product, and products shape future processes. Nevertheless, they are distinct things that are too often confused (especially by those who do policy). Planning emerged from the design professions (engineering, architecture, and landscape architecture). However, as the profession of planning has matured, it has been slowly captured by the process professions (law, policy analysis, management, economics).

Planning itself does not create products; it only specifies how products should be created. The plan may say what should go where, and which should come first. A plan is thus a blueprint for building something and a schedule for building it. Plans are applied in all fields of human endeavor, but we are most concerned about plans for transportation systems and networks and plans for cities and other places. Those two types of plans (transportation plans and land use plans) are now done by different professions, and this chapter investigates why.[1]

Urban Transportation

Early on, cities serving government, military, church, and/or local market functions were scattered about. The commercial revolution pushed the growth of those suitably sited either for transfer of goods by water or to hinterlands served by roads. Industrialization again pushed the growth of those cities as well as cities favorably sited relative to industrial resources such as coal. However, lack of internal transportation affected urban structure (Konvitz, 1985). Pittsburgh, Pennsylvania, for instance, was not in its early days an integrated city as we observe cities today. Rather, it was a collection of interdigitated, but largely independent, mill towns and commercial centers.

Around 1910 the automobile populations of cities began to grow very rapidly (St. Clair, 1986). As a result, several urban transportation planning activities were put in place.

The stage through the 1920s for these activities was very rapid urban growth (see figure 3.1), the centralization of income and wealth in cities, and the emergence of new concepts of planning and management, especially the progressive government movement. There was the grand notion that scientific principles could be used in planning and management to achieve efficiency.

By 1920 there were 6.7 million motorized vehicles in the United States (about 60 percent urban), a number that was to grow to about 23 million by 1930. That was about four urbanites per vehicle.

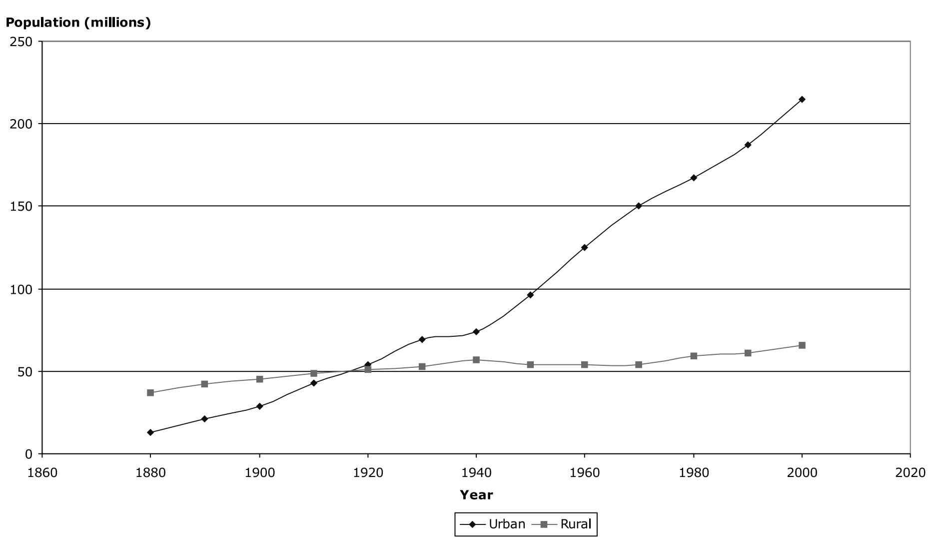


Figure 3.1. Population of the United States (in millions).

Transportation and Traffic Planning

Just about every city of some size undertook transportation and traffic planning during the 1910s or early 1920s to reconstitute streets for automobiles. Plans were sponsored by civic organizations, "great" men (such as Daniel Burnham of the opening quote) were imported to make pronouncements, and a fancy report followed. Typically, the first chapter said "What a fantastic city." Following chapters provided and discussed maps of arterials and land uses. Technical materials then provided street designs, including drainage, bridges, lighting, and so on. The plans also had fiscal and institutional recommendations. Local streets were to be paid for by special property assessments. Arterials were funded from citywide taxes. The city engineering office was to execute the plan.

These authoritative plans were very successful, and welcomed by various types of clients. The plans dictated what to do and how to do it. The imprint of these plans on cities can be seen today.

Plans met the expectations of social critics. Foster (1981) points out that the automobile was welcome for many reasons, among them to reduce crowding and social tensions, to lower housing costs, and to increase access to air and light.

Finally, plans were consistent with the ways previous tasks had been undertaken: improved water supply, drainage, sewage works, streets, and the rebuilding of cities following fires. They were based on learning, and they took advantage of institutional resources already developed. Schultz (1989) makes the point that the institutions and procedures developed to handle public works construction and operations formed the core resources for planning.[2]

A new activity emerged—traffic studies responding to the failure of capacity additions to solve capacity problems. The transportation and traffic studies of the 1910s and 1920s did lead to the construction of physical facilities with the assumption that the facilities would handle the traffic. They did not. So the cities began to commission a new type of study. The review of a typical study will be helpful.

Sponsored by the Chicago Association of Commerce, Miller McClintock's *Metropolitan Street Traffic Survey* (McClintock, 1926) is an example study. It was done in the great man/powerful sponsor style. The Association of Commerce was the sponsor; McClintock, Director of Street Traffic Research at Harvard, was thus the great man.

The existing situation was surveyed:

- Street use and congestion
- Factors complicating traffic flow
- Costs of congestion
- Traffic accidents and accident control
- Parking and pedestrian problems
- Traffic policy problems
- Traffic signals and signs
- Administration
- Traffic courts

The study recommended an ordinance that would:

- Create a division of traffic engineering in the department of public works.
- Reorganize the traffic division in the police department.

- Standardize signs and signals.
- Improve traffic law enforcement.
- Create a city traffic commission.

Again, studies of this type were common during the 1920s, and they continued with an intensified traffic safety flair into the 1930s. They did not address financing, their recommendations were mainly operational in type, and beyond the passing of the ordinance (a city council matter) they split the responsibility for execution between two institutions, the police and public works departments.

Although traffic engineering had begun to take on an analytic stance during the period when these studies were done, there was a mismatch between the scientific fact-oriented views in the Federal Bureau of Public Roads and the style of the traffic studies. The Bureau developed facilities; the output of the traffic study was an ordinance. Traffic studies proceeded in the "great man" style; the Bureau's style was different. Where the Bureau had been involved in urban areas (very rare), the Bureau study style was different. Whatever the reason, this round of traffic studies in the cities had little lasting impact apart from forming a market for the development of traffic engineering (Eno, 1939).

The plans and their execution by city engineering departments tamed the problem of the deployment of urban streets, but not traffic problems: the building of facilities did not take care of congestion, while traffic safety problems remained. Consequently, in later decades the traffic problem emerged and reemerged, and management of the traffic problem diverged somewhat from the management of the road infrastructure problem. We shall refer again to the traffic debate, although it will not be pursued particularly in the discussions to follow.

City Planning

Although city planning has ancient roots, it is proper to remark that it also came into its own in the first decades of the twentieth century, sometimes sponsored by city governments and sometimes sponsored by groups of concerned citizens. At the turn of the twentieth century, planning was highly aesthetic in orientation. The reasons seem numerous: the classical education of many social and economic leaders with interest in the architecture of Rome, Greece, and Egypt; the impact of the 1893 Chicago World's Fair with its emphasis on civic ideals; and the view that beautiful environments would uplift men's souls. So cities planned and built great regional parks, parkways, ornate civic centers, and museums. Frederick Law Olmsted, Daniel Burnham, and Arnold Brunner were leaders in that "city beautiful" movement (Wilson, 1989).

The city beautiful movement was badly damaged, although not dead, by the end of the first decade of the century. What seemed to have stopped it was the realization that in spite of monuments, haphazard growth was leading to many thorny infrastructure problems and that lofty ideals and monuments were not so relevant as were plans and designs to efficiently control growth and deploy needed facilities. Actually, the conflict between the practical and the aesthetic in design was longstanding. Pierre L'Enfant, for example, found his plan for radial streets in Washington, D.C. (reflecting a quasi-organic baroque city notion) in conflict with Thomas Jefferson's gridiron pattern of roads (an ordered city). L'Enfant was later fired over an environmental conflict (trying to run New Jersey Avenue through the newly built house of a signer of the Declaration of Independence). Matters such as these are discussed in several histories of city planning (e.g., Reps, 1965).

The "city beautiful" versus the "city practical" (or "city efficient") debate of the early 1900s saw advocates of ideas debating and pushing their worldviews. Frederick Law Olmsted was one of the more successful of the former. As a landscape consultant, he produced designs for dozens of cities, often working with others. In addition to producing plans that advocated his concepts, he debated in the literature. In contrast, the advocates of rational planning mainly did not use the medium of plans, with Nelson Lewis a notable exception; rather, they wrote (e.g., Ford, 1911).

The present incarnation of U.S. city planning emerged in the State of New York. In 1926, the State Legislature passed a bill enabling cities to engage in a planning process with the elements of that process spelled out in the legislation. Cities were to adopt official maps, create planning boards, improve and maintain records of plats, and undertake zoning.

The city planning movement affected transportation; the New York case is illustrative. The Regional Plan of New York and its Environs (produced by the Regional Plan Association [RPA], an elitist, nongovernmental group that had major roles in urban street and transit affairs) pushed the legislation. The argument for passage of the legislation was mainly transportation in content. The RPA argued that something had to be done to coordinate street development, manage the differences between public and private streets, and assure adequate street widths and street layouts. Issues of zoning, plats, and so on, had a somewhat secondary role, and they came in because of their transportation relevance. Transportation questions were also highlighted as other states passed enabling acts for city planning, and most of the legislation referred to transportation and land use planning. So transportation was an important matter in the genesis of city planning agencies.

The rapid adoption of city planning enabling acts by the states was assisted by work at the U.S. Department of Commerce. In the late 1920s, the U.S. Department of Commerce published a model enabling act for planning, created a Bureau of Planning, and issued publications to assist the states and cities in undertaking planning.

There is a second way that transportation steered the development of city planning. Large cities began as a collection of neighborhoods, and in the early days these were mostly self-contained. There might be a mill or some other type of employment opportunity, with workers and managers housed nearby. Shopping and recreation opportunities were also close. Horse trams and streetcars changed the scale of those neighborhoods, and they also enabled specialized downtown functions—shopping, banking, and so on. Next, the automobile brought a major change. It offered an order of magnitude more mobility than precursor technology and enabled the development of residential areas some distance from workplaces, the suburbanization of workplaces, and many other changes. The effect was to enable the development of areas with relatively homogeneous land uses.

Homogeneous land use was particularly valued for residences because individuals tend to select residential sites according to peer group criteria. Additionally, the externalities of noise, smoke, and so on associated with some land uses are particularly obnoxious in residential areas. Zoning took on the job of controlling externalities, and zoning and land use control began to be the central preoccupation of urban planning agencies.

In addition to supporting the emergence of relatively homogeneous land uses, there was direct consideration of transportation in planning agency efforts. First, a land use may have undesirable externalities because of traffic generation and the loads imposed on parking facilities. Planners and planning commissions give much attention to these matters. Second, there are transportation planning (or design) facets to subdivision developments. Some designs provide better sequestering of neighborhoods than others and fit the overall travel pattern in the city better than others. City planners have long attended to these matters, initially through the hierarchy of roads, now under the guise of traffic calming. Third, many city planning departments did engage in citywide transportation planning and extended their interests to facilities such as parkways, expressways, and freeways.

The early days of city planning saw priority given to creation of the official map and zoning regulations. This was a time-consuming problem because it required the coordination of existing records (as well as a fair amount of leg work). Concerns about lack of coordination of infrastructure that lay behind the creation of planning activities tended to diminish as the Great Depression came along and growth ceased in most cities. Also, in undertaking transportation work there was the potential of turf battles with existing public works agencies, and planning agencies were likely to be wary of these. Historically, when turf battles emerged, the engineering agency was usually the winner—the planning professional was overwhelmed by the technical arguments of the city engineers (Altshuler, 1965). However, this has diminished in recent years as environmental agencies have established technical arguments that the transportation engineers cannot counter. Ultimately it becomes a question of values as much as of facts, and preferences of citizens and decision-makers have changed over time as transportation has matured.

Even though transportation did not enter much into early planning agency work, it was on the agenda. It was on the minds of early public works engineers who worked in city planning, such as Harland Bartholomew. With the resurgence of city growth after World War II some city planning agencies began to make large plans for major transportation facilities. This aspect of their transportation initiatives, however, was coopted by the federal government and metropolitan area planning—a matter that we shall discuss.

Other Varieties of Urban Transportation Planning

It should be remarked now that what we have discussed up to this point is not the whole story. First, we should remember that a role continued during that period for civic planning groups—the Metropolitan Housing and Planning Council in Chicago, the Regional Plan Association in the New York City area, and SPUR and the Commonwealth Club in San Francisco, for example.

Some varieties of transportation planning were not mentioned. The urban railroad problem was an important one. On the passenger side, there was an effort to coordinate service and promote “union” stations. With the growth of the city and development of truck services, downtown teaming yards became obsolete. Also in the freight area, there were problems of coordinating movements among railroads and congestion caused by the operation of freight trains in crowded urban areas. Effort was given to the planning and deployment of railroads that would circumvent urban areas (belt lines) and/or provide better coordination of existing lines and facilities.

Urban airports started out as small facilities located on what was then the fringe of the city. Cities grew and larger facilities were needed, and planning and development activities commenced during the 1930s after service became available from DC-3 type aircraft. The Hopkins Airport in Cleveland was a development that many cities attempted to emulate (Barrett, 1987).

Maritime port development was also on the agenda of a few cities. By the 1920s, inland waterway traffic was dwindling and there was not much interest in inland ports except for those on the Great Lakes. (Traffic later expanded in the 1940s and 1950s as larger dams and locks were constructed.) Although there was congestion around maritime ports, especially those with closely placed single or finger piers, technology development of maritime transportation stagnated and port development problems were not on many agendas. Where there was demand for development, much was accomplished (Konvitz, 1978).

Finally, there is urban transit planning. During the first two-thirds of the twentieth century, not much new urban transit was deployed, although much was deprecated. As we shall see later, fleet conversion issues, financing issues, and ownership issues, which were as much policy as planning, dominated the conversation.

Planning: Who Controls the Turf?

As with most public works, the technical planning turf in transportation largely belongs to engineers. Planning applied elsewhere (for instance, health services, educational services, and land use) belongs to others. There is nothing surprising about that. Planning is organized in knowledge areas, and each domain holds special advantages embodied in notions of processes, available techniques, and professional traditions. Knowledge areas also have resources of institutional and financial arrangements. So, as expected, medical or paramedical professionals do health facilities planning, and macroeconomists play prominent roles in national economic planning.

We have observed that engineers played key roles in the development of urban planning and that transportation considerations loomed large in the creation of urban planning. For example, the first national conference on city planning had the title "National Conference on City Planning and the Problems of Congestion." Things have changed since then: engineers are only tangentially involved in city planning. Transportation planning, the engineers' domain, is a thing apart from city planning. So we have two questions: why did civil engineers give up involvement in city planning, and why did urban transportation planning become an engineering–planning activity apart from city planning?

Simple answers to those questions are:

1. that engineers gave up interest in urban planning after they found that rational analysis failed when applied to social problems, and/or
2. the pendulum had swung too far from aesthetics as embodied in the city beautiful movement and engineers' talents missed the mark of the middle ground. Even so, engineers continued in the transportation planning field because of its technical content and the need for rational analysis.

These explanations must have some truth in them, yet they are insufficient. They beg the question of how the fields of urban planning and urban transportation planning were claimed and divided. Moreover, this division is not permanent; fields encroach upon one another.[3]

Our second question is the extent to which the power of concepts (memes) explains turf wars and their outcomes? Is there a Darwinian survival of the fittest at work? Do the most appropriate concepts and techniques devour less appropriate ones?

Our questions are large ones. We shall deal with them by restricting their scope, discussing rational analysis applied to urban planning. We shall see that the engineers gained and then gave up the turf. We think that was not so much the result of a Darwinian competition between concepts and techniques as it was the engineers' views of their social role.

Rational analysis refers to the application of science and its techniques to practical problems. This is analysis in the tradition of Galilei Galileo (1564–1642). Galileo gave attention to topics in structural engineering, but the development of the rational analysis tradition in civil engineering is usually dated from John Smeaton's work (1724–1794). Smeaton is regarded as the father of British civil engineering and (thus) the grandfather of U.S. civil engineering. Careful problem definition, experimentation and testing, and calculations using physical laws marked Smeaton's work.

We refer above to the conflict between Jefferson's rational analysis and L'Enfant's aesthetic design work, and also to the "grand designs, city beautiful" mode of architecture-based urban planning. The city beautiful movement in urban planning gave way to rational planning in the early part of the 1900s. One has to conclude that the debate was over the power of concepts, but perhaps the real issue was that of the image of what ought to be done. The early 1900s saw the birth of the progressive movement, and rational planning gained the turf because it was consistent with the progressive movement, the idea that "Things ought to done in a progressive way!"

The debate is well documented, and some references to the debate were given earlier in the chapter. Ford (1911) states the rational case, and Olmsted (1910) states the design case. The high ground, so to speak, was taken by Nelson P. Lewis (1916), who, more than any other person, argued that planning should focus on the physical facilities of the city, and the planning and deployment of those facilities should use sound engineering. His argument coupled nicely with the then growing interest in the application of science to business; human factors and industrial engineering began to permeate industry. In addition, it coupled with the progressive movement in city politics. Concerned publics were beginning to argue against the politicizing of urban governments and for the use of experts to manage and operate technical programs (and for civil service-like arrangements for managers of other programs). Because of these couplings, Lewis's influence on city planning was enormous (Stine, 1981).[4]

In spite of these developments, engineers did not retain urban planning. They withdrew to public works. The Lewis tradition passed to urban planners.[5] Was the engineers' withdrawal forced by the lack of efficacy of engineering approaches or did engineers give up the turf because it did not fit their sense of social role?

An argument that is an alternative to the "lost interest in a social role" argument begins with the hypothesis that civil engineering concepts and techniques were inappropriate to a social role in the urban planning context. What is the extent to which the power of concepts or paradigms from different fields clash and the stronger drives out the weak, as in the world of Darwin?

Rational analysis is beloved by civil engineers, and one may say that it obviously does not fit artificial or sociotechnical systems. That may seem true. But when one looks at what is called "rational analysis," much of it is empirical. Empirical statements can be made about anything—urban land use just as well as the strength of concrete.

One might say that engineers are "nerds" or "geeks" and do not fit the kinds of social situations found when one is in social roles.[6] That is true overall, but professionals self-select their field of specialization: they want fields that fit their self-perceptions. So if civil engineering had a social role, then those who are politically effective would populate it.

We have a "perhaps civil engineers lost interest in a social role" conjecture. The alternatives that rational analysis does not fit social roles and that civils have the wrong personality seem weak. So we have the not very strong conclusion that the civils lost interest in urban planning because they backed away from social roles.

In applied fields, such as engineering and planning, outside criteria of success or applicability apply to a greater degree that they do in the sciences. For instance, irrigation engineering was established as a division in civil engineering in 1922. Outside criteria at the time said that irrigation was a great thing. Times have changed. Irrigation engineering still exists, but it has retracted and been encroached on by others.

We shall explore the temporal pattern of tasks as a system is created and deployed. Product engineering gets attention early on, for instance, designing bridges or ships. Process technology gets attention later, for instance, how to plan and construct systems. As a system moves to maturity, standardized products are tailored to their markets—market channeling.

Today, most transportation systems are well deployed and mature. As seen by outsiders (and too many insiders) the task is market channeling; for instance, get the capacities of the traffic signal system just right, balance the fine detail of airport capacity with demand, improve truck service schedules, and rebuild container yards. But in a mature system these are not as important as the tasks of managing a static system, and economists, entrepreneurs and managers, and financiers (rather than engineers) are experts on the management of such systems. Given a static production set, certainly the applicability of economics is strengthened versus engineering.

Those who say that present problems are not so much engineering as they are social or economic are, in our judgment, not so much commenting on the changing outside environment as they are on the state of the system. The system is in a phase where the comparative advantage goes from engineers, who are good at designing physical infrastructure systems, to those who know about management, and how to handle social systems.

Critiques

> *[T]he operating expenses from bad railroad location come by a gentle but unceasing ooze from every pore which attracts no attention. . . . Errors . . . are not likely to be discovered . . . the consciousness that there is danger of error becomes dulled.*
> —A. M. Wellington, *The Economic Theory of the Location of Railways* (1906), p. 3

By reviewing later chapters (and thus reading the book out of sequence) we can note what was accomplished in each of the modes by 1900. Small project planning know-how emerged as early ports, toll roads, canals, and railroads were developed. Engineering consultants did the planning; often they took part in construction. As the needs and opportunities for larger projects emerged (e.g., the Suez Canal, Sault Ste Marie, Union Pacific Railroad, ports to accommodate larger liners), projects became larger in scope. More complicated engineering designs were required, as were more complicated fiscal and management plans. Project analysis techniques were improved. Systematic work was begun on the interrelations of transportation and other activities, for example, by researchers interested in location theory.

It is not too early to begin to forge templets for critiques. We use the word templets in the plural because planning is diverse. The word "templet" suggests something with a shape or a figure in which things are to be fitted, and we have in mind criteria about how planning puts things together and fits the situation.

Many endeavors link a perceived opportunity with a development. The clients (who used the plan and gained or lost from its implementation) and the sponsors (who wanted it) were the same. If we ask "Did it lead to action?," the combination of client and sponsor into a single individual or organization greatly increases the probability that a plan will be implemented.

It should be noted that the words "client" and "sponsor" make useful metaphors. Who was the client for a transportation and traffic plan of the 1910s and 1920s? The immediate clients were the sponsor and the city council that would implement programs. But the urban population should be counted as a client also. Does a plan meet the needs of clients and sponsors? That would seem to be the question that precedes the "Did it lead to action?" question.

Implementation is one criterion. A plan is implemented, and we then ask "Is the result successful?" That question has a "Relative to what?" content. Whether plans are financially successful depends on their context. Many projects were undertaken as systems were deployed, rapid growth was under way. Because of market growth, success would be expected. How could the planner go wrong?

However, the fact is that a lot of plans were accepted and projects implemented that were not financially successful, rail and port facilities in particular, and also some canal and toll road developments. In a networked system where there are cross-subsidies among links, lack of success may not be obvious.

What is "a lot that were not successful?" We have never seen numbers, and they would be difficult to obtain. But the literature is full of references to failures. In some canal and port instances the engineering aspects of plans resulted in unexpected expenses and/or shortfalls in performance. The lack of enough (inexpensive) water for canal operations is an example. These instances do not seem to have been numerous. We would not expect them to be, for there was a build-up of technical expertise as project followed project.

Most failures appear to have resulted from the project scope of planning and, thus, the lack of system considerations. Development of a network link (say, a rail route from here to there) or a transshipment node (say, a port) might seem favorable in a project-scoped context, but prove not to be successful because of changes elsewhere in the system. That is clearly the case for ports, where projects were implemented although developments elsewhere did not bode well for the implemented projects. Sometimes, of course, system-scoped considerations boded success. Consideration of how the Suez Canal would interact with sailing routes around the Cape of Good Hope and the Horn of Africa said it would certainly be successful.

There are dynamic system considerations. As the market becomes saturated and as most opportunities have been taken up, success becomes increasingly harder. The presence of agglomeration economies and route and node economies of scale works two ways in this situation. First, existing, competing facilities may have scale economies supporting their viability. Preexisting agglomeration economies and/or route economies of scale may so enhance competing facilities as to make the outlook for new facilities bleak. Second, projects late in the game often incorporate superior and expensive attributes in order to lower unit costs. To get those lower unit costs, high volumes of use are needed. That is the case today with high-speed rail schemes. This creates a risky situation.

Economies of agglomeration refer to the accumulation of advantages. The early development and activities of the ports in the Bay Area, for example, enhanced the growth of banking, brokerage, ship repair, freight forwarding, insurance, maritime management, and other activities. The advantages held by the port facilities were, in turn, enhanced by these activities.

The discussion has emphasized scale and agglomeration economies, but the point is that the life cycle dynamic affects the likelihood of planning and project success.

There is a network morphology dynamic to be noted. In the case of toll roads, there is a corridor, say, between two major commercial cities (as shown in figure 3.2). Early toll roads targeted end-to-end links along the corridor. For instance, the need for improvements might be greatest in link D–E, and a toll link is introduced there first. As other links are filled in and as collector-distributor roads are improved, say, H–D projects work toward marginal returns.

In the case of canals, river basins form the context, and link-by-link improvements are made. For two basins, at some point the question of an upland link enters (a link between two river basins). Such links are generally expensive; for example, water supply is a problem in upland areas, and there are the uncertainties of traffic between basins.

Discussion

The scorecard on system-scoping of planning shows mixed results. There are several ways we can use the word "system." First, one might say that we have a system plan if we deal with the hard (facility) and soft (management, financing, control, etc.) aspects of what is to be done. Many plans achieve that system view, although what are called plans often deal only with specific subsystems.

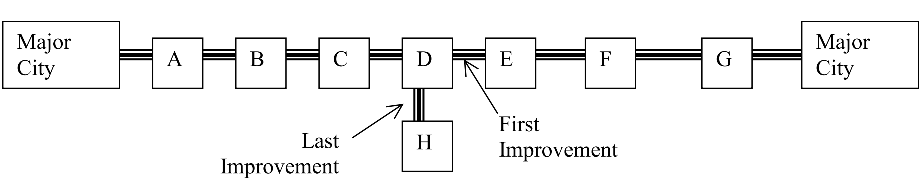


Figure 3.2. Step-by-step toll road improvements.

We can also ask if a plan dealt with the mode as technological system; that is, did it treat guideway-fixed facilities, equipment, and operations aspects of the mode? The railroads did, but other plans mainly focused on guideways: canals, dock facilities, roads, and so on. Equipment and operations were (and are) taken as givens.

Plans were mainly link- or node-scoped. As rail service matured, questions of viable subnetworks owned and operated by individual firms were not handled very well. The introduction of Interstate Commerce Commission-style control was an attempt to control behavior using common law precepts. The question "How do we manipulate the network so as to manage problems?" was not raised until 1920.

A project here affects things there. More generally, the development of the railroads affected the fates of canals and toll roads. The latter were orphaned. Planning was and remains almost universally mode-specific; while it promotes development here it fails to ensure graceful decline there.

In general, plans were made for projects and not for the evolution of systems: there was a project rather than a pathway stance. Some project decisions thus constrained development pathways.

4

Deployment

Always remember that someone, somewhere is making a product that will make yours obsolete.
—G. F. Doriot, quoted in *Time*, 15 May 1987

Introduction

To aid in trying to understand the behavior of a system over time, we have found the life cycle metaphor useful:

- There is a period of *development*, the early days. It is a period of discovery: What should the system's predominant technologies and institutions be like; what will be its markets?
- That is followed by a period of *growth*. Markets are captured, the technology is honed, and technology honing and economies of scale provide for increased efficiency.
- Finally, the system fills its market niche, and stasis tending to senescence describes the situation. The word *maturity* also describes the situation. Marginal improvements may yield a "polished" present that looks healthy but is failing to advance very much.

Recalling the disjoint pattern of decision making, we can say quite a bit about system change and system properties as a system moves along its life cycle. One property of systems, for example, is diminishing returns from investment and technology as a system moves through the latter half of its life cycle. Things move against technological limits; cost-effective things get done first. For instance, the fan jet engines used by jet aircraft are approaching the limits on the thrust that can be obtained from them, the Otto cycle engine is just about as fuel efficient as it can be made to be.

On the other hand, there would appear to be increasing returns in the first half of the life cycle, perhaps as the fixed costs of investment (including both "real" fixed costs such as plants and research and development, and more amorphous fixed costs such as changing the mindset of producers and consumers) decrease.

This discussion is divided into three parts. First, aspects of the (temporal) dynamics of system growth and development are discussed. Next, transportation network dynamics are considered, defining the process by which system elements are added and subtracted. Then the "magic bullet" is introduced to summarize the ways systems seek to use scale economies to lower costs and improve quality.

The Life Cycle of Transportation Systems

Throughout *The Transportation Experience* we trace the life cycles of various modes. S-shaped curves are a key feature of this work. These are diffusion curves showing the realization of a system over time. Researchers at the Institute for Applied Systems Analysis (IASA) in Austria have charted lots of data on American and European transportation systems, and the authors have also engaged in such exercises (Marchetti, 1980; Nakicenovic, 1988; Garrison, 1989; Grübler, 1990; Garrison and Souleyrette, 1996). The earliest known S-curve to track the diffusion of ideas was developed by Gabriel Tarde (1890) (and Rogers, 1962, 1995, looks at the diffusion of the S-curve itself). One would expect curves of this shape, such as in figure 4.1, for transportation is a product like others, it enters and floods a market.

Some questions that arise from observing the process have to do with the positioning of the curve in time, the time it takes for the process to run, and saturation levels. As a rule of thumb, we like to say that it takes 60 to 70 years for a transportation system to run its growth cycle. But for automobile populations, for instance, late adopting nations compress the time required.

Having observed empirical regularities and having in mind a *market flooding* logic for them, forecasting comes to mind. Interestingly, however, S-shaped curves seem not to have been used much in transportation. Forecasters mainly extrapolate data linearly, their thinking is that things just grow and grow forever. That kind of thinking reveals

Figure 4.1. Networks in the United States as a proportion of maximum extent. (Source: Grübler, 1998.)

itself in present debates about future highway needs in which it is assumed that vehicle kilometers traveled (VKT) will continue to grow explosively. We challenge that thinking. There are underlying causes to growth in travel (for instance the rise in female labor force participation) that ultimately must saturate. Thus we see a tapering off of vehicle travel (at least until speeds significantly increase).

Rather than use interpretations of the behavior of systems available in the transportation literature, let us intermix comments on transportation with comments on other activities.

S-curves of the type shown in figure 4.1 fit the temporal realization of transportation systems very well, as well as the deployment of many other technologies. Nakicenovic (1988) has plotted a large number of curves for transportation systems. Three remarkable things about his results are:

- Stability: the curves fit the data very well through good times and bad, shifts in energy costs, and technological evolution.
- Symmetry: the curves are symmetric around a central inflection point.
- Stimulation: deployment time decreases with time. For a place and system, the later in time deployment begins compared to other places, the less time it takes for deployment to be completed.

We should like to know why the realizations of systems have those characteristics. Naturally, our interest goes beyond drawing curves to ferreting out the causes of their realization. What is there about structure and performance that yields "perfect" S-curves? We see that service quality improved and costs dropped for the following reasons:

- Rapid improvement occurs in the hard technology, for example, the railroads began to use more steel and less iron, fuel efficiency increased, and so on.
- Lagging somewhat, rapid improvement appears in the soft technology—control, organizational arrangements, governmental regulation, and so on.
- With networking and the growth of the market, economies of scale and scope are found.

Batten and Johannsson (1985) show that investment in product development is high during the early days of the life cycle, but that as time passes more and more attention goes to processes of production.

For example, we shall see that during the first decades of modern system growth, product development was an issue for highways: "What should highway designs be like?" That was answered by the end of the 1930s when freeway designs had emerged, although they still receive attention. "How to build" was the question somewhat later; it was pretty much answered in the 1950s when the interstate and related planning, institutional, and fiscal arrangements were put in place. The urban transportation planning process is an example of market channeling, and tailoring the product and process to its markets is very much at issue in today's mature system.

A related issue is how a region adopting a product might switch from an importing to an exporting posture as the life cycle progresses. Japan's early import and now export of automobiles provides an example. For a within-nation example, the western United States imported rail cars from the eastern United States in the early days. Now, manufacturers in the western United States export to the eastern United States.

Mensch (1979) extends the Kondratieff (1935) model and suggests that the economy evolves through a series of intermittent innovative impulses that take the form of successive S-shaped cycles, what he calls "the metamorphosis model." The model further

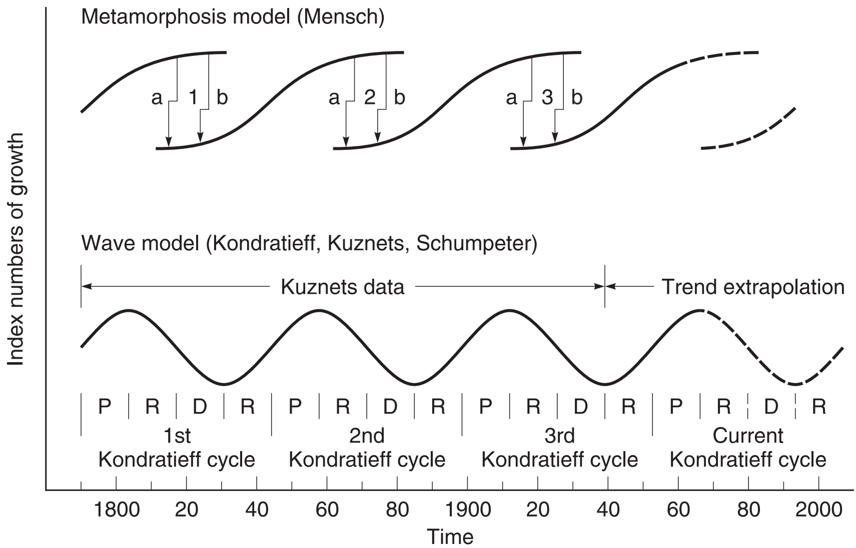


Figure 4.2. Mensch's metamorphosis model of industrial evolution. P, prosperity; R, recession; D, depression; R, recovery. a: stagnation sets off a search for basic innovations. b: These innovations provide a basis for investment and growth. (Source: Mensch, 1979.)

suggests that "surges of basic innovations will come during the periods when stagnation is most pressing, that is, in times of depression" (p. 131).

The upper portion of figure 4.2 displays long waves in the economy, Kondratieff cycles. When the economy is on the upswing there is prosperity. That is followed by recession and depression. Finally, recovery sets in followed by prosperity. What is the mechanism? Mensch refers to waves of innovations that trigger investment, jobs, and so on. As those technical systems begin to age there is recession and then depression. Recovery begins as another wave of innovations begins.

Mensch's reasoning leaves open the question "What causes waves of innovation?" As will be discussed later (chapter 28), we think the opportunities created when transportation (and communication) systems are innovated and deployed trigger waves of innovations and development cycles broader and deeper than those recognized for the model-building cycle (Isard, 1942; Garrison and Souleyrette, 1996).

Box 4.1 gives technical details about statistically estimating the S-curves that we have been discussing.

Transportation Network Dynamics

This book largely explores the macroscopic factors that affect network growth, from birth to maturity. However, these macroscopic explanations may not give us the specific information we desire, such as where is the next link on the network going to be built or expanded, or what is the next link that should be constructed. For that we need more explicit data and different kinds of models.

The planning or engineering question of where all of this activity *should* take place is addressed by the Network Design Problem (NDP), which has received a great deal of

BOX 4.1 S-Curve Math

The S-curves we present in the book are largely displays of data. On occasion we fit smooth curves to the somewhat noisier observations. We seek a curve that best fits the data, assuming the data takes on a logistic shape. The life cycle model can be represented by the following equation:

$$\frac{f}{1-f} = e^{at+b}$$

where

f = fractional share of technology (technology's size (P) of final market size (C)) = P/C
t = time
a, b = model parameters

The objective is to solve for a and b to best explain the relationship, which can be found with, for instance, an ordinary least squares regression, with a dependent variable of ln $(f/1-f)$ and independent variable of t.

One concern when using this for forecasting is to identify the final market size (C). While we may know the current system size (P), to use an S-curve requires a final system size. The models can be fitted for alternative final system sizes, one of which will best fit the data.

To apply the model, it is helpful to estimate the midpoint or the inflection year (t'). Again, this can be done retrospectively, but to do this prospectively requires assumption, though one estimate may fit the data better than others.

Knowing C, t', and a, we can then predict the system size in any given year t using the following equation:

$$\hat{P}(t) = \frac{C}{1 + e^{(-a(t-t'))}}$$

where

$\hat{P}(t)$ = predicted system size in year t
t' = midpoint (inflection point) year

attention in the operations research literature. It is hoped that if clear objectives can be stated for networks, they can be planned and constructed in an optimal fashion. A cursory glance at most large metropolitan areas suggests that road and transit networks are far from optimal, and that this is both an investment and a pricing problem, which need to be solved jointly.

The analysis of network growth has received recent interest again with the rise of the Internet, and it is thought that all transactional networks (transportation and communication) have similar structures and processes governing them.

Broadly we can think of several problems about predicting network growth: *node formation* (where will the next node form); *node expansion* (how do nodes grow); *link formation* (what two nodes are next most likely to be connected with links); and *link expansion* (of the existing links, which will be widened). As networks decline, the same questions can be asked in reverse, leaving us with the *link contraction, link abandonment, node contraction,* and *node abandonment* problems.

Node formation and node expansion are in many ways geographic questions, as many nodes depend on natural resources (e.g., the location of free energy) and nature's networks (the location of harbors, easy places to ford rivers, and river junctions). Other nodes are formed by the intersection of manmade network elements, the crossing of two roads for instance. The geographer's theory of central places is an important element here (Christaller, 1966; Lösch, 1967).

Link formation describes how and which nodes are connected. Within more recently built towns and cities, many networks are in the form of a grid system. But over larger areas, for example between cities, the shape of the network is not so predetermined. Garrison and Marble (1965) observed that connections to the nearest large neighbor explained the sequence of rail network growth in Ireland. Yamins et al. (2003) develop a simulation that grows urban roads using simple connectivity rules proportional to the activity at locations.

Link expansion describes which links will be widened. As many points are already connected, it is the sizing of the connections that matters. The analog in scheduled services is the increasing frequency of service along a route. Yerra and Levinson (2005) simulate link expansion, showing that a network becomes hierarchical even if it begins as a uniform network with uniform land use over a finite area, with all links identical except for location. The network, like observed networks, exhibits power-rule type of behavior, a few very fast links, some moderate speed links, and many slower links. In brief, a hierarchy of roads would exist even if no planners or engineers intended it, and even if there were no "central places." The question has also been attacked empirically by Levinson and Karamalaputi (2003). They found that existing capacity deters expansion (there are diseconomies associated with expanding wider links). Similarly, cost deters expansion, while total budget favors it. Importantly, it was found that increasing congestion on a link, and on upstream and downstream links, leads to expansion, suggesting that decision makers respond to demands placed on the network.

Magic Bullets

Links on many transportation systems have the property that average costs decrease and service qualities increase as throughput increases—there are sharp link or route economies of scale. (Economists give attention to the economy of scale in relation to firm size; we refer to economies resulting from the concentration of traffic on routes.) On a freight rail link, for example, the more traffic, the less the cost of movement and the better the service.

There are lots of "ifs" about that generalization. For example, a sudden sharp rise in traffic on a rail route will make for a congestion mess and low service quality. That has been the case in the United States in those years when exports of farm products and coal soared. But where there are gradual increases in demand, adjustments to hard and soft technology can be made easily, and the links work increasingly better. The Chinese railroads work very well, for example, even though they carry one-half the ton-kilometers of U.S. roads on one-fifth of the route mileage.

We also observe that some systems or system parts are exceptions to the general statement; urban highways and large airports and their immediate air spaces are examples. If demand increases, it is very difficult to make gradual changes to serve the demand, much less provide better service at lower costs. We think the modes that cannot handle changes in demand have serious design dysfunctions (not the least of which is an inability to raise prices when demand spikes upward).

As a system transitions from youth to maturity, both product and process-of-production technologies are standardized. Standards tend to thwart improvements that can be obtained from hard and soft technological changes, and product improvements come largely from returns to scale. Improvements also result from large-market-derived opportunities to provide variations on services or products tailored to market niches—specialization to market niches.

Those generalizations are supported by many examples, although every example requires some special case analysis. Take the case of air transportation. Hubbing and careful fitting of aircraft to route segments, careful scheduling to maximize the hours per day an aircraft is in profitable use, and the sales of within-cabin seats to market segments (coach, business, and first classes) are examples of the ways in which air transportation firms attempt to squeeze profitability from a mature technology. The firms are grasping scale economy and market segmentation opportunities. Except that one may feel that passengers are treated as if they are cattle being driven to slaughter, one must applaud the firms; we have no objections to their search for efficiency.

There is more going on in air transportation, of course. Fuel efficiency is a major consideration in aircraft buys. Many airlines are striving to reduce the costs of labor inputs, using means over and above specializing (standardizing) labor to tasks at efficient scale.

Today's transportation systems are standardized and pretty well deployed. The life cycle discussion concept says that one competitive option available is to locate and satisfy a market niche by tailoring products to those niches, to the extent that it can be done with a more or less standardized technology. The many models of automobiles are examples of market niche tailoring.

There is another option: strive for a big marginal gain (reduction in cost or improvement in product quality) by combining scale economies with quality-enhancing "new" technology. Combining is the important word, for standing alone neither scale nor quality-enhancing technology has much to offer. With respect to scale, reductions in costs can be achieved by serving more customers, but many systems have gone down that route, and at system maturity there is not much room for more cost reduction. The market is saturated. (Though saturated, markets are still increasing with wealth and population, and there are thus some options to achieve more economy of scale.) Quality-enhancing technology has been striven for too. But often only marginal things can be done in the absence of the spreading of costs over larger markets.

There is a great deal of technology at hand for improving product quality. Guideways may be improved to enable increased velocity by tunneling and reshaping of curves. Equipment, too, can be made to go faster; it can be made quieter and more reliable. Such options, though, are pretty well mined out at maturity. It is not cost-effective to invest further in such improvements.

So there are opportunities to combine new technologies with investments that yield scale economies as shown in figure 4.3:

- Increased use yields economies of scale. Those economies allow the use of product quality improving technologies and lower the per user cost of existing technologies.
- The improved product (lower cost) yields increased system use.

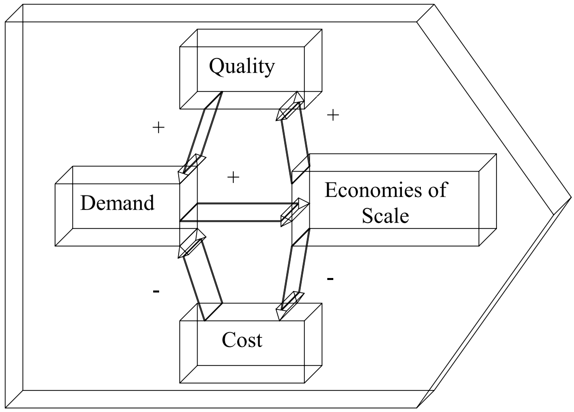


Figure 4.3. The magic bullet.

We have just found what we will term the "magic bullet." We use that term because many think it is the solution for improving systems.

The magic bullet has been framed as combining quality-enhancing technologies with economies of scale. That is one point on a continuum of options. At one extreme, improved quality can result just from scale—the quality improvement from more frequent service is an example. At another extreme, improved quality can be derived from technology alone. We have stressed the combining case because that seems to be the usual case. The extreme cases represent options already pretty much taken up by mature systems, as mentioned.

The combination of quality-enhancing technologies can be targeted on a market niche. We are not the first ones to find that magic bullet. Wonderful things could be done if there were just enough system use. A tunnel between Los Angeles and New York could offer a one-hour service of high quality (as shown in figure 4.4). There is the small problem that it only becomes cost-effective with high levels of use. We calculate that the level of use would be reached if everyone in Los Angeles went to New York and back every day and if demand were evenly distributed over 24 hours.

We have had many policy experiences where promoters put forth policies to steer users to systems so that wonderful things could be done to improve their quality. For example, we have heard many times that if policy would restrict air travel along the Northeast Corridor (Boston–Washington), then a wonderful train service would evolve. Service would improve because of higher schedule frequencies and from investments in quality-enhancing technologies.

Much of the former Urban Mass Transit Administration's technology program, now wound down, was aimed at producing systems so much better than the automobile that travelers would use them. No matter that large capital investments in new technology would be required; at the high levels of use, unit costs would be low. Perhaps behind that reasoning was the experience with the PCC car (discussed more fully in chapter 11), which, as a temporary success, came close to being a magic bullet.

Magic bullet proposals are very risky. To make a difference that is more than marginal, significant capital must be invested. If the technology doesn't work just right,

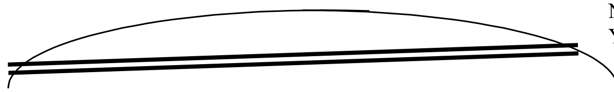


Figure 4.4. Tunnel from New York to Los Angeles.

or quality improvements aren't there, or costs are underestimated, or if ridership is overestimated, there can be a disaster. The planner must be very careful.

The Concorde, San Francisco Bay Area Rapid Transit (BART), and the Tennessee–Tombigbee canal projects were economic disasters. The proposed high-speed train from Los Angeles to San Francisco has the potential to be another. The list is long. These were blatant disasters. The economic dimension is the measure on which disaster is measured. System use did not emerge and/or costs were higher than expected, and failed systems are money sinks. Hall (1980) gives examples of disasters, and his diagnosis is more broadly based than the diagnosis in these notes. Flyvbjerg et al. (2003) treat some European "megaprojects" and reasons for their failure.

Often, projects are viewed as high-technology efforts that failed. For instance, perhaps the most important BART impact is the widespread disenchantment about new technology it engendered in the transit community. We have a great problem with that interpretation because the BART technology can hardly be described as high technology. It is true that there were some problems, but we place blame for those on the inability of BART managers to deal with the purchase of technology. At any rate, the reason for the failure of BART has to be placed elsewhere.

To balance this rather negative discussion, we should remark that there are lots of magic bullet successes. Federal Express (profiled in chapter 17) is an example (Sigafoos, 1984). Fred Smith, its developer, had a market niche in mind, and he fought the problem of getting scale to support quality service—a fight that lasted for several years. The technology tailored to scale and market was mostly soft technology—hubbing, efficient sorting, and so on. A noticeable distinction is that Federal Express is private whereas the others were often public enterprises. However, Federal Express has had its own disaster (discussed below) suggesting that sector of the economy is not the only factor in leading to the mythical quest for the magic bullet.

The high risk of blatant disasters is a feature of magic bullet efforts, and that point has been made. Yet there is a larger risk, the risk of disasters that are not blatant. We now attempt to develop this idea. This requires considerations of the development paths created by magic bullet solutions, the hidden character of some disasters, and effects of concentrating system use.

Consider the returns from system improvements that history tells us about. Early in the life of a new system, it is typically twice as efficient as previous systems. As it grows, takes on new functions, and achieves economies of scale, its improvement runs an order of magnitude, and there are large off-system gains.

Anything that serves society (finds a market) within profitability, environmental, and other constraints is worth doing. Even though we say they have a magic bullet character, society is certainly better off with Federal Express-type services than without them.

Even so, consideration of pathways for development raises the question of whether magic bullet type actions are a desirable way to go. Even if an endeavor is successful, it is on a path that carves out opportunities in a mature system rather than opening a new path of much greater potential. It is not getting the factor of two improvements over previous services, and it does not hold out promise for order of magnitude improvements and large off-system gains.

We have used Federal Express as an example because it is about the best of the magic bullets we can think of; it strains the claim in the paragraph above. But many other examples support the claim. The clipper ship era is interesting. Long a leader in maritime service, U.S. operators bet on the clipper ship over emerging steam and steel hull technology. Clipper ships offered fast service compared to previous sailing ships and their use was targeted on markets where they soon dominated. The clipper ship was a magic bullet in the sense that we have used the term, and it was a rousing success, for a short period of time.

But British operators bet on steam propulsion and metal hulls and the soft technologies that matched them. They got on a take-off path that displaced the clipper ships. U.S. operators gave up clipper ships and got on the steam path too late. U.S. maritime services have never regained the momentum they lost.

The point above is that if the wrong path is selected, a pathway disaster may result. An interesting thing about the Federal Express case is that there has been some action by managers that suggests they may sense they are on the wrong long-run path. Federal Express invested in electronic document transfer (Zapmail) because of its concern about fax services, but their investment lost $294 million (Pratt, 2003). Federal Express of course remains a highly successful enterprise that simply misjudged or mistimed the market (overestimating the number of people wanting to send faxes to people without machines, or underestimating how quickly fax machines would be deployed).

This raises another issue about magic bullets. They run the risk of technological obsolescence, and are very much at risk for loss of scale economies, which may turn a seeming success into a massive failure. The general rule was given in the chapter's opening quote.

We have discussed the clipper ship's sailing in the sunshine of its obsolescence. There are many other examples, such as the quick obsolescence of high-tech, fast passenger trains of the 1950s that were pushed aside by air service.

This wrong-path discussion is very value-laden. Benefits from magic bullet actions accrue in a short time frame. Their costs are in some unknown future. Our view that we would be better off to put our priorities on actions that open up new and rewarding paths stems from our ethical stance. We value highly creating options for the future.

There is another value-oriented thought. Capturing scale economies usually concentrates service and off-system benefits and costs. Air, ocean liner, and rail operators have captured scale economies by concentrating services on particular routes and terminals. Those who are in the right places have many advantages from such concentrated services; those elsewhere are relatively disadvantaged. There is a horizontal (spatial) equity problem. It is one thing to observe that in the aggregate everyone is better off, the distribution of gains is another matter.

There can be another downside. Externalities are concentrated, as those who live close to high-density coal haul routes or large airports are quick to remark.

To summarize, it is certainly true that many of the improvements in systems are scale-derived. That is especially the case as technologies are standardized and grow to maturity. The points made above stress that there is a downside too. In today's situation we are dealing with mature systems, and there may be traps when improvements based on economy of scale are sought.

We have made use of a strong paradigm of transportation system development—there is, say, a 60-year life cycle: youth, growth to maturity, and maturity or stasis. Decline occurs when competitive systems come along. Perhaps using inevitability to describe the process is too strong, but it is useful. Systems are born if there is a market. Once born and once market pull becomes a strong force, the structure and functions of systems and resulting behavior yield robust development paths. The paths are little affected by economic cycles, war, policy, and so on.

Planning's role is mainly driven by stage in system life cycle. While the life cycle paradigm is neither widely known nor used by transportation professionals, there is no question of its strength and the ways it affects what planners do.

The interventions (actions going against the tide, so to speak) to be treated here are by no means exceptional. We can find similar efforts from time to time in all the modes. In the transit case, for example, there was extensive planning and investment in subway improvements serving central business districts (CBDs) during the 1930s. Its purpose was to reverse the erosion of transit ridership associated with the decentralization of activities from the CBD. During the early decades of the twentieth century, European nations and Japan attempted to intervene in the growth of automobilization using taxation schemes and by restricting the development of infrastructure. National airport planning and investment programs have attempted to steer the development of the U.S. transportation system by decentralizing service.

In light of these efforts and others, we must conclude that intervention is certainly possible. It has been successful in two cases:

- First, intervention can slow down or speed up the temporal pace or realization of system development. This is consequential, for impacts running for decades may be involved.
- Second, it can counter system decision-making behavior in the accomplishment of things that are not very consequential. This statement needs qualifying. The record seems to say that it becomes more and more difficult to counter system behavior as systems age. Early on, systems are clay-like, and more consequential things can be done. As time goes by their features harden, they become more like bricks.

These cases are intended to be different. The first is a temporal-realization matter. The second has to do with within-system decision making.

We think of two situations where there can be intervention in within-system decision making. Systems are characterized by disjoint behavior. Intervention has forced joint action by components, actions that might not have occurred if matters had been left to run their course. Left to equipment owners and operators, for example, weight limits on trucks would not have been planned and implemented. The second case is where externalities are involved. There has been successful intervention to reduce noise emissions from aircraft and trucks, for instance.

Discussion

We have used the words "successful" and "consequential," and such words are subject to interpretation. We meant them to be interpreted in very limited ways. An intervention was successful if there was a result that would not have otherwise occurred. It was consequential if the monetary and service results had nontrivial impacts. (Now we have the word "nontrivial" to interpret, but we shall not.)

Experience says that improvements are forged by taking what we have and "carrying out . . . new combinations" (Schumpeter, 1934, pp. 65–66). The designs (new combinations) that seed new development pathways are built from "old stuff" (in the beginning).

The auto-highway system, for example, was built from existing highway facilities; wagon, bicycle, and buggy equipment and electric motors or steam, Otto cycle, or diesel engines; and know-how about the uses of transportation for passenger and freight purposes. The system also interfaced constructively with rail systems; it dealt with social, economic, and ecological problems of the day. Its deployment became an imperative, one strong enough to break existing social contracts forming barriers to deployment.

There are many opportunities to produce "new stuff" which could be the "old stuff" in the forging of new combinations or departures. Going beyond that, it suggests that we should be alert to the opportunities.

While history underscores inevitability, it also tells us how to break the inevitability of the life cycle. We know that the instrument of choice for the intervention in the life cycle should be technology, for we have noted that technology is the major force for change. History certainly tells us that. Indeed, as we examine transit, the search for improved air quality, and energy conservation efforts, we shall see that technology was one tool for planning. We shall also see that knowing that technology is the tool to be used is not enough. One must know how to make technology work.

5

Management

The combination of highly permanent construction and lack of realism in its conception is one of the worse legacies our time is leaving to posterity.
—Bjorn Linn, "Learning from Experience: The Use of Building and Planning History" (1979), p. 277

Introduction

As systems pass from growth to maturity, the administration of the system passes from entrepreneurs to managers. Organizations become more and more risk-averse, taking chances tends to be punished. Debate ensues about who captures the rents of this mature system (capital or labor) rather than how to grow the system. This chapter examines the management of mature systems.

Processes running prior to the maturing of a system run down, in a sense, as a system matures. Early on, the predominant technology is established (technological and institutional structure). Emphasis then is on the components of systems: first on the hard and then on the process technologies. The easy things get done first, and diminishing returns set in. So one characteristic of mature systems is the great difficulty of achieving productivity improvements (Abernathy, 1978).

With a fixed production system, productivity improvements and tools for improvements are usually tied to the achievement of economies of scale. Change is made at great risk. The production system is honed for scale. If a change is unsuccessful, scale is lost, which may be very costly. Mature system managers are thus very risk-averse. To obtain economies of scale, it is very desirable to have a highly standardized product, which is needed for production efficiency. It is risky to vary that product because economies of scale may be lost if unsuccessful.

In general, the manager's tasks are to know the environment within which the organization is operating and the status of the organization. With that knowledge, the manager should take steps appropriate to the situation. That is a "do the best one can" strategy. It accepts the life cycle and maturity as inescapable.

Another strategy rejects the predominant system structure as given, and instead invests in research and development (R&D), explores systems options, and explores market options so as to continually renew or break away from the tyranny of the life cycle. This should be a continuing effort so that new directions of development are available as the system passes its halfway point in deployment and the rate of growth begins to slow. Instead of having development and then growth to maturity, we seek development, growth, and renewal of development, growth, and so on.

We are sorry to say that the notion above has a "just words" character, especially the notion that managers should take early action in anticipation of eventual maturity. There is much talk about strategic management, but little practice. For instance, it has often been said that the railroads should have thought of themselves as transportation companies much sooner. Redefining your mission may be a way out of an unprofitable industry. However, until deregulation, the railroads were prohibited from such a redefinition. Once deregulation took place, the redefinition soon followed.

We have said that managers are in general risk-averse, mainly because having the scale just right is so important. Risks exist if the scale doesn't work out correctly. Some managers, knowing their situation and the resources held or obtainable, engage in strategic planning and actions to reconfigure the organization for new developments. In box 5.1 we indicate some ways behavior might differ depending on the situation.

We need to mention another matter that holds for all managers, the effort to differentiate products. The hallmarks of maturity are product standardization and market saturation. Despite market saturation, the size of markets may be growing (e.g., as population grows), steady, or falling (e.g., if a competitive product is invading the market). To maintain market share in such situations, managers attempt to differentiate their product and carve out market niches. Confrontation results between the desire for standardization and the desire for differentiation. The result is that we get a standard product that may come in many colors, with or without fancy features, and so on. With maturity, then, comes product variety, even though the product is quite standardized. We see this clearly in the automobile market.

This chapter investigates systems at maturity and suggests strategies for coping.

Policies for Maturity

We think that as systems mature, changes in public attitudes force systems to develop policies responding to the interest of diverse and not always friendly publics. As systems mature, more and more attention is given to problems that embedded policies do not handle well.

Although the division is not always neat, government policies can be divided into those that apply to activities generally (general policies) and those that are activity or mode specific (modal policies). The former have increased in number greatly in recent decades, as has the balance between the activities of state and local governments versus the federal government. Sometimes, general policies are given a special twist when applied to the modes.

It seems useful to think of mode-specific policies as contracts. The policies are adopted as parties to the contract give and take and agree on a course of action. Much of

BOX 5.1 Three Cases

A manager's behavior depends on the situation.

Case 1

If a competitive product is invading the market (e.g., steam versus sailing ships, buses versus streetcars), then managers may invest in R&D to try to produce that product or buy a successful producer of the new product (e.g., railroads buying trucking companies). Not infrequently, the competing product is attacked as antisocial and management behavior is rather erratic.

Case 2

Suppose producers are in a monopolistic situation or nearly so and competitors are not so much a problem. The firm or other organization may be used as a "cash cow" to support taking up other endeavors that have more potential for growth. The cash cow may be spun off to raise money for other ventures.

That has happened in several rail cases. Through institutional reorganization, railroads have been stripped of their more promising holdings, for example, land, pipeline, and communications and information systems companies. In a sense the railroad cash cow was used by the company to create new cash cows that they then lost control of.

Case 3

Suppose there is a situation something like case 2, but new producers invade the market with similar products offering higher quality or lower cost. That is the situation in numerous product lines as trade and competition have been internationalized. Managers seek to imitate lower-cost producers and/or dampen international competition via tariffs and quotas.

An example is in airlines where the larger network carriers (United, Delta, American) are threatened by low-cost carriers using a different model (e.g., Southwest, Jet Blue). The larger carriers then try to restructure themselves in imitation (e.g., Ted, Song).

Managers in this case often have exhausted most sources for productivity improvements as a competitive edge, mature system managers increasingly fine-tune services or products to markets, and getting the scale economies just right is essential. Airlines, for instance, try to price discriminate very carefully (people in adjacent seats may have paid thousands of dollars difference in fares), and aim to ensure a high load factor (as an empty seat is permanently lost revenue).

the policy action in the decades since the railroads began to mature, for example, can be thought of as:

- Efforts to modify policies (contracts) as things change.
- The reinterpretation of policies as the relative powers of the parties to contracts change.
- The reinterpretation of contracts as social and economic values and views change.

Turning to the agencies that manage policy, agencies seem to go through a kind of life cycle: early on they are full of vim and vigor, later they are dominated by bureaucratic and procedural matters, and they may be immobilized by inability to deal with conflicting demands. The reversal of policies in which much has been invested is difficult. That was the case for the Interstate Commerce Commission.

An asymmetric information problem evolved: Hayek's *Fatal Conceit* (1989) teaches that agencies cannot have as much information as is held by those for whom policies are made. This forces agencies to regulate in a broad-brush way (one policy fits all cases) and to miss or misread broad industry trends. This seems to hold in the rail case.

On the other hand, policies are responsive to broad changes in public attitudes and values (as expressed by legislators). In the rail case, the agency has been responsive to social cost, safety, labor, free enterprise, and monopoly issues as they have unfolded. However, the conflicts caused by agencies responding to many drummers are not well treated within agencies.

Government policies strove to handle problems that embedded (within-corporation) policies could not handle well. Government has been responsible for conflicts between and within other modes. Air traffic control is a government agency (or government-authorized company) in most countries. While it works in general (in that planes rarely collide in midair), it has been criticized for being too conservative in policy, resulting in congestion, and too backward in technology, resulting in safety problems. In the United States, the Federal Aviation Administration has been regularly lambasted for its difficulty in upgrading computer systems. The criticism reached a peak with the 1981 air traffic controller strike. Yet the problems were very slow to be solved. Newt Gingrich, an American politician, would routinely pull out a vacuum tube as a prop describing the state of FAA computers well into the 1990s, when private industry had long been using solid-state electronics.

Similarly, railroad-to-railroad problems were at the interfaces of the railroads and users. These seem to have been handled fairly well and, by the 1920s, the deeper problems of the "have and have not" railroads began to claim attention. Government policies did not handle these latter problems well. Instead, changes in markets, opportunities for institutional improvements, and changes in technological tools were recognized by the railroads and yielded policies about car handling, traffic concentration, and network design and operations that government policy seemed to thwart. Mergers and acquisitions were essential to realizations of these embedded policies, and government policies were not strongly supportive of mergers and acquisitions, though they permitted them subject to conditions. Labor productivity, shown in figure 5.1, has continued to improve.

Managers of maturing systems may attempt to renegotiate written and unwritten contracts that have evolved over changing times and environments. One such contract is with labor, and box 5.2 illustrates the railroad case. We must quickly say that ties and traditions also evolve in stockholder, community, management, banking, and other relations, and that parties to contracts often include governments.

The Management Imperative

The word "imperative" often enters the discussion of transportation, energy, and the environment. In highway transportation, there are imperatives to keep vehicle producers healthy, find the money to fix the road system, decrease congestion, as well as to increase safety, clean the air, and achieve energy independence. All these imperatives

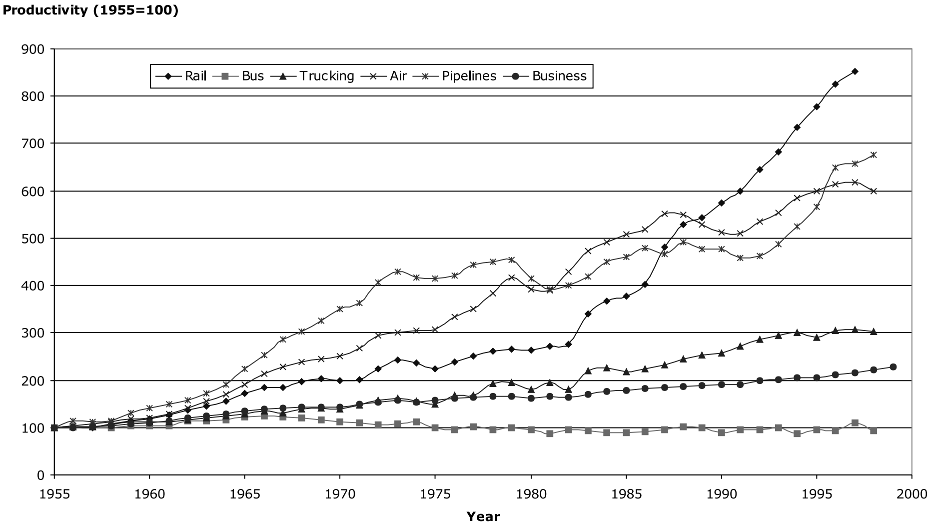


Figure 5.1. Labor productivity trends by mode.

BOX 5.2 Human Capital

Stakeholders in transportation enterprises include users, owners, managers, and labor, and the labor part of the equation is big—about one of every nine employed persons in the United States is employed in transportation or in a transportation-related activity such as gasoline service stations. Even so, one finds little explicit consideration of labor interests in the academic literature on policy (transit labor inputs are an exception). Labor has its own special *iron triangles*. Why is labor treated apart from general debates?

Labor organizations evolved with modern factory and transportation systems. Prior to modern production and transportation, there were artisan labor organizations (guilds), and the organizational basis shifted from things produced to workplaces. Early organizational purposes included social and retirement arrangements, but soon extended to the notion that labor could organize to sell its product (labor) to the workplace. That notion, however, was in direct conflict with common law. Labor was seen as conspiring to take the property of others, and court-made law said that conspiring to strike was the taking of the rights of owners to use labor as they wished.

That situation held until 1842 when the Supreme Judicial Court of Massachusetts broke the conspiracy theory, holding that labor organizations may exist for "public spirited" purposes. That was a means–ends doctrine. The end was lawful, therefore, the means were lawful. The case had to do with the refusal of union workers to work for employers using nonunion employees.

Means had to be mild. Workers could resign and thus not work. But they could not take actions to prevent owners from operating their businesses. Beginning in the 1870s, injunctions prohibited picketing, boycotts, and trespassing. That situation holds today, though the notion of appropriate means has been vastly softened.

The railroads were big businesses and, during the period we are discussing, were the stage for much of labor strife. (Coal mines, steel mills, and packing plants were other

BOX 5.2 Human Capital—cont'd

large stages.) They too attracted national attention because of the wide affects of labor disruptions.

Carrying forward the guild tradition somewhat, rail labor was organized into craft unions, which reduced its effectiveness because of the indifference of other unions to a craft union's special interest. There was common interest when railroads asked for across-the-board pay reductions and in other common interest cases. But when strikes occurred, injunctions stopped them.

Unions had other problems. For instance, Eugene Debs and other radical union organizers found little support for their views among the general population.

The perceived and real abuses by big business resulted in the Sherman Antitrust Act of 1890. "Every contract, combination . . . or conspiracy, in the restraint of trade or commerce among the several states . . . is illegal. . . ." Although unexpected by the drafter of the legislation, the Act was quickly used against unions. For years, indeed, its main use was against unions.

Strikes and strife continued, even so. The result was the ineffective Erdman Act of 1898 and the more effective Newlands Act of 1913 providing for arbitration panels. By this time the stage was national, for the railroads grouped and worked together as did labor.

But arbitration doesn't always work. The Newlands Act foundered on labor's desire to change the dual rate of pay from 10 hours or 100 miles, whichever came first, to 8 hours or 100 miles. Labor refused arbitration, and to avoid a crisis on the eve of World War I, the Congress passed the Adamson Act of 1916 granting labor's demand. (The matter was again arbitrated in 1985—the 100 mile component was raised by two miles per year—and in 1988, when 108 miles became the rule.)

In 1917 President Wilson seized the railroads, citing ineffective operations and labor difficulties. They remained in government control for twenty-six months, until March 1, 1920. Rail wages doubled during this period. The broadly important matter, however, was that government abruptly shifted from an adversary of organized labor to a supporter. It sought legislation to encourage union membership and to take labor relations out of the courts and avoid the injunction process.

A series of acts followed. The Transportation Act of 1920, the Rail Labor Act of 1926, and the Rail Labor Act of 1934 set up special provisions for dealing with the railroads (and the airlines in 1934). A parallel set of acts, and in particular the National Labor Relations Act of 1935, extended to labor generally. These acts state the right to organize and bargain collectively without interference from employers. In the rail and air cases, "It is the duty of all carriers and employees to exert every reasonable effort to voluntarily settle disputes."

For major disputes, the (rail, air) National Mediation Board established an Arbitration Board with subpoena powers over persons and documents. Awards are enforceable through the courts. If that process doesn't work, then the National Mediation Board notifies the President who can establish an Emergency Board. Once the Board is appointed, parties must hold the status quo while data are gathered and for 30 days after a finding is made. Findings have only the force of the status of the President and public opinion. If the findings are not accepted, then the President may ask Congress for special legislation. So today, major issues are settled by the Congress. The carriers are very unhappy about this, for labor often has more power in Congress than do carriers.

(continued)

BOX 5.2 Human Capital—cont'd

Our question is about the ways labor considerations enter the policy debate. We said that labor considerations are a thing aside. Labor is a thing aside because it has its own story and traditions. There are explicit processes for labor considerations that are distinctive. Legislative and administrative considerations and the trail of law for labor questions are apart from those used in policy generally. We made one not very surprising finding: the railroad experience had general spinoffs. As a large, early stage, railroad problem resolution served as a model for other activities. Much of labor law is based on the railroad labor precedence. Why, from a labor perspective, are airlines treated as railroads? Mainly, we see that as an accident of timing. Airlines were beginning to be regulated at a time when there were major revisions in rail labor legislation. Unlike interstate trucking, the airlines were regulated prior to the development of general labor law.

are treating symptoms of the maturity dysfunction rather than maturity itself. What policies are needed to treat the maturity dysfunction?

Insights into the answers to that question are aided by the birth experiences we shall review: experiences for railroads, inland and coastal transport, steam–metal ship marine transport, and the auto–truck–highway system. Birth is based on the old, yet often incorporates something new. System design is the process, and a new system design is the product. Market niches are involved. Sometimes a few actors are involved (e.g., Stephenson and Pease), in other cases it is a many-actor situation (the auto–truck–highway experience). The systems born successfully are consistent with economic and social trajectories of development; they do old things as well as new things, though often the new is discovered after a system is born.

Most experience is with incremental innovations applied to an existing system. Conventional views of innovation, as well of policies to support innovative activities, are based on that experience. It is judged that the policies needed should speed up technology development and its diffusion. Policies should apply to advanced technology. There is little appreciation of the need for policies that support new departures or new designs.

The inability to obtain patents may be a problem. Modifications to existing designs may be thwarted by standards. The system birth experiences we shall review each had to overcome barriers. They did so largely because their high payoffs pushed barriers aside.

The call for new system designs in market niches brings the response: We have tried that using demonstration projects. The experience with them has largely been unsuccessful. What needs to be different from present practice? For one thing, a large percentage of demonstration projects are just schemes for attracting funding. Congressmen arrange projects for their districts. Many projects have a technology transfer character. Where something new is involved, risk of failure may limit the richness of demonstrations.

Managers must tactically manage the existing system, but they must also strategically seek new opportunities, innovating in new markets.

Discussion

Setting aside issues such as market control by large suppliers, one cannot disagree in principle with deregulation, pricing, and, for that matter, other prescriptions for achieving economic efficiency in mature systems. Nonetheless, it must be recognized that the priority given these popular topics comes with opportunity costs. Other opportunities receive low priority. New ways of using technology, reducing the costs of labor, and reworking embedded policies may well have been more important to improved railroad efficiency than deregulation.

What is the overall bottom line for mode-specific policies? Reconsider the quotation opening the chapter. Perhaps it should be rewritten: "The combination of highly permanent policies (contracts), lack of realism in their conception, and difficulty of revising them is one of the worse legacies our time is leaving to posterity."

As a mode matures, new policies are needed. We are probably better off with new policies than without them. We would probably be better off with less permanence, more realism, and an improved ability to revise obsolete, dysfunctional policies.

Maturity creates opportunities. One can identify at a general level things to try out and things to avoid when working with mature systems. One might work toward a set of rules:

- Tune products to markets and specialize services.
- Shun standardized, one-size-fits-all design.
- Plan to achieve economies of scale. Many cost-reducing actions have already been mined out and something new or something revised has to compete where turf is already occupied.
- Avoid high capital cost projects that will require high volume use to cover capital costs.
- Recognize that managers are risk-averse, emphasize tried-and-tested solutions to problems.
- Exploit the cash cows and fat cows that cover the landscape. Downsizing and changing money flows are options.

This is a sample from a possible larger set of rules. Note that what to avoid and what to do is sometimes left implicit.

This page intentionally left blank

Part II

Life Cycle of the Railroads: Looking Back for Lessons from the Railroad Experience

Up to now, we have mainly been looking around and introducing ourselves to the worlds of policy makers and planners. We have taken quick looks at the deployment and management of systems.

It is time now to look in depth, and to do that we shall look back at the birth and deployment of railroads in the period roughly from 1830 to 1920. That was then. Even so, the experience tells us how systems are innovated and spread to market niches. Also, it begins to tell us about the emergence of the policy and planning roles for private sector actors and public institutions, and also about the motives and behaviors of service suppliers and users. There was lots of learning and lots of shaping of attitudes and institutions.

The more recent experience, say since 1920, will tell us how fully deployed systems cope with the constraints set by fixed technological and institutional structures, changing public attitudes, shifts in markets, and other matters.

Why the railroads? They (and the emerging maritime services) were the first of the modern modes and it is fair to say that they shaped the "mother logic" that is imprinted on other modes. It is a bit of a stretch, but one may also say that other modes or systems are just railroads in other clothes. There is "railroad think" ranging from the ways engineers superelevate highway curves to government, firm, and union labor relations in the airline industry.

Moreover, the lessons from how railroads have coped with and polished their aging technological and institutional formats are highly relevant to other modes and to those planners and policy makers who strive to bend the modes to their wills. Today's rather fully deployed modes suffer symptoms of railroad-itis, and today's questions are about its management. Indeed, many of today's policy disasters follow from failure to recognize the situation and use available lessons.

This page intentionally left blank

6

Railroads Realized

You can't find anything unless you are looking for it.
—Geologists' saying

Introduction

The Stockton and Darlington Railway in northeast England began as a rather ambitious project. The Pease family owned many of the Auckland coalfields near Darlington. The market for coal was increasing, but to develop and market Auckland coal, a considerable and risky investment in transportation was required. Edward Pease decided to take the risk, and secured an enabling act for construction in 1821 (Jeans, 1875).

The proposal was for a tramway. Carts drawn by horses or mules were to be pulled along rails fastened to stone or wooden chairs. Rails and chairs were spaced so that draft animals could walk between them. Rails at the time were made either of wood faced with an iron strip or iron plates with no wood backing. Where grades were steep, a fixed steam engine hauled cars using chains or ropes (cable cars); when practical, self-acting planes were used in which the gravity acting on the full carts rolling downhill pulled the empty carts uphill.

The technology for tramways is old, having evolved first in the metal mines of central Europe and in the copper, lead, and zinc mines of England. There was a natural extension from these beginnings to the coalmines and for hauling coal from mines to water. Propulsion was provided in near-level situations by horses. Sharp lifts were accomplished by horses turning capstans, and by steam power when rotary power could be obtained from steam engines (in about 1780).

The rail evolved from iron strips fastened to wood through L-shaped plates to forms that begin to look like today's T-shaped rails. Because the early tramways were associated with mines, they were financed, owned, and operated by mine operators.

As canals expanded, tramways expanded. At first this resulted from the new opportunities for mining. Later, tramways were incorporated in canal designs; some served as feeders where canals could not be practically extended, and some served as sections of canals, as illustrated by the Pennsylvania portage road. No particular institutional or policy problems were posed by these developments.

Tramways were poised for another round of development just before the Stockton and Darlington was developed. Thomas Telford (whom we shall meet later in discussion of turnpikes) had proposed upgrading the road system to tramways using L-shaped plates (edge plates). He had incorporated parallel granite stones in the Holyhead road for use by coaches.

The investment in the Stockton and Darlington tramway was risky because the tramway was to be long relative to tramways of the times. Also, the high elevation of the coalfields and the topography of the route were unfavourable—lots of up and down grades. In light of these difficulties, Pease's problem was to find an engineer who could keep construction and operating costs to a minimum.

He found that engineer in George Stephenson, a self-taught "mechanic" with an excellent reputation (Smiles, 1858). Stephenson did a superior job of engineering. Cuts and fills were balanced to reduce material hauling costs. Improving on "best practice" of the times, there was a combination of near-level grades and short, sharper grades to be worked with self-acting planes or steam engine rope haulage.

Stephenson had experience with steam engines at coalmines (lifts, pumps). He had also rigged some locomotives. For reasons that likely had to do with Stephenson's interests, two locomotives (figure 6.1) were ordered. These were to be used as a horse. Just as a horse could, locomotives were to move 3 to 6 ton carts on level or near-level ground.

The Stockton and Darlington (figure 6.2) was a success. It demonstrated that a well thought-out design could be a moneymaker. Success in the London coal market showed that clearly. It also showed that locomotives were a very effective substitute for horses. Indeed, they had the power to move multiple carts. Success was quickly emulated.

This chapter explores the realization of railroads, from stretching the state of the art of design using existing building blocks, to learning to operate a new technology in new markets.

Profile: George Stephenson

George Stephenson was born in 1781 in Wylam, England. His family homestead was adjacent to the Wylam wagonway, a facility with wooden tracks for horse-drawn carts, which had been built in 1748 to take the coal from Wylam to the River Tyne. In 1802 he took a job as an engine-operator at a coalmine in Killingworth, and was later promoted to engine-wright. There he developed a safety lamp that would not explode when exposed to the volatile gases in the mines. In 1814 he stopped operating engines, and started designing them. His first traveling engine, named *Blutcher,* shown in figure 6.3, was released in 1814. The *Blutcher,* the first locomotive to employ flanged wheels on a track, could haul 30 tons of coal at a time. By 1819, Stephenson had constructed another 16 engines.

His first railway ran for 13 km (8 miles) between Hetton and Sunderland. This railway used gravity to move the cargo downhill and locomotives to go flat and uphill. It is

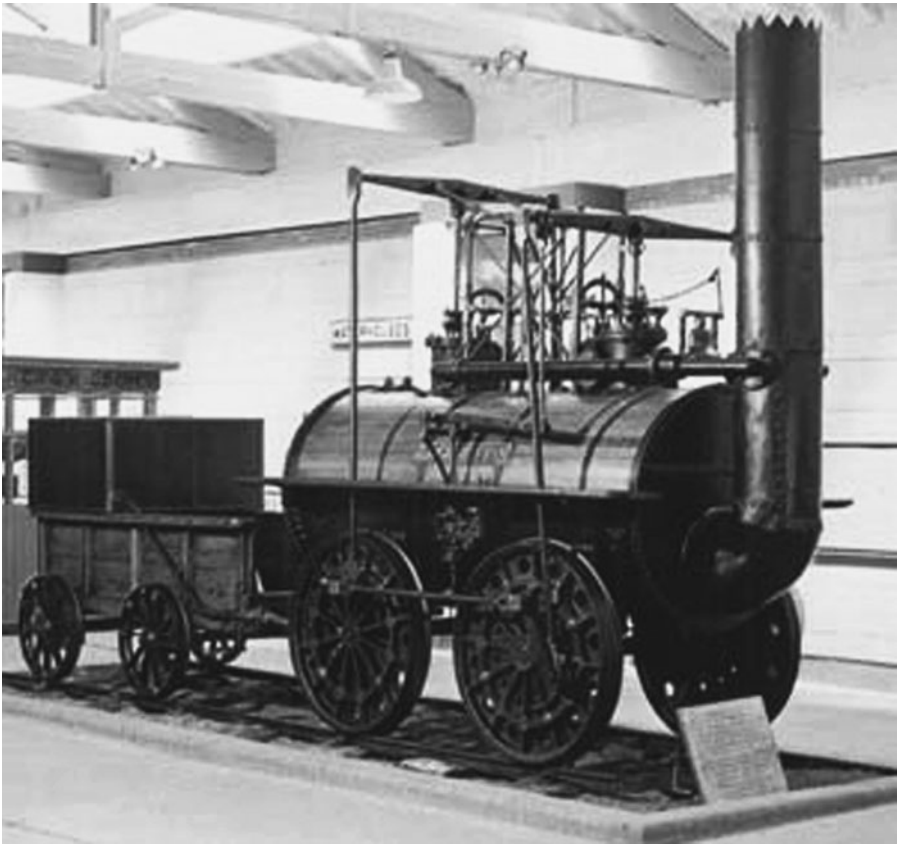


Figure 6.1. Locomotion No. 1. (Source: Darlington Railway Centre and Museum, 2004.)

considered the first railway to avoid animal power. This led to his gig with the Stockton and Darlington discussed above. The Stockton and Darlington broke some other records; the *Locomotion,* built with his son Robert, hauled an 80-ton load a distance of 14 km (9 miles), at a peak speed of 38 km/hr (24 mph). It also included the first intentional passenger car. His innovations were not simply with the engine, but also with the trackage and right of way. Stephenson insisted upon keeping railroad inclines to a minimum, using cut and fill extensively.

The Rainhill trials were conducted in 1829 to test the promise of locomotive engines to be used for the new Liverpool and Manchester railroad. Locomotives were to run at not less than 16 km/hr (10 mph), haul cars of three times their weight, adhere to a weight limit, and run the route without adding fuel or water. Stephenson designed *The Rocket* to compete; it was another, even faster locomotive engine. *The Rocket,* shown in figure 6.4, was innovative for its use of a multitubular boiler, as well as using a chimney to exhaust steam and bring in fresh air for the fire. Because all other competitors failed to finish the race, *The Rocket* won, but that should not diminish its accomplishment.

Stephenson continued as chief railroad engineer with the Bolton and Leigh, the Liverpool and Manchester, Manchester and Leeds, Birmingham and Derby, Normanton and York, and Sheffied and Rotherham. He died in 1848.

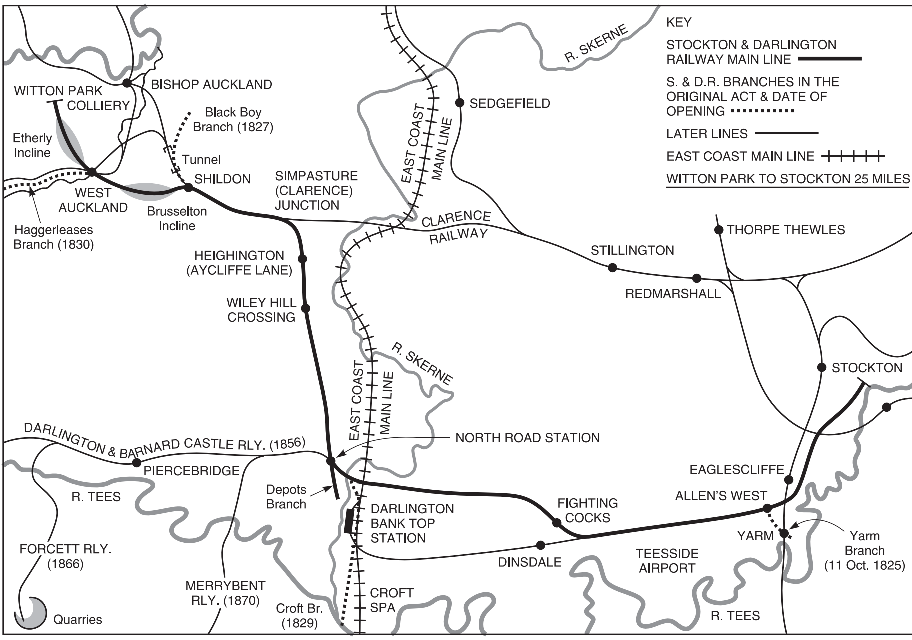


Figure 6.2. Map of Stockton and Darlington. (Source: Darlington Railway Centre and Museum, 2003; *Northern Echo*, 2004.)

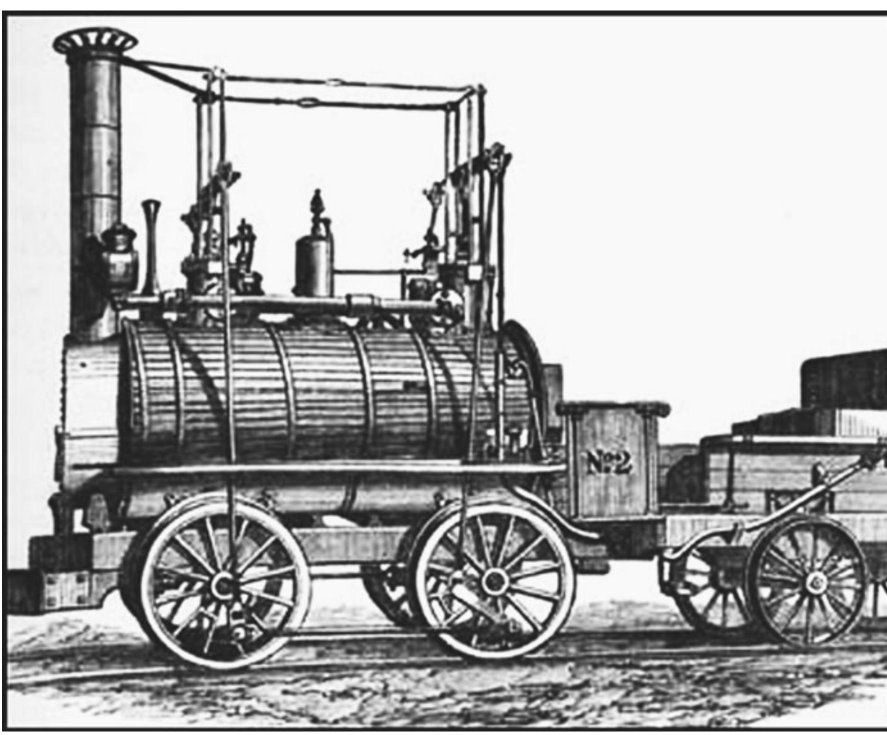


Figure 6.3. The *Blutcher*. (Source: Spartacus Educational Webpage, 2004.)

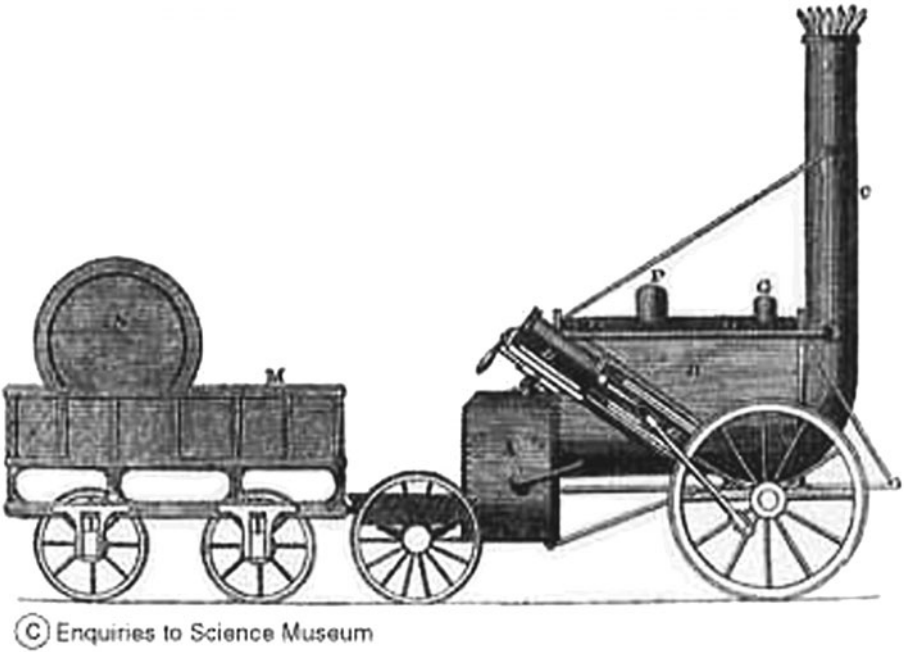


Figure 6.4. Stephenson's *Rocket* drawing. (Source: Grübler, 1998; Science Museum, London, 1829.)

Stretching the State of the Art

The above description of the Stockton and Darlington is just that, a description. Causality is explored only to the level of proximate cause (e.g., Pease had energy and took risks, Stephenson was a skilled engineer who knew cost-effective designs.) Once the Stockton and Darlington was in place, emulation played a major role, and diffusion was rapid. Let us dig deeper.

One remarkable thing about the Stockton and Darlington was the way it stretched the state-of-the-transportation-art. A critic of the times might have said that it had no prospects. Existing transportation systems were built out and mature. Canals, tramways, and roads had been built where the topography was reasonable and the economics was right. The task was that of managing what had been constructed and making marginal improvements. Indeed, John Loudon McAdam's famous book on roads and other publications were addressed to just that. They were mainly addressed to road pavements (macadam surfaces) and toll road management. Although today McAdam (whom we shall also meet later) is known for the macadam road, at the time his fame was as a manager.

With respect to the Auckland coalfields, a canal was out of the question. The coalfields were at a high elevation, and difficult construction and many locks would have been required. Road wagon costs were too high. A facility with some tramway features was the only option.

The text in box 6.1 emphasizes costs, features of the route, and details of engineering. Similar topics are found in the literature of the times. This was done here, that was done

BOX 6.1 Stockton and Darlington Railroad Described in Wood's *Treatise on Railroads* as Reprinted in an 1832 Issue of *The American Railroad Journal*

Stockton and Darlington Railroad

The road extends from Stockton, on the river Tees, to the coal mines, which are 12 miles distant from Darlington. The length of the main line is about 25 miles; and there are several branches which extend in the aggregate 15 miles. The line traverses an undulating and hilly country, and the amount of excavation and embankment was enormous. Some of the cuttings and embankments are 30 and even 40 feet from the surface. The curves on this road are abrupt and causing much friction, the repairs of the rails and wagons require unusual expense. The profile of that part of the road, where stationary power is not employed is undulating—varying from level to an inclination of 1 in 104 nearly, or 51 feet in a mile; the average is 1 in 246. There are two summits, the Etherley and Brusselton, where is passed by means of stationary engine on each, which works the two inclined planes on each side of the summit. The Etherley north plane is one half of a mile in length, and the amount is 180 feet. The engine is estimated a 30 horse power. The Etherley south plane is rather more than 1760 yards in length, and the descent is 312 feet. From the foot of the latter plane to the foot of the west Brusselton plane is four-fifths of a mile. This plane is one mile long, and the ascent is 150 feet; the steam engine on this summit is estimated at 60 horse power, the east Brusselton plane is one half of a mile in length and descends 90 feet. Thirty-two tons (including the weight of the wagons) are drawn up these planes, in one train, at the rate of 8 or 10 miles per hour. This Railroad is a single line, with four turn outs, each of 100 yards in length, in a mile; width between the tracks: 4 feet 6 inches. The rails are chiefly of malleable iron, 15 feet long, & 1.4 inches wide on the top, and weigh 28 lbs. per yard (the form of Birkenshaw's patent). The cost of the iron was more than twice the present price of that article. The expense attending their charter was £12,000, and the land cost more than this sum. Without including these items, the cost of the main line was nearly £5,100 per mile, being a much larger sum than any single Railroad in Europe had cost. The locomotive engines on this road weighed twelve tons, and this enormous and improper load materially injured the rails, which were of the lightest pattern. The cost of traction, with these imperfect and antiquated engines, was one-fourth of a penny per ton for goods per mile;* the cost and repairs of the engines were one-eighth of a penny additional. Horses were formerly employed on this road; their load was 16 tons gross each at the rate of 3 miles per hour. On the Tees there is a suspension bridge, supported by iron chairs.

Many writers have stated that this was the first Railroad intended for the purpose of general trade: this is a mistake. Several Railroads of considerable extent were made in Great Britain many years previously—The Surrey, the Sirhoway, the Cardiff and Merthyr Tydvill, and several other Railroads were intended to accommodate a general trade, and the tolls on them specified accordingly in the several acts of Parliament; although the articles conveyed on them, as well as on the Stockton and Darlington, are chiefly minerals and other heavy goods.

*This includes the profit of the contractors, toll, &c.; they also draw back the empty wagons without any charge. The prime cost of the wagons was defrayed by the Company.

there, where "this" and "that" refer to engineering details and costs. Today's reader might be surprised by how much was known about the strength of metals (but not fatigue), the resolution of forces, and other enduring topics.

The author of the printed text makes the point that this was not the first railway. He cites some tramways in England, and we know of some existing at the time in the United States, Germany, and France. The author failed to realize that on dimensions such as scale, capability to manage throughput, institutional arrangements, and profitability, the Stockton and Darlington was quite different from previous tramways. It was a new combination of old things that opened a new way to provide transportation services. The lesson is simply that the new has a lot of the old in it and that the essence of "new" is new combinations.

Design by Design

It was already mentioned that Stephenson used best practice from tramway and other construction. He borrowed from previous construction learning. Note that we said best practice and not standard practice, and note also that this best practice was carefully applied to the physical and market situations. Similar remarks may be made about the design and use of locomotives. The technology was tailored to the physical situation and to the market niche.

There was also borrowing and tailoring of other things. In particular, the common carrier concept was borrowed from the canals where schedules of tolls were published. Anyone could bring their boat and use a canal as long as they paid the toll. That generally was not the situation on tramways, which were associated with a particular property and operated by the owner. Most were short, downhill all the way in the traffic direction, and fed traffic from mines to canals.

With an expensive fixed plant, Pease needed traffic to cover costs and the desire for traffic was the motive for the common carriage policy. Some feeder routes were built to tap mines owned by others. Stephenson and Pease developed a design in a market niche. It was the design that was new, the innovation itself was a design. With a play on words, it was a design by design (i.e., on purpose). It was a new design built from old building blocks.

Except for the design, there was nothing new about the Stockton and Darlington. There was already knowledge and policy relative to transport enterprises—their financing, construction, tariffs, etc. The technologies were not new. (Stephenson had previously constructed a locomotive for the Killingworth Colliery, building on Watt's improvements of the steam engine. Others had built locomotives, and many were better than Stephenson's.) Yet based on the above arguments, we claim the Stockton and Darlington was not a mere tramway, it was the world's first railroad.

Defining the Railroad

Pease had a clear, but difficult, cost-oriented objective: to keep costs down in order to make money. The problem of costs was deepened when the decision was made to use locomotives; the original tramway charter had to be revised. The political deal-making to accomplish the charter revision worsened Pease's situation. A London coal dealer and Member of Parliament, John Lambton, insisted on a constraint on coal tariffs to be transshipped to London. Per unit distance rates on London coal were set at one-eighth those for local destinations. Pease had to have costs lower than that seemingly impractical rate. That is partly why Pease used the common carrier format.

Pease had to learn how to make the common carrier concept work. For instance, he began by purchasing cars/wagons for lease to independent operators. He was learning about noncoal traffic: how much, how to price it, and services to be provided. In particular, and much to the surprise of managers, passenger traffic swelled and became an unexpected source of revenue. Other questions included:

- How reliable were locomotives, how many carts could they train, and what were the costs?
- Would the wheels slip under load? Did rolling resistance increase with increased velocity?
- What type of rail worked best?
- How to control traffic?
- What were the best mechanical transshipment devices?
- Should passenger cars use stone or wooden chairs?

Not everything went smoothly. At first, passengers were hauled on coal cars. The first passenger car constructed was so heavy that it could not be hauled upgrade when loaded. Learning continued on railroads that emulated the Stockton and Darlington. The Liverpool and Manchester was pushed by Manchester merchants for freight movement purposes, but it was opposed by canal and road interests. How should such a situation be managed? Construction required building through a bog. How was that to be done? What type of locomotive should be used?

Two interesting things about the Liverpool and Manchester were (1) the rediscovery of the passenger market and (2) the alteration of the common carrier concept. The route was planned as a freight route, and passenger demand came as a surprise, even though the Stockton and Darlington had shown latent passenger demand. Indeed, coach operators saw no threat to their business, and they did not oppose the construction of the Liverpool and Manchester. Managing locomotives and schedules required that the railroad own and operate equipment. If brought to the stations, freight of all kinds (fak) was accepted for shipment, with charges at set rates.

The London and Birmingham and the Baltimore and Ohio (B&O) brought learning further. Each required the establishment of a company of considerable size and the raising of capital in capital markets. (The City of Baltimore put up much of the funding for the B&O; the State of Maryland waived taxes.) The problems of locating terminals in large cities and managing large-scale engineering works were confronted and managed. Experiments with the technology continued. Except for learning about organizational structures and distributed management, which occurred later on the Erie and Pennsylvania railroads, the very early railroads pretty much defined the railroad, how it developed, and what it could do.

Learning, and change based on learning, were so rapid that Wood's *Treatise* confused the question of the first railroad. In many ways, the Stockton and Darlington was a tramway with locomotives operating on level or near-level grades, and some things like that had been developed earlier. But the Stockton and Darlington was a proof-of-concept quite different from earlier developments.

Discussion

The Stockton and Darlington experience says a good deal about how revolutionary change occurs in transportation. Much of what it says is contrary to common wisdom, both today and at the time. At the time, it was well known that transportation was pretty much limited to tram, canal, maritime, and road systems, nothing else was needed or practical, and management of existing systems was the priority. A similar view is wisdom today. A fixed production set exists, let us manage it.

The experience says that revolutionary change occurs in market niches and by design. Old building blocks are arranged in new designs, and the steam engine and locomotive were among those old building blocks, for they had been available for about 30 years. Some building blocks were "hard" technology ones; others were "soft," such as the common carriage format and construction know-how. Building blocks are borrowed.

The experience says that markets and production formats are found by inquiring and learning. Change is very rapid when designs are found that bring new resources into the economy (Auckland coal) and support new activities (passenger transportation and its purposes).

Although not discussed, it says that financing will be found if a design is successful. Pease got his first funding from Quaker-controlled banks operated by his relatives. But once the viability of railroads was understood, there was an abundance of financing available. Also not discussed were the environmental problems faced by the developers. As seen in box 6.2, the railroad was not without its complaints. Environmental problems and externalities had to be managed. In the case of environmental issues, the Duke of Cleveland's concerns about his fox dens stalled construction of the Stockton and Darlington for about two years. Finally, experience says that radical change can occur in short time frames.

We view policies as rules for the control of the flow of information and materials. That is a broad abstraction. To use it, let us divide policies into (1) those based on social and political consensus and established and implemented by law or social custom and (2) those created by the modes for their own purposes and embedded in modal practice. Except for the remarks about obtaining charters from Parliament, nothing was said about the first type of policy. Parliament was exercising policy on how to birth organizations, policy based on previous experiences.

Embedded policy was discussed—we talked about policy borrowed from previous experiences (e.g., rules for construction, common carriage) and policy created by the mode to meet its needs. The latter were design rules in the main.

One purpose for beginning our review of the transportation experience by examining the Stockton and Darlington was to illustrate how we can interpret experience. Our discussion began with description. Widening it, we saw how the Stockton and Darlington related to its context and triggered consequential change in transportation services.

Our second purpose was more general. If we avoid concentrating on petty details and strive to generalize, we shall find that there has been a transportation experience. The realizations of the experience have involved different actors, technologies, and geographical and temporal stages, but similarities overwhelm differences. Although we have only begun to examine the experience, it is not too early to ask where the Stockton and Darlington fits in the experience, how is it similar to other things in the experience.

BOX 6.2 Comments by Social Critics

The railroad has been an important symbol in literature, and a subject of social critics. In *Dombey and Son*, Charles Dickens portrayed the railroad as symbol of power and ruthlessness. In *The Uncommercial Traveler* he said:

> I left Dullborough in the days when there were no railroads in the land. I left it in a stage-coach. . . . I was cavalierly shunted back into Dullborough the other day by train. . . . and the first discovery I made was that the station had swallowed up the playing field. It was gone. The beautiful hawthorn-trees, the hedge, the turf, and all those buttercups and daisies, had given place to the stoniest of jolting roads: while, beyond the Station, an ugly dark monster of a tunnel kept its jaws open, as if it had swallowed them and were ravenous for more destruction.

Nathaniel Hawthorne indicated considerable resentment of railroads in his *American Notebook*. Thoreau's *Walden* was kinder. Commenting on hearing a train, he said: "It seems as if the earth has now got a race worthy to inhabit it."

Finally, the press also had fun:

> We renew an idea which we have propounded before, but which has been lost sight of by Railroad managers and by our citizens—namely that an unnecessary number of trains are run on our railroads to accommodate travelers from distant States, and that one train daily would be all the passenger business that is now done on any of the roads. This extravagance is wrong and ought not to be continued. I have no doubt that to change it would add 8 to 10 percent to the dividends to suit these railroads. They should arrange their running and time to suit the citizens of Indiana, and not those of Massachusetts or Texas. All trains should arrive in this city between 11 and 12 A.M., and leave from it at 1 or 2 o'clock P.M.
>
> The Roads of New York sought to pass through a portion of Pennsylvania without conferring any advantage upon the State—in fact, drawing away trade from her own metropolis and conferring no local advantage even upon Erie, unless there was a break of gauge. . . . If the foreign companies succeed in their schemes, there is one great monopoly of railroad interest from Albany to Chicago, rich and powerful enough to buy out or trample upon any rival interest, combining a moneyed power which is without a parallel in the history of the country. We propose making at Erie a break in this interest, and it is this in reality which the railroad fears. (Dunn, 1919)

The reference is to Erie, Pennsylvania, and its situation is shown in the partial map of the Nickel Plate Railroad (New York, Chicago & St. Louis Railroad Company) in figure 6.5. Interestingly, Erie is today the location of much of General Electric's transportation equipment manufacturing, suggesting perhaps that the railroad did offer some advantage.

The anxiety associated with the railroad finds parallels today with the concern of the all-consuming "sprawling" city and the shrinking countryside.

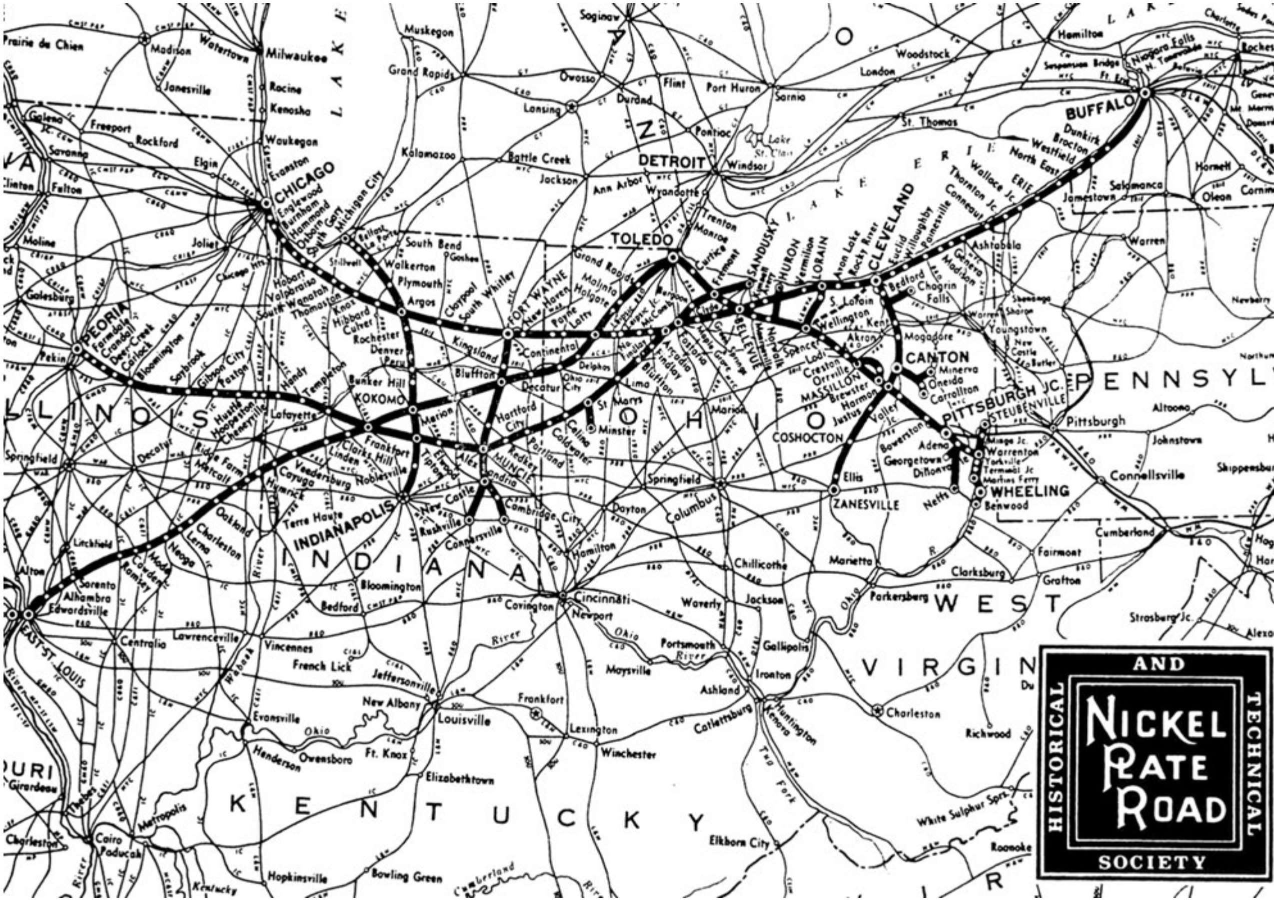


Figure 6.5. Map of Nickel Plate Railroad crossing through Pennsylvania on route from Buffalo to Chicago. (Source: Nickel Plate Historical Society, 2004.)

This chapter referred to the design of a new system using old building blocks. Although not yet discussed, we shall see close analogies among Juan Trippe's Pan American Airlines service developments of the 1920s and 1930s, Malcolm McLean's Sea Land container services of the 1950s, and the Stockton and Darlington. The early development of the auto-highway transportation and some other developments do not compare so easily, but they do compare.

Our discussion treated the Stockton and Darlington and follow-on experiences. We saw more than the birth of the railroad, for the discussion treated the search for workable institutional and technological designs. We saw the birth, system shake-out, and design revisions.

In a paragraph above we said "triggered consequential change." By consequential we mean that productivity at least doubled, by change we mean that it offered new options for production and consumption. Public policy did not play much of a role in occasioning consequential development. Development occurred because innovators did things. Can we learn enough about policy to be proactive on consequential transportation development matters?

7

Railroads Rising

Next to the originator of a good sentence is the first quoter of it.
—Ralph Waldo Emerson, *Quotation and Originality*

Introduction

The first railroad serving both passengers and freight on schedule, the Stockton and Darlington, began operating in 1825. Using Stephenson's steam engine and edge rail, it demonstrated that large volumes of bulk traffic (500,000 tons per year) could be moved at low cost. Though large for the times, today most rail routes move upwards of 10 times that amount.

Many looked at the Stockton and Darlington and read the easy lesson—tramways could be built at larger scale and scope than had been imagined before. As a consequence, fifty or so tramway proposals emerged in the decade after the Stockton and Darlington opened. Most were cable cars, powered by stationary steam engines and cables, both for incline and flat running; some were to be mainly locomotive powered. The idea extended to the European continent. The Saint-Etienne railway, completed in 1828, is said to be the first French railway. It was a tramway with some locomotives built on the English model and linked the Loire valley with Paris to move coal. It was soon extended to Lyon and carried passengers.

Canal/river facilities linking Manchester with Liverpool were strained, and Manchester businessmen sought congestion relief. The market situation called for increased capacity. Manchester was a major mill town, which by 1824 had 30,000 power looms and was importing 400,000 bales of cotton. A Liverpool–Manchester cableway was proposed, and William James had begun surveys in 1822.

George Stephenson replaced William James on the Liverpool–Manchester line in 1824, and his plans went to Parliament in 1825. After overcoming much opposition from landowners and canal interests, an Act was passed in 1826, and construction began.

Cable haulage was sure to work, and it had to be used in a tunnel connecting the station in Liverpool with the docks due to the steep grade and lack of ventilation. But there was concern about its use on the main line. It would provide excess capacity if traffic was light in the early days. Locomotives could be provided to pace the build-up of traffic. But would they be reliable and have the necessary power? The Rainhill trials proved they could.

Running at about 32 km/hr (20 mph), the 50 km (31 mile) line was opened to passenger service in 1830 and to freight service in 1831. Both services were an immediate success.

While the railroad attempted to arrange passenger service provision by a coach operator and freight service by a canal operator, the railroad's desire for control of both car training and train schedules and revenue, and tepid support from private operators, led the railroad to elect to operate services, a major reinterpretation of the common carrier tradition championed by canals.

Freight cars were built from tram and wagon experiences. First-class passenger cars were, essentially, three road coach bodies mounted on a flat car. Second-class cars were open-sided cars with roofs. If a traveler wanted his own road coach, it was mounted on a flat car.

This chapter traces the rise of the railroads, from the emulation of the first system to learning about networks, technology, passenger travel, freight transport, and embedded policies.

Emulation

Success followed success, and by the 1850s a good bit of the fabric of the world's rail routes was in operation:

- 1825: The Stockton and Darlington opened.
- 1827: The Baltimore and Ohio (B&O) obtained a charter.
- 1829: The Baltimore and Ohio (B&O) opened for service.
- 1830: The Liverpool and Manchester opened.
- 1834: B&O extended to Harpers Ferry (now in West Virginia).
- 1831: The Pontchartrain Railroad (New Orleans, Louisiana) opened.
- 1833: The Charleston and Hamburg (South Carolina).
- 1834: 14 short railroads had opened in the United States.
- 1837: The London and Birmingham opened.

The London and Birmingham, Baltimore and Ohio, and Charleston and Hamburg were larger enterprises with longer routes. They required larger-scale organizational and financing arrangements. Otherwise, they adopted what had been learned.

Given the answer to the questions of what railroads would be and what they could do, deployment was very rapid. Figure 7.1 shows the growth of the network in England. As the pace of growth suggests, the system had largely climbed its S-curve by 1880. There are several excellent histories of transportation in England (e.g., Aldcroft and Freeman, 1983). For the U.S. experience see Ringwalt (1888).

Because the railroads were the first of the modern modes, there was much interesting learning-from-experience as they dealt with their growth and development problems. Later modes emulated much of what the railroads learned. For this reason, learning will be the operative word in our organization of the discussion.

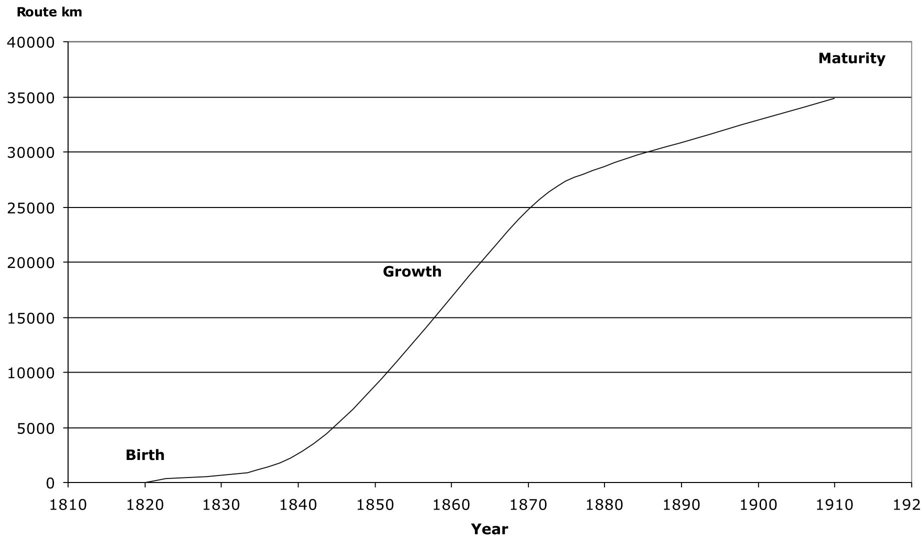


Figure 7.1. S-curve of route kilometers of railroad in England.

Learning About Networks in France

The Legrand Star plan, centering railroad service on Paris, was produced in about 1830 by the French Corps des Ponts et Chaussées. Louis Navier, leader of the Corps, saw speed as the advantage of rail, and railroads were to move passengers and priority freight in a fashion complementary to canals. He felt that others, especially the Americans and Germans, were not building to high enough physical standards, and the plan called for limited curvature and grades.

But there was a problem. In spite of taxing power, public capital was not available for the high-quality railroads. The compromise was that the government would create the fixed facilities and that private companies would finance equipment, stations, and so on. There would be private operations for 99 years, at which time the properties would revert to the State. In practice, there was some compromising of standards to reduce facility costs. Twenty-eight companies were created and eventually consolidated into six regional monopolies. To meet the requirements of the plan, main routes cross-subsidized the operation of routes in small markets.

State engineers planned the routes, and there were complaints from places not well served. State financing was partial, as mentioned. State engineers also established tariffs and fares (and, to some extent, service). Private companies could and did build feeder lines, as was the case with toll roads built in the regions. The point is that the central government took actions in an absolutist way in the spirit of Colbert.

These accomplishments were not made without great debate, and there were periods when antistatist, antielite, liberal Adam Smith-like forces held power. Antistatists argued that the time value of money made high-quality facilities inefficient and that marginal cost ideas should take priority over state-determined prices and cross-subsidies. The authority of government engineers versus engineers in the private sector was also debated, with "cheaper and better" argued for private sector engineers. But even with these debates, absolutism continued. This was in spite of the Revolution and Napoleon. Indeed, the Napoleonic Legal Code (which was based on Roman law), in contrast with English common law, may have eased the implementation of absolutism.

Most critics say that France overexpanded its rail facilities and invested in canals when they were no longer competitive with rail. High standards for canals resulted in expensive facilities, and they did not fit instances where water and/or traffic was in short supply.

Bismarck's invasion of France in 1870 brought the Paris-centered rail system into question, for the French could not move troops to the front as quickly as the Germans could. As a result, a grand plan was produced in 1880 resulting in the northeast rail corridor.

Other critics say that France developed very fine systems as a result of the professionalism of the central government and the engineers' uses of science. There is no question that, from a strictly physical engineering view, the French developed superior facilities using superior knowledge (Smith, 1990).

SNCF was created in 1938, and another round of superior engineering was seen as the railroads were electrified after World War II (25,000 volt, AC transmission converted to DC by locomotive rectifiers). The TGV and today's expressway system followed.

Figure 7.2 illustrates intermodal complementarity; in the River Zorn valley side by side are the Rhine–Marne canal, the River Zorn, the road leading to Lutzelbourg, and the Paris–Strasbourg railway.

Learning About Technology in the United States

Railroad development began in the United States at a time when the predominant technology was still in a hardening phase, and the technology was specialized to the U.S. situation. A key actor was Robert Livingston Stevens (1787–1859), son of Robert Stevens, the competitor of Robert Fulton of steamboat fame.

Figure 7.2. Transportation in the Zorn River valley. (Source: Heitmann, 2004.)

Trained in construction and steam technologies by his father, R. L. Stevens was first president and chief engineer of the Camden and Amboy Railway (later, part of the Pennsylvania system), incorporated in 1830. Stevens journeyed to England in 1830 to meet Stephenson, and he purchased a Planet series locomotive, the *John Bull*, which arrived in the United States in 1831. Stevens designed the “T” rail, which was known as the Stevens or American rail and is now universally used. He also developed the rail–spike–crosstie system. The bogie truck and methods of wood preservation were developed on the Camden and Amboy. Also on that railroad was Isaac Dripps, the innovator of the cowcatcher, which not only redirected lost livestock, but also (with additional wheels) helped to keep the locomotive on track. Stevens was America’s Stephenson, and the Camden and Amboy was its Stockton and Darlington.

The hardening of the technology America-style also yielded the “American” locomotive. Rigid British locomotives did not ride the poorly aligned, light American rails very well, nor did they serve well on the sharp turns of mountain passes. They were also designed for coal burning.

To meet the U.S. needs, Henry R. Campbell of Philadelphia developed and patented the “American” 4-4-0 locomotive in 1836. (The numbers are based on Frederick Methvan Whyte’s system of classification. The first number is the number of leading wheels, the middle number is the number of driving wheels, and the last is the number of trailing wheels. Thus for the 4-4-0 there were two leading axles (four wheels), four driving wheels, and no trailing wheels and axles.) The chief feature of the American locomotive was a four-wheel, two-axle pivoting truck at the front which would turn and guide the locomotive around curves.

John B. Jervis produced the first versions of the American design; his locomotive was a 4-2-0 and weighed about 7–10 tons. But with in a year or so the Campbell design evolved to 4-4-0s weighing about 15–25 tons. A typical American locomotive is shown in figure 7.3.

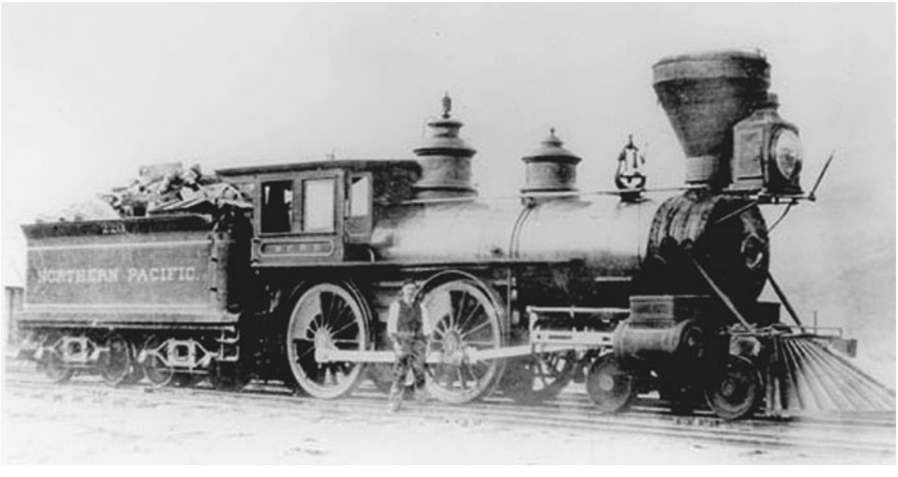


Figure 7.3. American locomotive from Northern Pacific Railroad. Note: Class C-13, 870-898, 4-4-0 Standard, total built 29, Portland Locomotive Works, 1881–1883. (Source: Carlson, 1884.)

The wood versus coal question was touch and go. Initially, coal was expensive in the United States, but rail service soon began to make anthracite available. Just at that time, though, the demand for coal was affected by rapid growth of “hot blast” iron and steel production, which put pressure on anthracite prices. Less expensive wood became the fuel for most railroads, but a few railroads used anthracite.

As the technology hardened in a suitable form, railroad construction boomed (starting in about 1845). The American locomotive dominated American practice through 1900. The weight and power of the locomotive increased by at least a factor of three, yet the real price remained steady, and even fell during some decades. There was a shift from wood to coal fuel in about 1880. There were many American-type locomotives still on the properties when diesel replaced steam in the 1950s. Quite a number were exported, some to England. Later, many 4-8-0 locomotives used in Europe were based on American designs.

One reason for the quick demise of canals was the unusually cold winters of the middle 1840s; there were short shipping seasons just at the time new canals were opening and facing competition from railroads.

A so-called debt-repudiation depression began in about 1839 and continued to about 1847. The conventional reason given for that depression is the write-down of investments made in canals and some changes in currency and banking policy. While not dismissing those factors, Santini (1988) links the depression to the clash between the new and old technology and, in particular, to the displacements that the uses of the technology occasioned.

From the 40 km of railroad in the United States in 1830, in about nine decades mileage grew to about 400,000 km. Subsequently, the length has declined to about what it was in 1890. Figure 7.4 shows the change in the length of railroads in the United States from 1830.

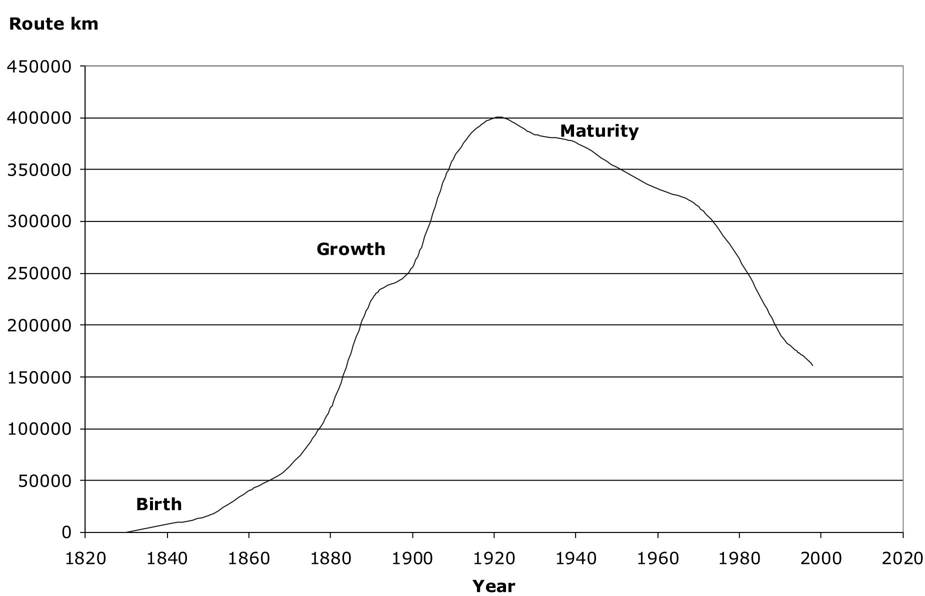


Figure 7.4. Railroad route kilometers in the United States.

Learning About Passenger Transportation in England

Charters for the Liverpool and Manchester and the London and Birmingham were obtained after debates about their diversion of freight from other modes. But diversion of freight was slow and selective. The latent demand for passenger transportation, however, came as a surprise.

Recognizing a role in passenger service, the Act of 1844 responded to public claims for rights to travel and set a minimum level of service availability. Known as Parliamentary trains, service was to be provided in each direction each weekday. Stops were to be made at each station. A maximum fare was set and running speeds were to be not less than 20 km/hr (12 mph). This was third-class service.

First- and second-class service reflected the coach, fly wagon, post horse, and freight wagon services available on roads and flyboat service on canals. The classes of passenger service offered by the railroads mirrored canal and road services. They substituted for canal and road services and pretty much captured the market. The same economic rationale continues today. It yields, for example, first, business, coach, and a collection of lower-cost special fares in air transportation. Jules Dupuit (1849) considered a situation where there was a fixed cost of providing service. Using concepts of consumer surplus and utility differentiated among users, he demonstrated the wisdom of differentiated tolls for differentiated passengers—the idea of price discrimination, referred to today as Ramsey or inverse-elasticity prices.

Railroads found demand and costs such that they could lower fares and upgrade service. Although figure 7.5 does not reflect early experiences, it shows the consequences

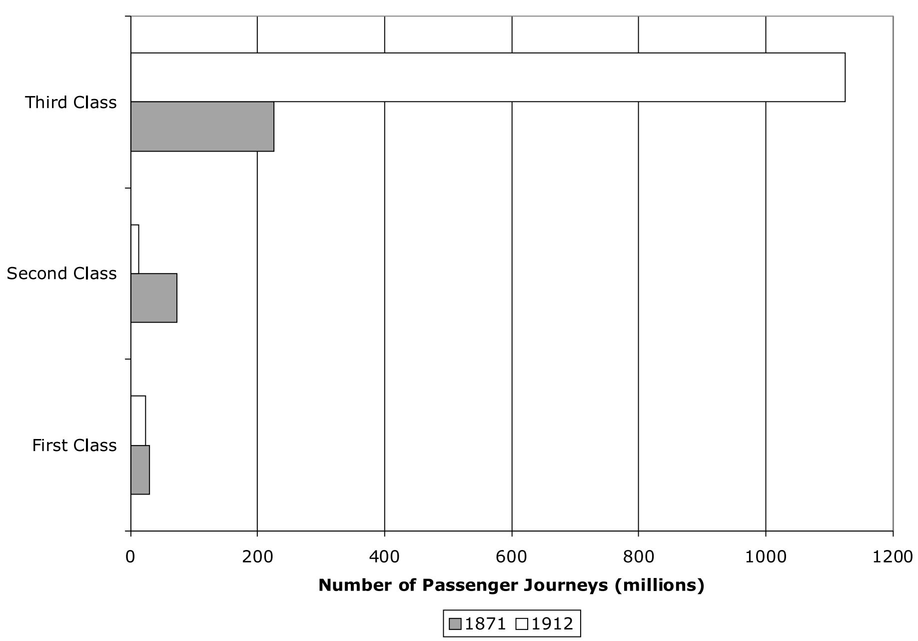


Figure 7.5. English passenger railroad data.

of railroad actions: low-fare services grew very rapidly, while in absolute terms high-fare services withered.

Things were improving, and there was no need for central government action, with one exception. The railroads found the obligations of the 1844 Act onerous, especially the requirement to stop at every station. They pressed for relief and obtained it in an 1866 Act. However, there was a tradeoff. As railroads asked for relief, some were required to operate workmen's trains in the vicinity of large cities (more on that later). We have seen:

- Policy stated as a minimal level of service requirement. A standardized requirement, one policy fits all situations.
- Requirements for minimal level of service policy are mooted if service performance improves, as it does in the early days of a system.
- Policy revision, and the use of tradeoffs to obtain revision.
- Experience said "offer differentiated services" and custom and tradition have caused differentiated services to continue.

More generally, what had been learned in the prerail experience was incorporated in the rail experience and modified in a pragmatic way and the rail experience led to additional modifications.

Learning About Freight Transportation in England

In the case of roads, the local justices of the peace were required, under an Act of 1691, to set maximum freight rates and service conditions. This was early in the development of the wagon trade, and the concern was that wagoners were setting rates at excessive levels. It seems likely that they were. One had to have considerable (for the times) capital to enter the business, and competition must have been limited. The wagoners had mutual interests, and price rigging must have taken place off and on.

The experience of setting rates and service conditions was reflected in canal and turnpike charters: the canal firms and turnpike trusts were not allowed to monopolize the boat, wagon, and carriage business. Maximum tolls were set, and later refined. Road tolls, for example, had some relation to cost. They were computed on the basis of wagon wheel width and tons. Flyboats paid higher tolls than freight boats. In river navigation projects, there was a tendency toward complex tolls that charged according to value.

From a policy point of view, the Stockton and Darlington was a canal. Anyone with equipment could use the track. Maximum tolls were set. These conditions were carried over to the Manchester and Liverpool charter. But the "anyone can use" policy was never implemented. The London and Birmingham charter simply required the railroad to carry all freight brought to its docks.

At this point in time, the system took off, and by 1850 there were some 215 railroad companies in England. Additional problems emerged begging policy attention. One was the amount of time the legislature was spending on the private acts, one for each firm. Could generic legislation be stated and action delegated to some creature of the legislature?

Debate continued on this prior to the 1844 Act and a proposal was developed, but there was no full response to this problem until 1872 when the Railroad and Canal Traffic Act created a railroad commission and gave it powers. (This was about 15 years before the Interstate Commerce Commission was created in the United States.) An interesting aspect of the 1844 debate treated government ownership. Using the turnpike model of reverting to government ownership, it was recommended that newly chartered railroads become the property of the government after 21 years (compensating their owners at reasonable prices).

Another problem was the growing complexity of commodities to be moved. Classification was the name of the game as was the basing of rates on the value of the product. Traders pressed the railroads hard for advantages in order to attract traffic, and classifications and rates began to be complex. About 300 articles were recognized by 1850, and by 1871 the number had grown to 2,753. Classes were recognized, articles were placed within classes, and charges for them were related to class rates.

The situation was more complex than just the increase of articles and classes would suggest. With the growth of the economy and trade, more and more shipments moved over multiple properties. By the 1880s there were 40,000 stations between which shipments could move. Some system-wide referee standardizing rates had to be established. Would government do this?

Not at first, although government did pass lots of acts relating to rates. The railroads created a clearinghouse to do the rate work and to articulate shipments among roads. Government action mainly responded to claims that the firms were making too much money—maximum rates should be reduced. Government tried to protect the public from monopolies by authorizing competitive lines and controlling amalgamations. It gave running powers to railroads that were locked out of markets.

Most researchers say that government actions were not very effective. Government control of rates was ineffective partly because control was aimed at line haul charges. Carriers could set terminal rates and collector/distributor rates.

The classification-rate problem was settled by mutual government–industry action. The clearinghouse had enforcement problems, and government had its problems. The clearinghouse had been working with Parliament's Board of Trade (which had been created to work with the clearinghouse—no powers, but likely a lot of clout).

The Act did more. It extended to terminal charges *and it introduced tapered rates*. In this small way, the Act, for the first time, related charges to costs. Previous Acts (in 1868 and 1873) had required that rates be published and that charges be itemized.

Government became involved in setting rates because while the railroads could get some agreements on rates, an authority was needed to enforce agreements. Once government became involved, it did begin to exert some social policy influence. The requirement for the publishing of rates reduced the problem of asymmetric information between users and service suppliers.

The above discussion treats a lot of borrowing and learning. First, the railroads and government borrowed from previous experience. Next, they responded in pragmatic ways to the rail experience. The overarching challenge was to deal with complexity. Government worked with the railroads to create institutions for that purpose.

Learning About Embedded Policies in the United States

The discussions up to this point have stressed how railroads began by borrowing policies from previous modes and then modified policies based on experience. A similar statement may be made about government. Passenger and freight services were examined. Now, the discussion turns to how policies became embedded within the structure of the mode.

By the late nineteenth century, many small rail starts had been absorbed by larger systems, and strong large systems had emerged. Within-railroad embedded policies evolved to manage these large systems, namely, functional and departmentalized administrative structures for day-to-day routine operating decisions with precise accountability for expenses and use of human resources. The telegraph provided operational control—on an hourly basis for trains and on a daily basis for (1) expenditures, (2) work performed by men and machines, and (3) freight and passenger movements. These innovations are attributed to D. C. McCallum of the Erie Railroad beginning in 1854. They were widely publicized and served as a model for other railroads and for industry generally (Chandler, 1979).

J. Edgar Thomson of the Pennsylvania Railroad, who, after adopting McCallum's scheme, divided the Pennsylvania into operating divisions in 1857, took the next step. Each division had a superintendent in charge of three functions: transportation, way, and equipment. The headquarters superintendent and the division superintendents were delegated operating authority over men and machinery. Headquarters was primarily involved with finance and planning and rules and procedures.

Other railroads in the United States quickly adopted this organizational system. Adoption elsewhere seems to have been slower, mainly because systems were smaller.

These organizational developments eased the problem of within-railroad embedded policies (but not the making-markets or profit-cost centers problem to be discussed shortly). Developing between-railroad embedded policies proved tougher.

In the post-Civil War decade there were four major systems connecting the east coast with terminals just west of the Allegheny Mountains, and those trunk lines sought alliances with western railroads and steamship lines to curb rate wars. Some purchased stock in the western roads, and all made agreements on through rates and services. But this did not go smoothly because individual roads could gain by seeking favorable changes in the status quo. (Jay Gould sought such changes when he gained control of the Erie in 1867.)

A variety of supplemental techniques were attempted. The Vanderbilts, for example, sought to federate the New York Central with lines to the west. The western railroads, which were generally weaker than the eastern trunk lines, sought to pool receipts in order to reduce motives for price wars.

These efforts were unsuccessful, and in 1877 the eastern railroads formed the Eastern Trunk Line Association headed by Albert Fink. This was soon joined by similar Midwestern and New England organizations, with the several organizations unified by a common executive committee. The regional organizations determined rates and classifications, which were then adopted for the areas covered.

Things seemed to have worked smoothly for about a decade until Gould and the Vanderbilts became aggressors in this nonzero-sum game. Figure 7.6 indicates the size of the properties that we have been discussing (at a date a little later than the period we have been discussing).

Discussion

As noted in the introduction, transportation systems have a three-component, triad structure:

- Civil engineers (through, e.g., a public works department or the U.S. Army Corps of Engineers) create and manage fixed facilities.

- Mechanical engineers (through, e.g., General Motors or North America Car) manufacture equipment.
- Pilots, train engineers, or drivers operate the vehicles.

Mirroring that structure, railroads are organized as shown in figure 7.7.

The answer to the question of why railroads are organized that way requires little discussion: that was the division of talent and problems at the time. For the other modes, “modeled on railroads” is a good first approximation to the answer to the question of why they are organized the way they are.

But this structure yields considerable dysfunctions. The question is that of why modes have continued to be organized in triad structures in light of the dysfunctions. That is especially a question for railroads. As corporate entities, they should be able to adopt restructuring policies more easily than the other modes.

We may term one dysfunction the inability to make markets. A conversation with a railroad person would be misleading. Most of them can tell everything about the goods being hauled and why. Those that have to know have deep knowledge of the trading

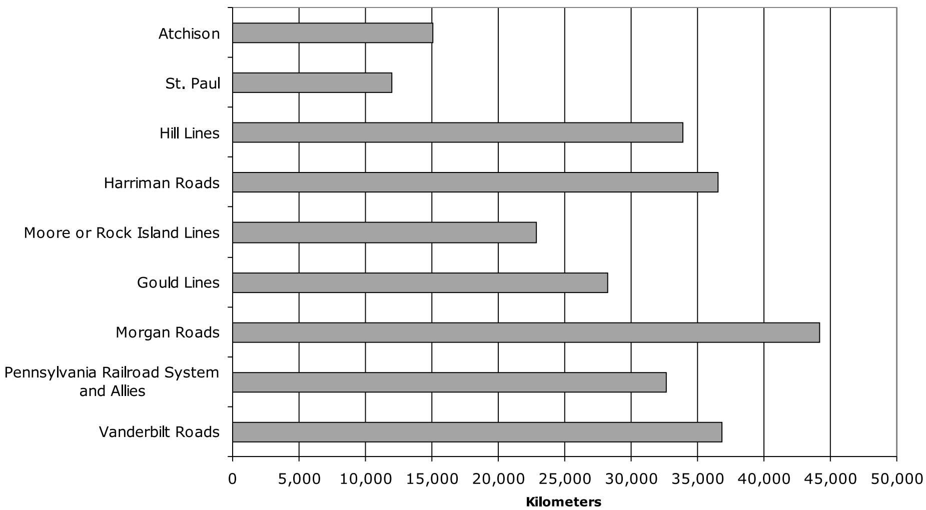


Figure 7.6. Nine leading U.S. railway groups and systems in 1908.

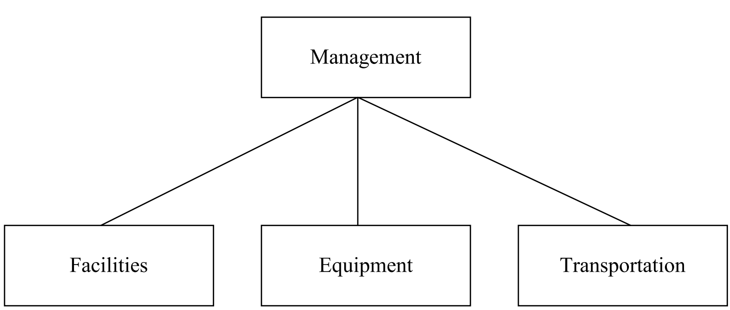


Figure 7.7. Illustrative organization chart of railroads. Note: Actual organization charts are much more complex. The triad structure extends into geographic divisions, and does not include legal, personnel, and other corporate functions.

terms and transportation cost interrelations in the capturing of markets. They know that a cent here or a quality of service attribute there can change the terms of transport. But the level of freight movement knowledge by railroad people has an important constraint on it. Railroad people do not have sharp knowledge of the cost to the railroad when making a market.

The reason is structural. Each division of the railroad claims a budget to carry forward its task, and each tries to minimize costs and/or maximize output from given inputs. At the level of a geographic division, for example, the transportation (operations) manager sees certain tons to be moved. Given the equipment and fixed facility situation, a good manager keeps the transportation inputs required to a minimum. Individual shipments move across divisions and impose costs on way, equipment, and operations. Shipments are handled jointly with other shipments in different combinations at different places and times. So it is very difficult to identify the cost of a particular shipment.

Railroad people know this very well, and they give a lot of attention to costing. Indeed, Wellington's *The Economic Theory of the Location of Railways*, written in the late nineteenth century, centered on cost information and its use. Where special services are offered, such as unit trains on heavy haul routes, cost information may be pretty good. Some railroad marketing departments are organized by commodities and try to match costs and services as best they can.

Even so, there is a longstanding dysfunction locked in by structure. The situation is worse in other modes where the structure is not within mode-wide organizations. In air transportation, for example, we have authorities that operate airports, a Federal Aviation Administration that manages the airways, and airlines and private operators that move passengers. Individual firms such as trucking companies and shipbuilders know their costs and markets, of course. System costs are another matter. No one is in charge. In the economist's pure atomistic world, if there were perfect competition that is of no great concern. But structural interdependencies in transportation are strong and competition is far from ideal.

The second dysfunction is associated with patterns of dynamic decision making. The operations group on the railroad occurs costs on a car basis, so they press the equipment division to buy larger cars. That is acceptable to equipment managers because it lowers their costs. But it has been found that large, heavy cars impose many costs on track structure. What has happened is that incremental decisions were made on the basis of component criteria, subject only to the conditions that it fit the system in a technical way.[1]

One term for this pattern of behavior is disjoint incrementalism, and we are not the first to use the term. Dahl and Lindblom (1953) made much of incrementalism, stressing attributes that were rather favorable. They saw incrementalism as allowing exploration of options in cases where wants could not be known, as reversible and low risk, as allowing for organizational stability, as permitting compromise among goals and stakeholders, and as having other desirable attributes. Much is said in the context of their presentation.

Perhaps stasis from constrained behavior gives an additional flavor to the idea we strive to communicate. Actors in a component of a mode are constrained to do things that fit the structure of the mode, and actors' goals, values, and priorities are constrained to their component.[2]

As a consequence of the constrained behavior of components, systems have a highly constrained path of system development. The options that can be explored are very, very limited, for example. Actions may be costly because of impacts on others.

We think that the limitations on the exploration of options are the major cost of disjoint incrementalism. When is this failure costly? It is clearly costly when systems age. Inability to change is one reason they sail along in the sunshine of their obsolescence. It can be costly early on, because it can lock in dysfunctions. Policy bearing on Brunel's wide-gauge railways (to be discussed later) is an example.

Describing the dysfunction following from the organization of systems, Churchman (1979) refers to the environmental fallacy. Actions are taken without considering the environment and feedbacks from environmental adjustments. That thought could be used at the level of how components interrelate with each other and at larger scope.

Efforts to mitigate externalities and other system dysfunctions often rely on regulation, and that is where the next chapter leads.

8

Railroads Regulated

We do not ride on the railroad; it rides upon us.
—Henry David Thoreau, *Walden*

The "Act to Regulate Commerce" goes into effect on Tuesday next. . . . The National Commission . . . is now in session. . . . The railways as well as the public generally . . . will give them every encouragement possible for the execution of their duties.
—*The Railway Age* magazine, April 1887

Introduction

The Federal Triangle, located in Washington D.C. just south of Pennsylvania Avenue between the Capitol and the White House, was the largest building program the U.S. Government had undertaken by the time of its opening in 1934. The new buildings aimed to show the "dignity and power of the nation." The Interstate Commerce Commission occupied both the apex of the "iron triangle" of regulators, the regulated, and the legislators, and one of those Federal Triangle buildings continuously from 1934 until its dissolution in 1995.

A late 1980s or early 1990s visit to the outwardly impressive ICC building, a walk down the green narrow halls with cracked linoleum floors, visits to offices, and attending an ICC hearing gave an impression of senescence. It was a sharp contrast to the impressions from the newer regulatory agencies, with modern fixtures and furnishings if not modern policies. Hence the replacement of the ICC by the Surface Transportation Board (housed elsewhere) came as little surprise—its old and run-down furnishings and fixtures symbolized its old and run-down ideas.

Like the ICC that regulated them, most of today's transportation systems are mature or nearly so. They are fully deployed, structures are fixed and inflexible, and the mix and variety of the services that can be offered are limited. Given that situation, how do systems respond to changes in their environments? We explore that question, using the U.S. railroads as a case in point.

This chapter emphasizes modal behavior and policy matters as systems trend to full deployment and are forced to adjust to changes in their environments. Using our life cycle scheme, we are in the maturity phase of the cycle, and the matters we treat generalize very well to the situation across the board in transportation today. It is fair to say that most systems are nearly or fully deployed, and service is available everywhere—that is certainly true in the more developed nations. Designs are fixed; unitary technologies are used. So while we are looking at the rail system, we see behavior, problems, and reactions to problems that have commonality across today's systems.

In the early days, as discussed in the English context, the government role was largely enabling (e.g., chartering firms) and, by default, doing things in the interest of the railroads where, for one reason or another, the railroads couldn't build a consensus for action (e.g., Board of Trade intervention when railroads couldn't agree on running rights).

Tasks similar to these carried forward into the near and full deployment phase of development, the phase now examined. The government role was broadened and fine-tuned. In addition to this already established role, we shall see some other roles emerge. In general, we can say these emerged because the "bloom was no longer on the rose." During the start-up and expansion phase, new services were being made available and existing services improved. Improvements tend to stagnate as the unitary technology is locked in and service becomes widely available. At this point, the debate over who claims the transportation rents becomes fiercer, in the absence of improvement, ills are more visible, and problems covered up by improvements emerge for management.

In response, we see a wave of tightening regulation, with regulation steered in many ways by the "Who gets the rents?" question. We also see a notion of rationalization emerge and be increasingly modified.

The topic divides into two stories, and the next two chapters reflect the two stories. The first covers the period when government learned how to craft policy legislation and operate regulatory institutions and enforcement tools. Government had to innovate. Also during that period, government continued largely to create policy by default, that is, to take care of things not satisfactorily treated by embedded policy making and by the broad social contract. It concludes with the pendulum having swung back to deregulation.

Rationalization, the operative word during the decade of the 1920s and subsequently, is discussed in the next chapter. Its meaning has changed with the decades, and the next chapter will trace the notion of rationalization to today's meaning.

Turning the Clock Back

The within-railroad and between-railroad embedded policies and rules explain much about their structure and behavior. (A similar statement holds for all transportation systems.) However, governments were asked to develop policies when the railroads could not develop and enforce needed embedded policies. One case is when the domain of the policy extends beyond the domain of the mode; for example, policies needed to assist in acquiring right of way. Another case is when there are winners and losers within the modal community, and governments are asked to play the referee. The granting of track rights and criteria for the division of income from movements involving more than one firm are examples.

This development of government policy "by default" seems especially true during the early days of systems. Such policies have a "help the system get deployed and work" character. Later on, government policies respond more to broad social consensus about systems. They have a "control the system for social purposes" character.

Regulatory Acts and institutional and administrative actions relative to freight tariffs and passenger service occurred in Britain in 1868, 1873, and 1893. Those initiatives and the U.S. federal initiatives of the late nineteenth century involved values, ideas, and concepts that were commonplace then and remain so today in the verbiage of common law. Yet, the imposition of those ideas on the railroad "turned the clock back."

Medieval society ran on the common will. Later, as commerce extended from village to village, shops and inns and larger enterprises were subjected to medieval, common law attitudes. Shopkeepers and others derived their rights and powers from the community, and communities specified the terms of services and prices charged. For example, inns charged "fair" rates; they could not refuse service without good reason. As communities developed in the United States, they were clothed in that spirit. The villages and towns continued to control the activities within them. In addition to stating the terms in which individual entrepreneurs operated within their span of control, these communities undertook public works to serve the members of the community.

But railroads and canals were big enterprises, and they were more than villages and towns could handle from the standpoints of financing and geographic scope of activities. Extending the medieval tradition, rail and canal organizations were chartered by the states to serve the public. Essential elements of those charters were the notions that service to the public was to be without discrimination and favoritism; users in like circumstances were to be served the same; and government was entitled to regulate rates, terms of service, quality of service, and so on. Government delegated authority necessary to the purposes of the corporations—for example, the power of claiming eminent domain over property was delegated to the railroads.

In the early nineteenth century, public attitudes drifted from medieval logic. The spirit of Adam Smith and laissez-faire gripped the nation. (Actually, the spirit was behind many early settlements; they were commercial enterprises with certain rights and restrictions—the Virginia Company and the Massachusetts Bay Company were examples.[1]) Small farmers, merchants, and larger organizations began to do what they wanted to do. There had been a breakdown of the medieval village and, at any rate, many new activities were nontraditional and also did not fit traditional governing units. The nation was growing very rapidly; most people shared in that growth, and laissez-faire was seen as a touchstone for growth.

Box 8.1 describes the financial shenanigans that emerge in network industries under a regime of laissez-faire. Box 8.2 compares the different regulatory regimes in the developed world.

Social Contract Strained

The social mood of the times was that the public and individual interest was very much served by entrepreneurial freedom (Hillman, 1968). The railroads on some measures were providing better and better services, so the public should have been pleased by the current service compared to previously and have expectations for even better service in the future. Given this situation, what kinds of issues strained the social contract?

BOX 8.1 Financial Shenanigans

In the late 1860s, Cornelius Vanderbilt, proprietor of the New York Central Railroad, tried to acquire its principal competitor, the Erie Railroad, by cornering the market in shares (and driving up their price). Erie Board members Jay Gould, Daniel Drew, and James Fisk released 50,000 new shares of stock on the market in March 1868, defying a court injunction, and breaking Vanderbilt's corner. The Erie Board members fled to Jersey City across the river (and out of state) from New York. They lobbied (well, bribed) the New York state legislature in Albany to legalize the issue of new shares and prohibit the merger of the two railroads, which the legislature did. Vanderbilt and Gould, Drew, and Fisk settled their disagreements, and Drew retired. Gould and Fisk, along with Erie Board members (including William Tweed), then issued enormous amounts of stock to water down the price of shares.

Gould proceeded with other dubious measures, including trying to corner the gold market, which resulted in an 1869 stock market crash. The backlash against Gould resulted in his ouster from the Erie Board in 1872. However, with his fortune (estimated at over $25 million), he moved his attention to the western railroads. He acquired controlling interest in the Union Pacific Railroad from 1874 to 1878. He purchased the Kansas Pacific, Denver Pacific, Central Pacific, and Missouri Pacific. In 1880, by threatening to extend the Kansas Pacific from Denver to Salt Lake City, and connect there with the westward lines of the Central Pacific, he was able to force the Union Pacific, under Henry Villard, to buy out the railroad for $10 million. He plowed the payout back into the industry, buying and efficiently running the Missouri Pacific, Texas and Pacific, and other lines, giving him one-half of all traffic in the southwestern United States. In 1881 he also bought the New York elevated railroads, and the Western Union telegraph company.

BOX 8.2 Comparisons of the Developed World

> *Sometimes when you have everything, you can't really tell what matters.*
> —Christina Onassis

Striving to summarize the English, French, and U.S. policy experiences and anticipate the developing world's future experiences, some broad-brush remarks will be made. With the exception of France, experiences similar to those discussed for England held on the Continent.[2] Early on, France differed because of its strong central government and its traditions of scientific work, rationalization, and professionalism (Smith, 1990).

We think the term *entrepreneurial capitalism* best captures English policy. English policy had a "hands off" character, and this seems to have flowed from the notion that the national interest was best served by competitive, independent firms creating jobs and wealth. Rate setting by agreement among firms, rates high enough to return profits, and so on, resulted in profitable firms. There was a bit of welfare tempering—for example, workmen's trains, publication of rates, and listing of charges—but not much. Also, Parliament's careful examination of requests for charters protected property owners, existing properties, and investors from poorly developed schemes.

(continued)

BOX 8.2 Comparisons of the Developed World—cont'd

The French policy experience may be labeled *absolutism* or statism—all decisions turned on what was taken to be good for the State and were made by the State. Plans were made by the State, instead of by firms as in England. The same was true of tariffs (rates, fares). There was State financing (partial) instead of private capital. Operations had heavy State input. There was to be eventual State ownership of facilities.

United States policy does not summarize so easily. Early on, *local and state mercantilism* makes a good label, and there was also flirtation with aspects of federal absolutism (when railroads linking the west coast with the Midwest were debated and when regulation was considered). After some bad experiences, policy evolved into what may be termed a U.S. version of entrepreneurial capitalism—capitalism constrained by antitrust and rail-specific regulation. That continues even though the Interstate Commerce Commission has been eliminated. Let us call it *constrained entrepreneurial capitalism*.

An example may aid in contrasting the differing national approaches to policy. Early trains had no brakes, and as trains became larger, faster, and heavier, hand-applied mechanical brakes began to be used. However, poor braking was the cause of many accidents. In the late nineteenth century, George Westinghouse developed the air brake. The French adopted it by fiat: "Use it." The English took the attitude that when the properties saw that air brakes made good sense they would adopt them, so no government action was needed. Indeed, the English had a "hands off" policy on safety generally. There were government inspectors who reviewed properties, and their reports were published, but government took no action beyond that. The U.S. government negotiated with the rail properties and adopted a legislative requirement for air brakes. But the refinement and implementation of air brakes was pretty much left to the railroads and their decision-making arrangements.

We think of the summary just given as broad-brush. We would be remiss not to point out even broader-brush thoughts. Each national rail policy experience was rooted in situational attributes, as well as the ideas and attitudes that influenced the thinking about related government organizations and roles. All that can be termed political, national, ethic or culture. That is the kind of thing Alexis de Tocqueville commented on so skillfully on in his *Democracy in America* and in his book on the French Revolution.

As stated, the rail experience provides a "mother logic" for policy in other modes. We need to go beyond that to point out that rail mother logic was shaped by national culture; it was also a shaper of national culture, especially in the United States. In this respect, a very broad-brush view of rail policy provides a comment on national industrial policy. Note that the labels we have attached to English, French, and U.S. rail policy apply to industrial policy in general—the French have elected to develop key industries, the British and the Americans have had rather different industrial policies. Other countries, including the less developed ones, fall here or there between the extremes of absolutism and entrepreneurial capitalism.

We claim that all nations are developed, given historic paths, resources, tools, and other attributes. We now invert that statement, for if we accept that change in transportation is possible, then new futures are available to all nations.

In some ways the transportation development problem is most urgent in the so-called developed nations. The old systems have clearly run their courses, and that is one reason for the slowdown in development and lack of investment opportunities.

But there are other urgent development objectives, many of a "reduce constraints" type (reduce government regulation, limit the number of product liability cases). Some objectives

BOX 8.2 Comparisons of the Developed World—cont'd

call for investments, such as in new technology and education; that is, there are a lot of urgent things to do that are more visible and closer than transportation to the mainstream of economic and political thought.

Wilfred Owen, a long-time student of economic development, now gives overriding attention to equity. He says that all less developed nations should be provided with upgraded road systems. Without such systems, residents cannot participate in modern life, acquire health services, and so on. Leaving aside the point that roads are not enough, Owen has an attractive thought: a basic level of transportation service may be prerequisite to the rest of civilization.

Compared to other nations, the existing transportation systems of the United States are regarded as in pretty good shape despite congestion and some disrepair.

General problems began to be perceived of the following sort:

1. First was the question of the relation of the value of capital stock to the value of the plant, which varied widely among railroads; there had been a number of well-publicized abuses through watering stock.
2. A perception of unfair treatment of users existed, and users organized themselves in various ways.
3. Finally the railroads had problems they could not manage. They had natural monopoly characteristics leading to cutthroat competition. Attempts to control this competition through pooling and ratemaking turned out to be a rough and unworkable game. Further, railroads needed protection from large shippers and express companies.

So although the terms of reference in which the federal government exercised control over the railroads seem very familiar today, federal control was a turning back of the clock (from laissez-faire) so far as the evolution of the economy and the roles of individuals and corporations within it were concerned. Government began to exercise its traditional medieval rights in a manner that had not been exercised visibly and strongly for some decades, if not centuries.

The states attempted to manage using additions to general laws so that they dealt with specific ills and by development of commissions—some advisory and some regulatory—to make the laws work.

Problems arose in the grain elevator industry. Although individually owned, the grain elevators colluded in the setting of prices, and they controlled the movement of grain from much of the Midwest to markets in the East. In 1873 the State of Illinois passed a Warehouse Act to regulate the rates and terms of service in Chicago's grain elevators. This act was challenged by successors to the firm of Ira Munn and George Scott, whose elevator business failed during the Panic of 1873, in part because of corruption.

Munn v. Illinois (1877) worked its way up to the Supreme Court. Citing common law, the Supreme Court, in a decision by Chief Justice Morrison Waite, found that the activities of the grain elevators were a matter of great public consequences. He wrote, "Common carriers exercise a sort of public office, and have duties to perform in which the public is interested. . . . Their business is, therefore, 'affected with a public interest.'"

Countering the claim that the law destroyed private property, Waite argued that legislators, elected by the people, were the appropriate forum to establish regulation, and the courts should behave with self-restraint in the economic arena. Thus, Illinois had a clear right to regulate those grain elevators in the public interest.

Munn v. Illinois was a precedent-setting case, and it applied clearly to the railroads. This enabled the states to regulate the railroads and federal regulation of interstate commerce. Reasoning from *Munn v. Illinois*, findings in *Wabash, St. Louis, and Pacific Railroad v. Illinois* established the right of Congress to regulate interstate commerce.

The state actions were, however, ineffective and debates escalated to the federal level. In 1872 President Grant appointed the Windom Committee to look into the matter. It recommended government ownership of railroads. However, legislation failed until the McCullom report, which led to the Act to Regulate Commerce of 1887, recommended an Interstate Commerce Commission to regulate rates. The Act was not much more than an appeal to common law, and it lacked enforcement means. Its first three parts required rates to be just and reasonable, forbade personal discrimination and rebates, and outlawed undue or unreasonable preferences. All of this is very much in common law tradition.

Other requirements limited long-haul and short-haul rates, prohibited pooling arrangements, and publication of rates and fares was required as well as due notice of increases. The long-haul and short-haul limitations referred to equality of rates under "substantially similar circumstances."

All of the phraseology rolls smoothly on the tongue. We nod in agreement—that is how actors are supposed to behave. But the Act served up general prescriptions, and it was not exactly clear how the Interstate Commerce Commission (ICC) was to implement common law prescriptions. After all, the ICC was a small, new organization created to regulate a vast enterprise when communications, office record keeping, availability of skilled bureaucrats, and other attributes that are commonplace today were not available. The Interstate Commerce Act more than anything else strengthened the license of individuals and organizations to ask the courts to make decisions about the activities of railroads. However, this was unworkable due to the tremendous volume of case law involved. Moreover, it resulted in individual courts deciding on matters of preference, reasonable treatment, and other such factors that require guidelines and comparisons. The courts would not expedite injunctions to enforce ICC orders. They took testimony and acted on their own. They limited ICC control over just and reasonable rates, and they interpreted the phrase "substantially similar circumstances and conditions" in quite a literal manner. Rebating continued.

Congress seemed satisfied with the situation for about a decade and a half and then moved to strengthen the ICC. The Elkins Act of 1903 amended the 1887 Act limiting rebates. Congress corrected this problem in the Hepburn Act of 1906, which removed the courts from the critical path. The Act further extended jurisdiction of ICC regulation to sleeping car companies, express companies, pipelines, and railroad terminals. It prohibited free railroad passes, permitted specification of maximum rates and prescription of through and joint rates, forbade the railroads to haul goods (except lumber) they produced, and put commission orders into effect in 30 days without prior approval of the courts. Finally, the Mann–Elkins Act of 1910 reformatted the long- and short-haul clause by deleting the "substantially similar" phrasing, and extended ICC rule to telephone, telegraph, and cable companies (later to be regulated by the Federal Communications Commission).

Although there were additional Acts affecting the ICC, the ICC as we have known it during the decades of the twentieth century was mainly shaped by the Hepburn Act. To make a long story short, we may observe that laying down "fair" rules of behavior and giving the ICC enough clout to enforce them solved the problem of planning for the operations of railroads.

The legislation discussed above deals mainly with rate discrimination. The predatory behavior of firms, stock watering, traffic pooling, and monopoly practices were somewhat slower in being managed and began to be treated under antitrust law rather than ICC law. Acts eventually tempered that treatment, while the ICC gained control over security issues and bankruptcy proceedings, and the Reed–Bullwinkle Act circumvented the effect of antitrust on rate bureaus.

The above discussion does not begin to list all the details of legislation, but it is enough to identify trends and major matters at issue, especially rates. Because of the very large number of things carried, commodities were grouped into classes, and rates developed for classes. On account of fixed terminal costs, these rates incorporated a tapering distance scale. (This convention did not hold for intercity passenger rates.)

Rates reflected what the traffic would bear, and also considered the weight–volume relationships. (Actually, comparatively little traffic moved under class rates. Most moved under commodity rates that were specific to commodities and points of origin and destination. Nonetheless, the rate class concepts were reflected in commodity rates.)

The era we are treating ended during World War I (actually in 1920). The Transportation Act of 1920 emphasized the responsibility of government to ensure that adequate transportation was provided—very much a change of mood. These are important words; they stress the positivism of governments. It is a notion that has reappeared in bits and pieces of legislative rhetoric at all levels of government. Yet that positive role in strengthening activities does not occur in the present rail debate, which seeks to "get the government out of the way."

Deregulation

Jumping to the railroad situation in the last two decades of the twentieth century, there were new ideas floating around, with the return to laissez-faire conditions via deregulation carrying the day. One reason for the deregulation thrust was the ICC's debilitating impact on the viability of the railroads. It has been said, and it is no doubt true, that regulation cost the nation a great deal in efficiency terms. Without regulation, the railroads would act more wisely, obtain efficiencies, and the nation would be better off. In general, it is accepted that competition is a good thing.

It was necessary to regulate the railroads at one time because they were monopolies. Also, conditions of entry were such that no reasonable organization would enter the market even if the actor already there misbehaved—the critical factor being the large investment in fixed plant required in order to enter the market. A related matter was that fixed costs were relatively high, so marginal costs decreased over the range of outputs feasible in markets. This phenomenon blocked marginal cost pricing guides, as well as the ability of competitive actors to enter the market.

The deregulation argument is that much has changed. In particular, trucks offered competition to rail (and barges and pipelines under certain circumstances). No actor can misbehave for long. The extent to which that is true has bothered Congress, and the ICC examined the question of captive shippers and found a few of them. It required that the railroads make the contents of contracts public.

Thinking about the impact of the ICC on the industry involves what we may call the internal dynamic of a bureaucratic agency. Political scientists and students of organizations have written a variety of things on this. One way to summarize is to say that agencies go through a life cycle. They start out by having trouble getting their feet on the ground and learning how to walk, then they walk with great vigor, and finally they fall into fixed patterns of behavior and stasis. That notion fits the ICC and other regulatory agencies very well, and it is fair to say that in its last decades the agency had a certain rigor mortis.

A companion factor is that regulatory agencies become captives of those they regulate. That was the case for the ICC; it generally acquiesced to what the railroads wanted to do. Beyond requiring hearings and publications, it did not regulate rates much at all. Another observation stems from an interpretation of what the railroads collectively "wanted to do." There is a common denominator interpretation of what the railroads wanted to do. For instance, if a railroad wanted to do something very aggressive and other railroads didn't agree, the aggressive railroad would be stifled. This was especially the case in merger policy where third-party railroads would be very demanding. Deregulation is aimed at avoiding such least common denominator actions.

The debate over deregulation concerned the stifling impact of a bureaucracy and the advantages of competitive behavior, the latter enabled by arguments about the nonexistence of monopolies because of truck competition or the potential for service by competitors. Note that this debate is in essence quite different from that of the late nineteenth century, which had more to do with how organizations should act under the rules of common law and the notion that big, important things are clothed in the public interest. The second observation is that the debate in the ICC arena was limited to mergers, rates, and terms of services. It overlooks the presence of much regulation elsewhere in government, and in organizations created by the railroads themselves—rate bureaus and Association of American Railroads standards setting, in particular—as well as by organizations such as the National Industrial Transportation League (formed in 1907 to serve shippers before the ICC, but which since deregulation has sought a broader role serving carriers as well). Rate bureaus are no more. (Rate bureaus never told the railroads what to do anyway. They were a communications medium and a consensus-building arena.)

By and large, the return on investment in railroads has never been very great. Many railroads were in trouble before the ICC was created (before 1887), during the period when the ICC gathered some strength (1887–1915), and later.

Much of the economic literature on rail cost and deregulation largely justified moving toward a deregulated system (Meyer et al., 1959; Friedlaender and Spady, 1980; Keeler, 1983). The ICC was replaced by the Surface Transportation Board in 1995 after steadily losing importance due to the deregulation promoted by the Staggers Rail Act and the Motor Carrier Act, both passed in 1980.

Discussion

Although rail construction continued into the twentieth century, the fabric of rail networks was pretty much deployed in the United States and Western Europe by the last third of the nineteenth century. At this juncture a series of problems became more visible, and there is a striking parallel between those problems and the ones commonly listed for today's transportation problems.

Management of the system became the priority. That is, interest shifted from planning construction (tactics) to planning control (operations), and little attention was given to planning technology (strategy), which was largely thought too late to shift.

The ICC was imposed in a fashion satisfactory to interested publics—the stockholders of railroads, railroad management and labor, shippers, the states, and so on. The conventional view for the origin of the ICC is that actors in the so-called Granger states coalesced politically around an effort to achieve fairness of treatment from railroads. Miller (1971) stresses conflicts between the states and the federal government as well as the differing regional interests in the Granger area. Kolko (1976) stresses an opposite view: the railroads wanted to stabilize their environments and dampen competition. His view helps explain why the railroads seemed to welcome regulation.

Government control was imposed to (1) manage the fiscal problems of the properties and assure their fair treatment (i.e., by other roads and large shippers), (2) obtain fair treatment of individual users large or small, (3) stabilize the competitive positions of regions, and (4) rationalize investment and disinvestment. Many would use the term "regulation" to characterize ICC activities. We think it is useful to see regulation as the outcome of a style of planning. The goal was to maintain a viable physical system; the concentration was on soft instruments rather than investment.

Regulation was innovated. It was trial and error, especially with respect to needed legislation. Things that worked were adopted. The building blocks of the times were used. Such building blocks included the "rules" tradition, then accounting systems, legal styles of inquiry and management, and the ratemaking agencies of the roads. The ICC agency culture and style resulted, a culture and style imitated as government began to regulate in other areas.

That is one result of railroad regulation: it taught governments how to regulate. What were other results?

It took a while, but regulation did repair most of the tears in the social contract. With respect to the embedded policy problems the railroads could not solve, regulation enforced rate and service agreements and stabilized competitive relationships. It protected weak roads from the strong.

Stabilization is perhaps a key word. Mergers and purchases were slowed down and price changes were tempered. At least to some extent, management became concerned with regulation rather than efficiency, and innovation suffered in some respects. Changes that would have occurred in a more open situation were slowed down.

The resulting lack of responsiveness began to be seen as a problem in the 1920s, and an acute problem was recognized as other modes, especially truck, inland water, and pipelines, began to compete. The solution to that problem was to rationalize the situation, a matter to be discussed in the following chapter.

Before leaving this topic we should point out that government regulation was hardly a standoff, "provide for the public interest" matter. This was especially true after ills in the social contract were repaired. Chapter 2 introduced the notion of the "iron triangle." Wilson (1980) makes the point that regulatory agencies get coopted by the organizations they are to regulate. The Ralph Nader study group's *The Interstate Commerce Omission* put that in harsher terms, "the ICC and the transport industries forged a corporate state that utilized public power for corporate purposes" (Fellmeth, 1970, p.vii).

The chapter began by looking back in time, all the way back to medieval society, in order to interpret the regulation of the railroads in the late nineteenth century. Before regulation, laissez-faire ruled. But laissez-faire behaviors sow the seeds of regulation. Regulation controlled the behavior of railroads to bring them in line with common law norms.

However, just as free market excesses create the rationale for regulation, regulatory excesses of the ICC type build in their own destruction. There is a life cycle. In the early days, political interest is high, and young professionals have the political power and energy to aggressively pursue regulatory tasks. But regulators age, the low-cost, big-payoff things get done, political interest and power decrease, and agency culture and procedures harden. Special interest groups can exert more and more power as others pay less attention. Agencies become a liability to a democratic government, and are at risk of death.

9

Railroads Rationalized

Once I built a railroad, now it's done. Brother, can you spare a dime?
—Edgar Harburg, *Brother, Can You Spare a Dime?*

Glendower: I can call the spirits from the vast deep.
Hotspur: Why so can I, or so can any man: But will they come when you do call them?
—Shakespeare, *Henry IV, Part 1*

Introduction

By 1917, U.S. railroads, the country's largest industry, operated over 400,000 km (240,000 miles) of track and employed 1.8 million people. While the war was raging in Europe, war traffic was congesting America's railroads, especially at East Coast ports, even before the American Expeditionary Force went "over there." The American Railway Association tried to coordinate its member railroads to avoid car shortages. The Interstate Commerce Commission (ICC) was granted greater powers to ensure efficiency and that priority cargo received priority treatment. Yet the progress made by these organizations was insufficient.

On December 28 the Federal Government's Director General of Railroads, William McAdoo, took control of the largest private railroads and placed them under the control of the United States Railroad Administration (USRA)—a creature of Congress.[1]

Nationalization had more form than substance to it. Railroad employees were given military titles, and a few interrailroad arrangements were forced on the properties. Some standardized locomotive designs were developed and engines were constructed. Labor arrangements were imposed that the railroads might not have agreed to under other circumstances. Railroads were granted compensation equal to their prewar profits. The shipping costs per ton-kilometer rose, however, in part due to a rise in wages.

While the railroad regulatory regime clearly collapsed with the onset of World War I, the regulation initiatives of the late nineteenth and the early twentieth centuries worked for their times. They managed the gross inequities that worried the public. Government served as a referee for ratemaking disputes among railroads, and government had begun to assert its power over who gets the location–transportation rents (via maximum rate prescriptions). The list of problems that regulation did not manage remained long, of course.

One of these was the vast difference in the economic fortunes of the different properties. This was not just a matter of concern to the managers, stockholders, and bondholders of the railroads that were not doing well. Shippers had an interest in strong railroads, as did regional groups. They were worried about good, stable service.

This chapter treats the notion of rationalization as attempted in several ways. The goal was efficiency; the means was often consolidation. But the shape suggested depended on who was suggesting.

Rationalization: Congressional Style

The Transportation Act of 1920 returned the railroads to private ownership. The debate in Congress went beyond the transfer of ownership to the problem of a viable system. It extended beyond the railroads to a general call for transportation improvements. It sought to improve the system rather than merely controlling its ills. The Act ordered waterway improvements and began what later became a remarkable renewal of inland waterway transport. The Highway Act of 1921 reflected the debate.

The Transportation Act of 1920 directed the ICC to prepare a plan for the consolidation of all common carrier line-haul railroads. It limited the number of systems to a few large systems of similar economic strength and overlapping turfs. Unlike the consolidation proposals that emerged in Britain and elsewhere at about this time, competition was to be preserved (the British established three regional monopolies).

The ICC engaged W. Z. Ripley, a railroad expert and Harvard professor, to produce a plan. After some revision by the ICC, a 21-system plan emerged in August 1921, and the ICC began to hold hearings on it. The 1920 Act had given the ICC authority to regulate construction and abandonment, and they were supposed to adhere to the plan. That planning was in the "great men announcing results" style common at the time. However, Ripley's plan was not a win–win plan, in the sense that all railroads would be better off if the plan was implemented.

The hearings on the 1921 proposed plan did not go smoothly, and a final plan was not adopted until 1929—just in time for the Great Depression. It too had 21 systems, but differed in that it excluded many small railroads and had different arrangements for the large ones. It never really had much effect, and was abolished by the Transportation Act of 1940.

The term "rationalization" is applied to the attempt of the 1920 Act. Rationalization has lots of different meanings. Perhaps the sense of it is to change structure so as to get some desired behavior. The 1920 Act focused on spatial structure.

Another sense of rationalization emerged in the activities of the Federal Coordinator of Transportation, Joseph Eastman. The Emergency Transportation Act of 1933 established his office. Eastman was to study rail transportation, identify economies, and recommend means for achieving them. Eastman's findings were to be submitted to regional committees for implementation (which was voluntary), and the committees were composed of railroad representatives. Eastman quickly realized that there was little promise in grand plans of the Ripley type imposed from the top. So he put his energy into small improvements: in the main, consolidation of yards, terminals, or parallel routes here and there. He advocated pooling of cars, container-like service, and competition for the railroad-controlled Railway Express Agency (REA).

As expected from this voluntary structure, nothing happened. Even so, Eastman worked on the possibilities for consolidation of yards and terminals for which there were many options and the economies were quite clear. Nothing happened, yet Eastman felt so strongly about his proposals that he discussed issuing an order for implementation. (He had the power, and this would make a strong case if challenged in the courts.) Still nothing happened. It is said that he was blocked by rail labor, but railroads that would have been losers must have had a say in that.

He was interested in consolidation of parallel routes, but made no proposals. This option made more sense later when new signal systems came along. Eastman proposed pooling of cars, another idea ahead of its time. Finally, Eastman had very interesting merchandise traffic and intermodal ideas. He proposed the use of containers and, where the traffic warranted it, unit trains. He wanted more competition in merchandise service and the addition of servers to compete with the REA.

When the Office of the Federal Coordinator was abolished in 1936, nothing had been accomplished. Perhaps this was because Eastman was an outsider. After all, by that time the ICC, the railroads, and interested congressional committees occupied the regulatory turf.

He accomplished nothing; yet many of his ideas have subsequently been adopted. The introduction of the diesel locomotive, long trains, centralized traffic control, and the large "hump" sorting yard yielded another round of operations planning, beginning in the late 1940s and continuing today. By and large, this work was done by the individual properties. Its results are clear from the ways operations have changed. It is also clear that some properties succeeded better than others.

Rationalization: Commission Style

The idea of Ripley-style railroad consolidation and the idea for Eastman's Office came from the Congress. We turn now to the ICC. What was their idea of rationalization? The answer to that question is hard to discover.

The Interstate Commerce Act required the establishment of through routes as well as joint freight classifications and joint rates. The through route notion argues for moving freight in a spatially rational way. Why did the railroads not do that? Many alternative routes between places were available. Let us move freight as far as we can on our own route; then, let us give it to a *friend* who gives us freight.

The ICC did three things. It used the shortest route to calculate cost and thus the tariff that would be charged. This is in the interest of efficiency. The tariff that can be charged encourages the railroads to move goods in a cost-effective way. Second, the ICC gave the shipper the right to specify the route over which freight would be moved. That gave the shipper control over the available service. The third thing was a little more complicated; it has to do with the way *friends* are treated in the sense of the paragraph above. Early on, it prohibited a railroad from discriminating among connecting lines (in those cases where the shipper does not specify routing). The question of how to identify discrimination was answered mainly through reference to historical patterns of handing off traffic.

Next is the special case of when railroads merge. A variety of things were tried. The conditions imposed on the Detroit, Toledo, and Ironton (DT&I) Railroad required that traffic would flow after the merger just as it did before. Those conditions were made standard. That is some sort of comment on what the ICC took rationalization to be. Efficiency must be an objective of a merger, and that surely has to with traffic management and concentration. Yet the ICC gave more value to stability—preserving historical relationships.

The Act of 1920 gave the ICC control over construction and abandonment, as mentioned. By that time the network was pretty much in place and other modes had begun to claim traffic. Although the ICC looked for the convenience and necessity of new services, in the main its experience has been with abandonment.

Cost reductions result from abandoning routes (maintaining a route to be serviceable, even if it is unused, costs money, and nature takes its toll on track and equipment). Did the ICC operationalize rationalization as the capturing of those cost savings? The answer is clearly "yes." Although one hears horror stories about the difficulties in getting permission to abandon track, the empirical record says that the ICC allowed just about all that were applied for, some big ones and numerous small ones. Some question that record. First, it costs money and takes management time to abandon routes, so we do not know about routes not abandoned because they were too costly. Second, following the Transportation Act of 1940, the ICC was required to give "weight to the interests of carrier employees affected. . . ." Some conditions were worked out, and they are rather costly. These may have held down applications for mergers.

Rationalization: Corporate Style

Problems begging the rationalization of firms and routes remained and they began to receive attention after World War II. The first phase ran until about 1970, and its focus was on the consolidation of regional services, the Ripley thrust reborn. Initiated by the rail properties, railroads acquired or merged with competing properties in their service areas. The Norfolk and Western (N&W), for example, acquired the Virginian, essentially a parallel coal hauler in the N&W's service area. In this case some redundant line was abandoned, and the N&W obtained a lower-grade east–west line for heavy-haul coal movements.

Ripley wrote as if he were a Czar who could stand back and manipulate the entire net. That was not a real option, however. Merger control was an option. Mergers were allowed when they were proposed by two or more railroads. The conditions imposed by the ICC varied over time. By 1940 they had to do with (1) the effect of the proposed merger on adequate transportation service, (2) the public interest effect of the inclusion, or more often, noninclusion of railroads in the area served, (3) costs, and (4) the interest of railroad employees.

Item 1 was considered because mergers usually include abandonment items. Item 2 was almost always a question, and costs should not swamp benefits (item 3). It is very difficult to judge the outcome of rationalization by merger policy. First, there was a long history of railroad mergers and consolidations.[2] Did policies and variations on them make any difference? The process was expensive and lengthy.

Often mergers had so many conditions attached to them that the economies proposed could never be achieved. Conditions had to do with the ability of the merger partners to alter traffic patterns. They may require that "landlocked" railroads be given track running rights. The data we have seen suggest that merged railroads as a class have done a little better than they would have standing alone, but not as well as the merger proposal claimed.

A large number of system changes emerged, with the largest during the ICC era being the merging of the New York Central and Pennsylvania systems, yielding the Penn Central. Even so, there was little payoff from the Penn Central and other mergers; the expected efficiencies were not realized. There were several reasons. First, the ICC often insisted that weak roads be included in mergers or acquisitions. In the Penn Central case, the New Haven and other weak railroads were included in the new system. Second, where there was redundant property and service as a result of mergers, the ICC was slow to allow abandonment. Third, the ICC insisted that previous traffic flow arrangements be honored, that is, the railroads had little control of the diversion of traffic to the more efficient routes available after mergers. Fourth, the merger took four years to complete.

This era ended with the financial failure of the Penn Central, resulting in government takeover of the properties and the creation of Conrail (Burt, 1998). The ills facing railroads included lack of capital (low profits, if any), excess physical plant (discussed in the case of low-density branch lines), and inability to achieve efficiency through consolidation of traffic flows. The solutions offered included more pricing freedom for railroads and a more hands-off role for the ICC in approving mergers and abandonment.

As a result of changes in the view of the problem and its solution, the Congress pressed for reduced regulation (the 1980 Staggers Act) and there was another round of network rationalization. There have been many end-to-end mergers of properties. Inaction has resulted in the bankruptcy of firms (such as the Rock Island and Milwaukee Road) and the sale of some of their assets to other rail properties. The Illinois Central Gulf provides an example of the spinoff of low traffic routes (the Illinois Central was ultimately acquired by the CN, Canada's national railroad, in 1999). It has trimmed to a high-density north–south route by selling lines (serving collector distributor and/or east–west services) to small operators.

Mergers and acquisitions have redrawn the network map. Presently, a handful of major systems handle the vast majority of ton-kilometers of freight moved. That is not to say that the number of railroads has decreased (though it has over the longer term); rather, the size distribution has changed: as figure 9.1 shows, there are fewer and fewer Class I railroads, though the total number has been relatively steady for the past few decades. While mergers and acquisitions decreased the number of large roads, the spinoff of short lines has increased the number of small roads.[3]

Rationalization: Conrail/Amtrak Style

The railroads emerged from World War II in a strong cash position. This plus the adoption of the diesel engine for line-haul service and some labor productivity improvements tilted them toward a "healthy" financial position for some years. But strains emerged. Truck, waterway, and pipeline competition deepened. Passenger traffic eroded sharply with competition from air and intercity bus and auto services. The beginnings of the Rust Belt to Sun Belt trend began to be felt. Regulation's slow price adjustments for inflation hurt. Finally, the ability of railroads to self-rationalize via mergers continued to be sharply constrained.

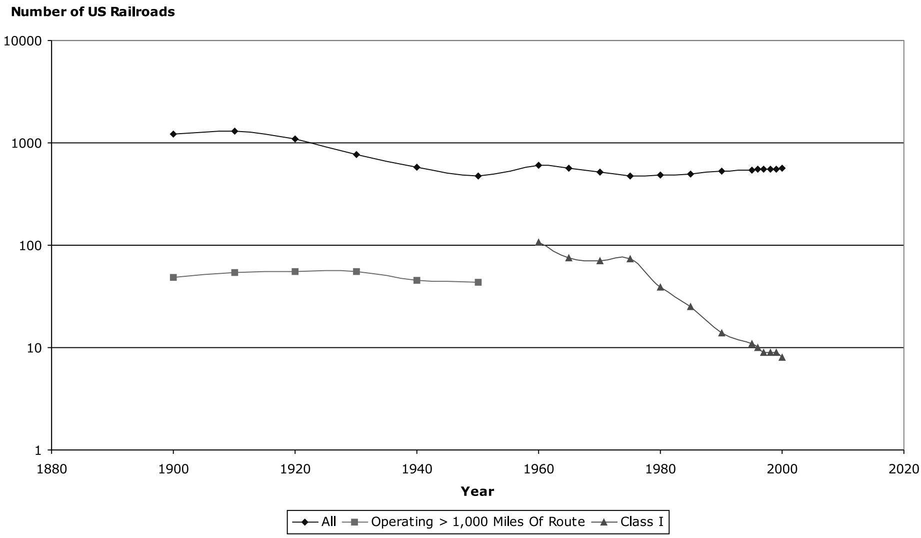


Figure 9.1. Number of U.S. railroads. (Source: Bureau of Transportation Statistics, 2000b.)

Crises and reactions to them at first came bit by bit. The Rail Passenger Service Act of 1970 created Amtrak and relieved the railroads of their obligations for passenger service. (The railroads had already been gradually reducing service at the slow pace allowed by regulation.) Although of national scope, this Act was somewhat of a special law—one-half or more of the service abandoned was Pennsylvania Railroad service. The railroads were not all in agreement and some railroads, such as the Sante Fe and the Southern, did not surrender service to Amtrak at the time. Next was the crisis of the bankrupt northeastern railroad companies, and the Regional Rail Reorganization (3R) Act of 1973 established the Consolidated Rail Corporation (Conrail). It provided grants for interim operations and loans for rehabilitation of some properties elsewhere.

The stopgap 3R Act was followed in 1976 by the Railroad Revitalization and Regulatory Reform (4R) Act. The 4R Act authorized $2.1 billion for Conrail. In addition, the Act had a Christmas tree character, something for everyone. Amtrak received money for its northeast corridor and the Act assisted the railroads with abandonment of routes. Increased regulatory flexibility was called for and the ICC was instructed to give greater consideration to the financial health of railroads in its rulings. A short timetable for merger decisions was prescribed. The 4R Act, in our view, was a response to an emergency, plus some side-payments to gain the support of all players. The connection between the side-payments and the problems was loose, though the connection was in the right direction. See Burns (1998) for a guide to mergers and other changes in the decades following the 4R Act.

Rationalization: Community Style

Activities initiated in the 1970s included the accelerated abandonment of light-density track and the elimination of failed railways, as well as end-to-end mergers and acquisitions.

The railroads began to identify lines they would abandon and those they might abandon in the future. The states were very concerned about disruptions of service, so Congress had the Federal Railroad Administration (FRA) develop a procedure and fund state rail planning activities. The FRA presence was high because the feds committed to transition funding to assist the states during a transition period.

The states have now gone through several rounds of state rail planning, and it is fair to say that state transportation agencies have proved fast learners. They examine lines proposed for abandonment by railroads and consider the alternatives of abandonment or knitting devices for the continued operation of lines. Continued operation is contingent upon a benefit–cost study that scopes wider than a railroad's calculation of profitability. If there is potential for viability or some other reason to keep a line open, the states usually arrange for operation of the line by a short line operator. Subsidy to the operator may be involved.

State rail planning served its purpose. The railroads managed to spin off track of little value to them. The states figured out what was and was not worth saving and came up with action plans. Many of those plans did not lead to successful operations, and adjustments were required. Even so, operators of short lines gained experience, and the large railroads worked out ways to relate to short line operators. As a result, and although the states are still involved, to a large degree state planning was so successful that it put itself out of business—deals can be cut to create viable short lines without the involvement of state planning.

The process for developing the state rail plans, as well as the content of the plans, was prescribed by the Federal Railroad Administration (FRA). That is another example of federal cooptation of what should be local planning. Even so, the contents of plans are influenced by what the states take to be their chief problems. Traditional concerns have been grade crossings and safety and the effects of railroads on traffic in towns. Some state plans were influenced by these concerns. Proposals for line abandonment affected some states very much, and concerns about the relationships between freight transportation, towns and industries, and major economic sectors influenced plans.

Let us look briefly at modern abandonment analysis. As stated, there was a prescribed procedure established by the Rail Service Planning Office (RSPO) of the ICC (and an alternative established by the U.S. Railroad Association that was used in the Conrail area). Studies provided a description of the route. There was then treatment of the alternatives of continuation as is, continuation with subsidy, abandonment, acquisition of right of way for banking for future use, and so on. Rail revenues from the operation of alternatives were estimated and then compared with the avoidable cost of continued service. Avoidable costs include on-branch cost and off-branch cost. They generally include calculations of the costs that would be incurred to upgrade the line to a Class I facility (condition of track, ties, ballast, etc.) for acceptable service. On nearly all branch lines, the avoidable cost is greater than the revenue.

An additional calculation was made, termed avoidable community impacts. These impacts include the increased transportation cost if rail shippers were forced to use other modes, salary and wage shifts, and so on. This number was then compared with the difference between avoidable cost and revenue and a recommendation made about the future of the line.

The rail planning activities focused state DOTs on rail issues, and most have activities in the area. There was a healthy broadening impact on the agencies. However, state rail planning is now somewhat mooted because many of the urgently needed abandonments have been made. The big railroads continue to spin off thin traffic lines. Usually, these lines have potential for viable operations by a low-cost operator. Because the railroads want to keep the traffic generated on the lines, they assist a low-cost operator's entering the business. Due (1979) and Due and Leever (1993) review the state rail plans that were available at that time.

Box 9.1 illustrates the issue of rationalization by investigating the case of Iowa. Box 9.2 looks at the case of labor relations.

BOX 9.1 Rationalization in Iowa

The mainline mileage of U.S. railroads peaked between 1920 and 1930 at about 400,000 km (240,000 miles); today there are about 160,000 km (100,000 miles). A main reason for the reduction is that a lot of redundant mileage was constructed. (Of course, trucking made tracks redundant as well, since it was no longer necessary to have tracks so close to the customer.) Some long routes were constructed in areas where the market was already well served (e.g., the Milwaukee Road: Chicago to Seattle). On a smaller scale, many such lines were built in the Midwest. One force for overconstruction was the money that construction contractors could make. Examples illustrate the scope of abandonments and other forces at work.

Iowa had about 16,000 km (10,000 miles) of route at the turn of the twentieth century and now has about 9,300 km (5,800 miles). The temporal pace of line abandonment is shown in figure 9.2. Much of Iowa is highly productive farmland, and much of the agricultural land was near a railroad. Wagons were used to move the farm products to the railhead, and the rail network then served as a collector system to move the products to yards and markets. Within the state, movements must have been evenly distributed across links of the network. That is in sharp contrast to today. About 12 percent of the route mileage handles 50 percent of the gross ton miles (GTMs) moved in the state (1981 datum). That, however, overstates the within-state concentration case because about 62 percent of the GTMs are overhead traffic (traffic passing through the state) and overhead traffic was concentrated in the early days, though not as much as it is now.

The reduction in route mileage is not unique to the United States. By 1960–1970 British Railways route mileage had been reduced by about 35 percent, Swedish State Railways by about 20 percent, and the French National Railways by about 8 percent.

Returning to downsizing and the Iowa example, what is the cause? The data supplied are not very helpful in answering that question because they fail to relate downsizing to anything other than time.

Things have changed a lot. The economy of Iowa has grown; demand has increased. Farm population has been reduced sharply. (More people lived on farms than in cities during the early decades of the period we are examining.) This has concentrated the demand for final products in medium-sized and large cities. The mechanization of agriculture and improvements in seeds and fertilizers have yielded this; the result is more product with fewer people.

The mechanization of the farm-to-market or farm-to-railroad interface was a major factor in changing the demand for low traffic rail routes, of course. (That is a long way to say that trucks came along and substituted for horse-drawn wagons.) As roads and trucks

BOX 9.1 Rationalization in Iowa—cont'd

were improved, truck service became competitive with rail over a range of about 500 miles (longer in the case of products such as grain), and collector/distributor rail lines became redundant. The auto, bus, and airplane proved competitive to rail passenger service, and demand for passenger service no longer supported low-density routes.

That is the textbook explanation for the Iowa situation, and the same general explanation is used to explain most cases. However, passenger service has held on better in Europe than it has in the United States largely because of government policies and the closer spacing of large cities in Europe. Some exceptions to the textbook explanation exist, mainly cases where routes were redundant when they were built.

BOX 9.2 Labor Rationalized

Responding to situations from time to time, policies were developed and adopted that preserved labor rights in mergers and acquisitions. The roads agreed to that in earlier days when excess labor following a merger could be spun off through attrition. Now, things have changed. For a variety of reasons, larger quantities of labor must be dealt with. There is the special problem of the short lines created when large roads abandon mileage. These short lines often can be profitable if paying local wages instead of paying railroad wages and using railroad job classifications. It was not so difficult to modify policy in favor of the short lines.

But it has been difficult and it has taken many years to modify policy in the case of mergers and acquisitions, and revised policy has been tied up in the courts. On March 19, 1991, the Supreme Court found in favor of railroad interests:

> UNION CONTRACTS
> Let railroads ignore their union contracts when completing mergers approved by federal regulators (*Norfolk and Western v. American Train Dispatchers Association,* 89-1027 and 89-1028).

The contract modification responded to "things changing," and it was permitted by the weakening power of labor unions and changing public attitudes about the railroads and unions. It took a long time and it was costly.

Discussion

This chapter focused on a particular aspect of planning, *rationalization,* to make the mode work better in current conditions. Toward the end of the nineteenth century, rationalization strove to control the behavior of the railroads and to bring behavior in line with common law norms. Subsequently, rationalization has meant many things: changes in the network and the spans of control of firms, bringing prices in line with costs, route abandonment, and the discarding of old and the development of new

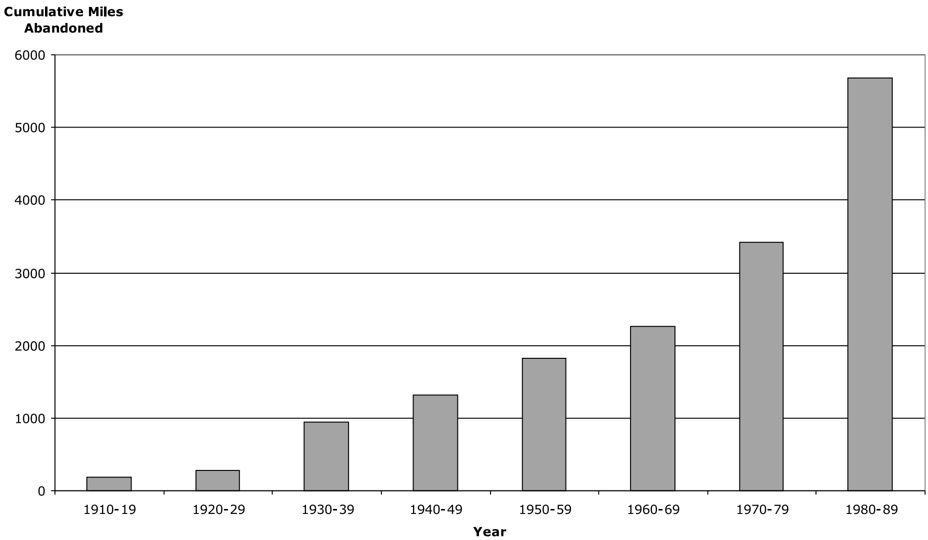


Figure 9.2. Railroad route abandonments in Iowa, 1910–1989.

service arrangements. The latest wisdom (from the last quarter of the twentieth century) is that regulation isn't rational, deregulation is.

Where do the rationalization efforts of the twentieth century leave us? The good news is that there is a viable freight railroad system. The tonnage moved has increased and, although reduced in mileage, the physical infrastructure has improved in quality and capacity. The bad news is that the systems are barely viable. The return on investment of the large railroads, while positive, is not large enough to cover the cost of capital.

10

Railroads Reinvented

Build a man a fire, and he'll be warm for a day. Set a man on fire, and he'll be warm for the rest of his life.
—Terry Pratchett, *Jingo*

Introduction

After five years of construction, and coinciding with the 1964 Tokyo Olympics, the first Japanese high-speed rail (HSR) system, the Shinkansen (new train) or bullet train, opened. While the dates coincided, they were not mere coincidence; both events were aimed to promote globally the image of a modern Japan.[1]

In 1967 a second line, the Sanyo Shinkansen, was begun. By 1970, Japan authorized a national Shinkansen network. Construction plans for five additional lines and basic plans for twelve others were approved in 1973, but despite the approvals, the cost of the five lines (5 trillion yen, or about $50 billion) combined with the oil shock and recessions delayed the lines until 1989. High petroleum prices, which increase the relative demand for nonpetroleum-based transportation such as high-speed rail, also increased the construction cost for HSR and reduced available revenue, thus delaying construction.

Many of the new Japanese lines combine narrow-gauge and wider-gauge lines on the same structures, allowing both conventional and advanced technologies to use them. While the hybrid technology limits the speed of the bullet train on these routes, it permits later upgrades. As with the birth of the Shinkansen some 34 years earlier, the 1998 Winter Olympics in Nagano were a target for the opening of a rail line extension.

Within Japan, high-speed rail has confronted the break-up and privatization of the rail system, begun in 1987. The restructuring aims to achieve more efficient methods to ensure profitability in the passenger rail sector.

The Japanese have continuously improved all aspects of their system over the years (JRE, 1994). Major improvements since the first opening in 1964 include the introduction of computerized crew training systems, double-decker cars to expand capacity, the use of regenerative brakes to conserve energy, lowering the weight and increasing the strength of cars, the use of electronics in mechanical system management, mechanization of track maintenance, the introduction of tilt trains, and the incorporation of aerodynamic considerations in train design.[2] As a result of these improvements, travel time from Tokyo to Osaka has dropped by 90 minutes from 4 hours in 1964 to 2 hours and 30 minutes, achieving a speed of 220 km/hr (138 mph). The current bullet train is shown in figure 10.1.

This chapter considers the reinvention of passenger railroads. While this chapter focuses on passengers, box 10.1 examines the new freight railroad, the Dakota, Minnesota and Eastern line. In the United States, the passenger railroad is thought to be dying; yet significant investment elsewhere in the world seeks to fight the trend. Strategies include redesign, new rights of way, and restructuring by privatization.

Reinvention by Redesign

High-speed rail is touted as a way to reinvigorate rail demand by reinventing the technology. There are two main strategies for high-speed rail: maglev and enhanced conventional.

Maglev, or magnetic levitation, has been operational on a 30 km (19 mile) section in Shanghai, China, since the start of 2003, reaching a peak speed over 400 km/hr (250 mph). This is a somewhat different technology than railroads as we know them, sharing the concept of cars being trained together and a track, but using completely different

Figure 10.1. Japanese bullet train (Shinkansen). (Photo by DML.)

BOX 10.1 Freight Moving Forward

The Dakota, Minnesota and Eastern (DM&E) Railroad's new Powder River Basin line is the first significant new railroad being built in the United States in over 80 years (Sellnow, 2000; Sommer, 2002). It intends to lay 416 km (260 miles) of new track from Wyoming's Powder River Basin to connect to existing rail lines in South Dakota, and then rebuild track across South Dakota and Minnesota. It has also acquired other connecting lines, reassembling much of the Chicago and Northwestern Railroad, which had been abandoned. This is the first significant new railroad in 80 years. Does it suggest any rejuvenation in the freight railroad sector, or is it a mere tweak on a mature network?

The Powder River Basin Project was initiated in February 1998, when the DM&E submitted an application to the new Surface Transportation Board (STB) for the new track in southwestern South Dakota and northeastern Wyoming. This track would serve the low-sulfur coal reserves, and bring them quickly to market in the Midwest. (The advantage of low-sulfur coal is that it burns more cleanly than high-sulfur coal.) About 100 million tons of coal per year could be moved by the line, more than one-third of the coal mined in the Powder River Basin.

The STB gave its approval in January 2002 (almost four years later). To supplement this goal, DM&E acquired the connected Iowa, Chicago and Eastern (IC&E) and IMRL (I&M Rail Link) railroads, and is now the largest of the Class II railroads in the United States. However, the hurdles to building a new railroad are large. There is the $1.5 billion price tag, which is especially large considering the size of the DM&E itself. There are additional challenges.

Getting the line approved has been no easy matter. In particular, getting approval for construction through the city of Rochester, Minnesota, home to the famous (and politically powerful) Mayo Clinic, has been contentious, as the city is worried about a constant stream of coal trains running back and forth across the city. The Mayo Clinic has been pushing for the railroad to build a bypass around Rochester. This is a far cry from the days when towns wanted train service, and is a different reaction than most towns along the line that believe the railroad will provide a benefit. Nevertheless, a number of lawsuits have been filed by the city of Rochester.

Groups representing Native Americans in the basin have also filed lawsuits, arguing that historic sites and burial grounds will be crossed by the railroad. Farmers worry that coal will take precedence over grain, a special problem in smaller communities where the line is a monopoly.

The Powder River Basin is already served by lines of two Class I railroads, the Burlington Northern and the Union Pacific. Is a third line necessary or in the public interest? The proposed project also begs the question why the coal cannot be processed on site and the electricity sent back east. Certainly this would minimize transportation (and energy) costs as electricity weighs less than coal and high-voltage lines are cheaper than track. This would have fewer environmental impacts on most places, though of course more in the basin itself. However, capital costs for new power plant construction would probably be less than the capital costs for a new railroad.

technologies for propulsion. However, the other aspects of system building, from land acquisition to managing stations and scheduling services, will inevitably copy their logic from railroads. China plans to expand the system, developed by the German organization Transrapid, but its cost of nearly $1 billion per train may constrain those plans.

The Transrapid organization is seeking to fill three market niches with maglev technology: airport to downtown, regional or commuter rail, and long-distance intercity rail. However, with only one real system in operation (and that still in a testing phase), its future is unclear. It seems likely to be a technological success. (A test track in Japan has recorded 500 km/hr on a maglev line). But just because the engineers can do something, does not mean society should do it. If only because of its novelty, the economic analysis of this technology has yet to be resolved. However, as time progresses, if costs can be brought down due to scale economies of various sorts, maglev holds some promise.

In contrast to maglev, rail may be reinvented through enhanced conventional service. These lines include technological improvements in the train as well as more conducive right of way conditions (dedicated, straighter right of way but potentially steeper grades [since the rails do not serve heavier freight trains]). The operating high-speed rail lines have to date followed this less technologically risky (but perhaps less rewarding) strategy. Serving high-volume, nearby, intercity markets, examples of this enhanced conventional service include the Shinkansen between Tokyo and Osaka in Japan and the Train à Grande Vitesse (TGV) between Paris and Lyon in France, both of which have been further expanded, in the French case to a trans-European network. The French TGV achieves an operating speed of 300 km/hr, with maximum test speeds of 515 km/hr in 1990.

Prelude to Reinvention

During most of the twentieth century, U.S. (and other) railroads lost passenger traffic to autos, buses, and air services. Loss to the highway modes began in the 1930s, especially in short-distance markets. In the 1950s, those losses continued, joined by losses to air service in longer-distance markets.

Most of the rail properties did not manage these losses gracefully. Passenger traffic had long been a source of institutional pride, as well as a source of revenue. Contrary to conventional wisdom, management worked hard to stem the tide of losses. It purchased new equipment and created improved services. The famous long-distance trains of the 1950s were the result, such as those operated by the Santa Fe. There were also efforts in shorter-distance markets, with the Rock Island's Rockets providing an example.

Why did we say the losses were not managed gracefully? Management, in our judgment, did not recognize the depth of forces driving the loss of markets. It invested at a time when graceful disinvestment (rationalization) should have been undertaken. Management did not examine possible residual market niches where efforts to create and preserve markets might have been successful.

The Pennsylvania Railroad was an exception to the latter statement. Long a leader in the New York–Washington corridor, it saw service hard pressed in that corridor by auto, bus, and air services. Distances were such, however, that high-speed rail might be quite viable in the market niche. Seeing that, the Pennsylvania Railroad developed a plan for advanced technology, air-levitated services that could have been quite successful had not the Federal Government coopted high-speed train programs. The Pennsylvania work was company-confidential, and most in the transportation field remain unaware of it.

Despite the decline of passenger rail service for over half a century, intercity high-speed ground transportation has seen renewed interest in the United States. America's National Passenger Rail Corporation, Amtrak, was formed in 1971 by assuming the passenger services of the commercial railroads, which were left to focus on freight. Despite a charter to be profitable, Amtrak has never seen black ink system-wide, and really only has hopes in the Northeast corridor (Boston–New York–Philadelphia–Baltimore–Washington). The organization is perpetually in danger of being shut down or radically scaled back; however, it provides service in many Congressional districts, giving it some political strength.

In the Northeast corridor, Amtrak deployed the Acela service in 2001, which travels at a peak of 240 km/hour (150 mph). However, the actual scheduled time is 2 hours and 44 minutes from Penn Station in Manhattan to Union Station in Washington. Thus the effective speed for this 368 km (230 mile) trip, including stops, acceleration, and deceleration, is 134 km/hr (83 mph)—somewhat faster than an automobile, more so in congested periods. Table 10.1 gives rail passenger use in the United States; a rough comparison with population suggests at best 0.5 boardings and alightings (or 0.25 round trips) per capita per year.

Conception of Reinvention

When discussing the life cycle of a technology, we noted three phases: birth, growth, and maturity. At any time, renewal or reinvention is a possibility, but there is a long mating dance before pregnancy. In the case of U.S. high-speed rail, this mating dance has gone on for over 40 years.

The deterioration of passenger train services in the Northeast corridor (Washington–Boston) and air traffic congestion became relevant in the Congress around 1963 when Senator Claiborne Pell of Rhode Island introduced a bill asking that Shinkansen-type trains be run in the corridor. The bill was resisted by the administration in the absence of cost and market studies. However, after a good amount of pushing and pulling, the High-speed Ground Transportation (HSGT) Act of 1965 emerged.

Table 10.1 Amtrak Boardings and Alightings at 10 Busiest Stations (2001)

Station	Boardings and alightings
1. New York, N.Y.	8,589,534
2. Philadelphia, Pa.	3,764,734
3. Washington, D.C.	3,518,423
4. Chicago, Ill.	2,152,241
5. Newark, N.J.	1,430,144
6. Trenton, N.J.	1,013,138
7. Boston, Mass.	989,749
8. Los Angeles	984,870
9. Princeton Junction, N.J.	915,396
10. Baltimore, Md.	879,136

Source: Bureau of Transportation Statistics, *National Transportation Statistics*, Table [w.Rail.xls].

It provided funds to begin upgrading the corridor (there were rather different problems in the Washington–New York and New York–Boston segments) and for government research and development.

The status of work was reviewed annually in the reports on high-speed ground transportation (U.S. DOT, 1976–1987). The competitiveness of high-speed ground transportation was reviewed in a U.S. DOT/Amtrak study of upgraded service in city pairs (U.S. DOT, 1981) and the first chapter of that report provides a useful summary. NASA supported a series of studies by McDonnell-Douglas, Lockheed, the Aerospace Corporation, and Stanford University in low-, medium-, and high-density markets.

The references above provide information through the early 1970s. There followed a period of several years when interest in corridors seemed to wane. The High-speed Ground Transportation Act programs were defunded—the Act remained for a time, but no money was provided. Amtrak continued its corridor upgrading. The U.S. DOT phased out the work it was doing on maglev and other high-speed technologies. NASA studies of short-haul air transport had not yielded technologies with great promise, and their program was reduced, although the tilt rotor aircraft has received attention recently.

Agency wisdom at the federal level was influenced by the National Research Council (1975), which recommended that conventional speed rail systems be monitored, with the prospect of deploying high-speed (250 km/hr) systems in promising markets in the medium term. If markets evolved, then very high-speed systems (480 km/hr) were to be considered in the long term. The Committee report just mentioned reviewed a number of corridors where there was interest in such a service, but the report was not addressed to nor known to those promoting those corridors.

Although agency funding was reduced to zero, some interest continued in Congress, mainly because Congress was approached for funds to support local interest in systems. The result was a report by the Congressional Office of Technology Assessment (1983), which emphasized that there was no clear-cut case for maglev or other varieties of high-speed service, and that data should be obtained and carefully evaluated on a case-by-case basis.

Even though the OTA report was not optimistic, federal interest was renewed in 1989 when news of high-temperature superconductors emerged, and the Congress asked for an analysis of maglev transportation systems. (Actually, and in spite of what was asserted, such superconductors would have only a modest impact on maglev costs.) The result was a U.S. FRA (1990) report calling for "further analysis." Other reports have been prepared with groups working directly with the Congress. Both the Corps of Engineers and the U.S. Department of Energy (Johnson et al., 1989) joined the National Maglev Initiative. As roles evolved, it appeared that Argonne wanted to be a leader in technical work, with U.S. DOT evaluating and funding local efforts. The Corps of Engineers was to be left without a role. The 1991 Intermodel Surface Transportation Efficiency Act (ISTEA) funded maglev R&D, but funding was sharply reduced in 1994 and disappeared in 1995. The reason given was "It's too expensive."

Yet, like a ghoul from a horror movie, it would not die, and high-speed rail reappeared in later funding bills (TEA-21). Building on deployments in France and Japan, as well as the Acela line in the Northeast, preliminary planning is being undertaken to bring high-speed rail transportation to the rest of the United States.

Those U.S. proposals include corridors in California, the Northwest, the South Central, the Gulf Coast, the Southeast, Pennsylvania, New York, and northern New England, and a proposal to feed a Chicago hub from a number of regional lines in nearby Midwestern states. Some proposals have been killed (e.g., the "Texas Triangle" connecting Dallas, Houston, San Antonio, and Austin) and others seemingly won't go away; for instance, the Florida Corridor was killed by Governor Jeb Bush and reinstated by voters.

Reinvention by Restructuring

An alternative route for reinvention of passenger rail is privatization. A decision taken in 1987 divided the Japanese National Railways into six regional passenger companies and a freight company. The British separated the ownership of the track from the trains. Private firms, including well-known brands such as Virgin, operated trains on specific routes, with scheduling and pricing freedom. Privatization has resulted in an increase in passenger trips (see figure 10.2). Mismanagement of the RailTrack organization, which operated the track for the carriers, caused an increase in the number of accidents. While the idea of having a separate track from carrier works in other sectors (roads vs. trucks, airports vs. airlines), trains and tracks are more integrated technologically (tracks steer trains, roads do not steer trucks), so the management tasks are more intricate if they are separated. This should not cause the concept to be dismissed immediately, but should suggest caution.

Transport for London, the organization that runs the subway (underground) system in London, reorganized the Tube using public–private partnerships, wherein the infrastructure would be maintained by private companies, though ownership would stay public.

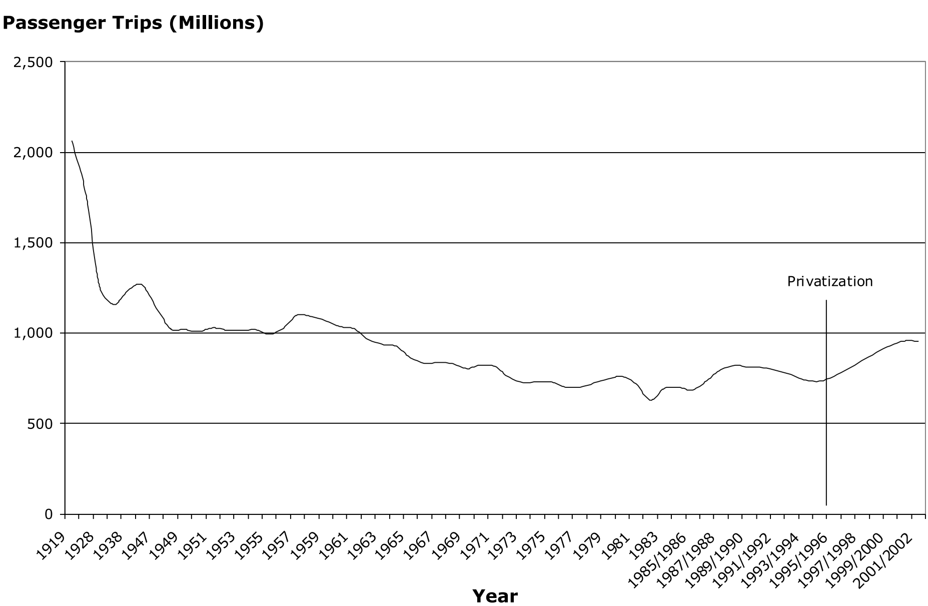


Figure 10.2. British railroad passenger trips, 1920–2000.

Discussion

Unlike traditional railroads, whose emergence was at least in part due to a forceful entrepreneur, for example George Stephenson, high-speed ground transportation has been a product of central planning in Japan, France, and the United States. Operationally, the systems are largely adapted from conventional rail systems, with similar labor organization and ownership in Japan and France and similar architectures in many other respects.

Despite a great deal of legislative effort and lobbying by the large engineering interests, it is doubtful whether without considerable subsidy high-speed rail could be constructed, much less be profitable in the United States. Despite assertions of "operating" profitability (which conveniently ignores the very high capital costs), HSR has in all cases required government subsidy. It is clear that a free market would never develop HSR. That leaves open the question of whether government should.

The conditions in Europe and Japan during the conception and birth stages are significantly different than in most parts of the United States. Land uses are denser and cities are closer together

A key distinction is that the regulated transportation sectors in Japan and Europe prevented competition from air travel to the same degree as in the United States when the HSR lines were planned and deployed. Thus the market for high-speed rail probably appeared more promising than in a deregulated environment due to these limits on air travel. Had air travel been deregulated and privatized at the time, the decision to proceed with high-speed rail, particularly in Europe, may have been different. A ride on many of Europe's high-speed intercity lines finds nearly empty cars, which is due to the recent deregulation of air travel. As an illustration of this, Southwest Airlines was a major opponent of high-speed rail in Texas (Krumm, 1994). Another distinction is the willingness of European governments to engage in subsidies and tolerate what Gerondeau (1997, p. 123) terms "a catastrophic level of debt."

Real constraints on the growth of the highway and air travel systems exist. Widely cited are congestion, or capacity limits. Airports have limited capacity to serve aircraft in peak times, as do highways. In a priced system, this would result in higher user charges, but in an unpriced system there are simply queues formed. High-speed rail, which has potentially very high capacity on its fixed corridors, offers the promise of relieving congestion on the other systems. In Europe and Japan, with important, though declining, conventional rail services, its extension and adaptation to a higher-speed technology was a more obvious choice than in America.

In the United States, congestion/capacity problems are less severe than in Japan and Europe. Moreover, conventional passenger rail has long been a less important mode than the other two. Further, the markets for which rail is best suited—high-volume, short-distance markets—are less common in the United States. For these reasons, high-speed rail remains in a birth or pre-birth stage in the United States.[3] In short, while the conditions were favorable for the development of HSR in Europe and Japan, they are clearly less so in the United States.

While its technological advantages over conventional rail are obvious, as with all rail modes, there is a significant amount of inflexibility associated with the system design. The high-speed networks are limited, and the rails require specialized vehicles. HSR lacks the point-to-point convenience of the auto and the speed of the airplane on long trips. Compared with the greater flexibility afforded the untracked air travel system or the ubiquitous highway system, high-speed rail faces serious difficulties. As noted earlier, in mature systems, the benefits of new infrastructure in an already well-served area are elusive.

It will be interesting to observe the progression of the Japanese and European high-speed rail systems from growth to maturity, and to compare this with the earlier history of conventional rail. An interesting chapter in the story is opening in Japan where there is stagnation in the number of passengers served and deregulation is concentrating services on the more profitable routes (Takeda and Mizuoka, 2003). Whether high-speed rail is a new story, or simply the final chapter to the history of conventional passenger rail, waits to be seen.

This page intentionally left blank

Part III

The Modal Experiences: Looking Back and Looking Around

The railroad experience appears in the nonrail modes in the ways institutions are organized, firms and government agencies see their roles, policies are thought about and implemented, and plans and actions are executed. That is for the better. The railroads have taught us how to create, deploy, and manage big sociotechnical systems, such as the nonrail modes now to be discussed.

But for reasons about which we shall speculate later, there are some lessons on which the nonrail modes have turned their backs, so to speak. The American railroad engineer Arthur Mellen Wellington's much used and admired book on the economics of railroad location, first published in 1887, illustrates two of these.

First, Wellington had a systems view of design tasks. Route location, the weight of rail, controlling grade, curvature, operations protocols, and the equipment to be used all turned on the situation and the tasks to be performed on the route, as well as the way the route was to perform within the network to which it belonged.

That kind of function-scoped design, investment, and service often gives way today to "one solution fits all" investments and services that are not sensitive to market niches and system performance. "How big?" is about the only question raised and answered—how many highway lanes, the number of cars in light rail multiple units, and the sizes of school buses. Reliability, safety, and cost are among the reasons (excuses), and it is forgotten that service variety may open opportunities for innovation, as well as providing better services.

In his preface, Wellington refers to routes that are "bleeding and oozing from every pore," and he points out that this is not recognized since it takes a bit of expertise to recognize ill-performing investments—economic and service dysfunctions. Looking around today, many of the nonrail modes enjoy government subsidies and there are cross-subsidies between and within modes. With plenty of money they often have a polished veneer and their bleeding and oozing is hidden.

Railroads have achieved improvements by tailoring investments and services to markets and reconfiguring services to eliminate dysfunctional activities. The nonrail modes have those tasks before them, but with the partial exceptions of air and maritime services, they have not begun to recognize them.

11

Transit

"I see a place where people get on and off the freeway. On and off. On and off. All day, all night. Soon where Toontown once stood will be a string of gas stations. Inexpensive motels, restaurants that serve rapidly prepared food, tire salons, automobile dealerships, and wonderful, wonderful billboards reaching as far as the eye can see. My God, it'll be beautiful."
—Judge Doom in *Who Framed Roger Rabbit?*

"Nobody's gonna drive this lousy freeway when they can take the Red Car for a nickel."
—Eddie Valiant, Judge Doom's nemesis

Introduction

In the 1920s, a General Motors (GM) subsidiary acquired streetcar systems in Springfield, Ohio, and Kalamazoo and Saginaw, Michigan. Contracts required the transit systems buy only GM and Mack buses, Firestone tires, and fuels and lubricants from Standard Oil of California. In exchange, GM, Firestone, and Standard Oil provided the capital. In 1936, E. Roy Fitzgerald, a bus company operator who hauled miners in northern Minnesota, was made President of National City Lines (NCL), General Motor's transit holding company (controlled through GM bus units Yellow Coach and Greyhound). By 1946, NCL and its subsidiaries American City Lines and Pacific City Lines owned transit systems in 45 cities (including the Red Car lines in Los Angeles and the Key Lines in Oakland). That same year, industry trade publication *Mass Transportation* named Fitzgerald "Transportation Man of the Year." Fitzgerald also made the cover of the July 20, 1946, issue of *Business Week* as NCL became a publicly traded company on the New York Stock Exchange.

On April 10, 1947, United States Attorney General Tom Clark indicted nine corporations and seven individuals (including Fitzgerald) on antitrust charges of conspiracy in the sale of equipment to a "nationwide combine of city bus lines."[1] On March 13, 1949, they were all convicted on one count of conspiring to monopolize a part of the trade and commerce of the United States. National City Lines and General Motors and the other companies were fined $5,000 apiece, while their managers were fined $1 each.

It is important to rail transit advocates to tell the story that America's streetcar system was destroyed by a conspiracy, because if it was a conspiracy, rather than market forces or democratic preferences, it was a wrong to be righted by new investment in rail transit. Advocates tell this story in a number of forums, including the (relatively) widely seen documentary *Taken for a Ride*. Glenn Yago's *The Decline of Transit* (1984), a comparative study of the United States and Germany, posits a grand conspiracy to do away with transit by automobile and suburban development interests. In places, it states that the whole story had to do with finding employment for labor in a capitalistic society.[2,3] Similarly, in the early 1970s, Bradford C. Snell charged that General Motors (GM) had used NCL to destroy thriving street railways in the interest of selling buses and, in the longer run, automobiles. Snell's *American Ground Transport* (1974) was first published as a House Committee Print. It was not limited to NCL. It charged GM with forcing the railroads to adopt its diesels and with aiding the Nazi government during World War II. Needless to say, Snell's charges garnered significant newspaper attention.[4,5]

Did a Judge Doom-like General Motors do in the streetcar, or was the streetcar already doomed due to the general rise of the automobile and the greater flexibility of the bus? Before we continue with the fall of the streetcar, let us first examine its rise.

Inauguration

On-road mass transit began with for-hire horse-drawn passenger services, often called the "omnibus." (Clearly there were mass transportation modes before the omnibus, ferryboats and intercity carriage services among them.) The services that urban mass transit could offer were greatly improved when rail technology entered the city: urban extensions of intercity train service by about 1850 and commuter (workmen's) trains soon afterwards. With electrification, streetcars and elevated/subway services expanded rapidly and many commuter train services converted to electric power. Interurbans, heavy streetcar-like services, also expanded rapidly.

The electric utilities promoted and often owned electrically powered transportation properties. The markets the properties provided aided the utilities by providing for base load, aiding in the achievement of scale economies in production and distribution of power, and also aiding the diffusion of service throughout urban areas.

Rail-like services pushed aside other services, so the predominant technology of transit shares much with railroads, as does the embedded policy. Public policy was railroad policy writ small for the scale of the city.

Figure 11.1 illustrates the history of streetcars in the United States. In the upper left corner of the figure is a tram (or horse) car (using rope or cable haulage), the *John Mason*, placed in service in New York City in 1832. Note both its similarity to road coaches and how later designs evolved.

Early railroads penetrated cities along lakefronts, along rivers, or through lands that had not already been coopted for urban purposes. If the urban area were large and dense (e.g., London, Paris, Beijing, or New York), railroads were unable to penetrate all the way to the heart of the city.

The passenger business was a big part of the rail business, and railroads established passenger stations as close to the centers of urban markets as practical. For competitive

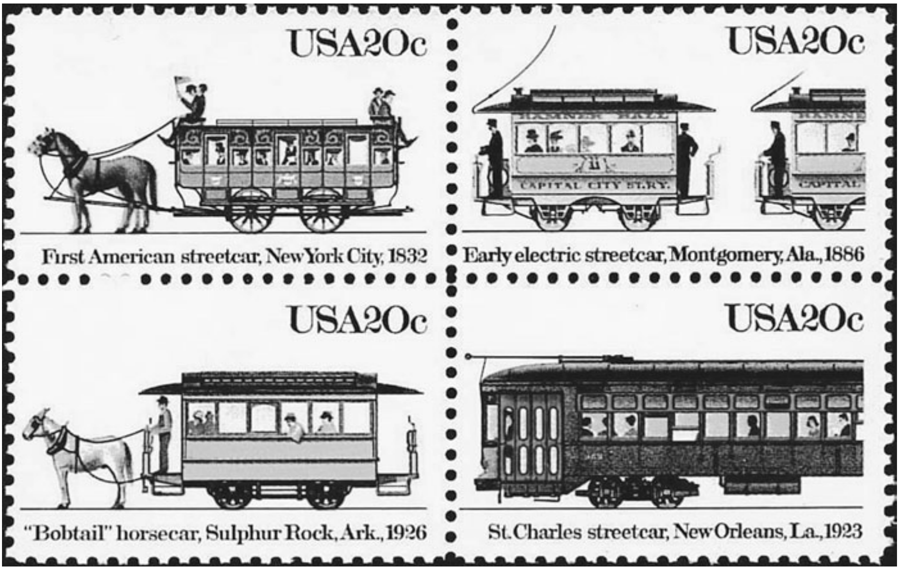


Figure 11.1. Streetcars in United States history. (Source: Senkus, 2000.)

reasons, each railroad established its own stations. To accommodate nonbulk freight, teaming yards were also built near downtown. Because of the requirements for car storage as well as room to work teams of horses, the yards involved considerable amounts of land.

As cities grew, additional teaming yards and considerable industrial track were constructed. Today, the parts of cities built during the period we are describing have considerable interlacing of rail facilities within them.

As cities grew and incomes increased, entrepreneurs began to run local coach (omnibus) services. Coaches appeared in Paris, London, and New York during the 1820s and were no doubt found elsewhere. Owner operators provided service; the capacity of individual coaches was from 10 to 20 persons.

Horse trams (on rails) had been used in special circumstances, such as mining, for a long time, and they appeared in cities as passenger traffic grew enough to warrant investment in rails. These trams were quite competitive with the omnibus because of higher productivity—larger vehicles and increased speeds. Because rail investment was required, firms provided the service. New York had over 30 tram roads by 1860.

With continuing urban growth, higher capacity modes became practical. Also, the great epizootic (an influenza) and threats of its recurrence were bothersome. The shift from feed for animals to fossil fuels for energy became more and more justified as energy conversion processes were improved and favored fossil fuels. Along routes where traffic warranted it, steam trains were run. (These evolved into subway/elevated systems, commuter railroads, or some combination of the two.) The superior technology for many surface streets next became the cable car, and cable car systems were installed in many cities (Hilton, 1982).

Systems were given charters (franchised) by the cities and policy treated safety, service, and prices. A flat fare policy was widely adopted, usually 5 cents. (The suburban railroads used distance-graded fares.) The 5-cent fare was not a burden in the early years when traffic was increasing and economies of scale were achieved. It became a burden as inflation (especially at about the time of World War I) decreased buying power and the transit worker unions demanded higher wages and better working conditions.

Electrification

> *After being tried for eighteen months a street railroad in Richmond, Va., which has been operated by electricity has been declared a failure, and the company will go back to horse or mule power.*
> —*The Railway Age* magazine (1889)

Electric railways (streetcars) were deployed rapidly between 1895 and 1915. As is true of many new developments, some false starts were made. However, once established, streetcars enjoyed a sharp cost advantage over precursor systems. Numbers we have seen suggest that the cable car gave a cost saving over horse cars of about 20 percent. At first, cost savings were not so marked for streetcars because of the voltage drops on early DC streetcar lines. It was not until AC electric power was more widely distributed that converters could be used to supply DC to outlying lines. Car size and service frequency adjusted to markets, and streetcars quickly won over cable car markets, except in very hilly terrain. Cable car mileage peaked in 1893. The cost comparisons tell only part of the story because electric cars were larger than precursor vehicles, and they offered service advantages such as higher speeds.[6]

These electric railways (and steam trains where they had been deployed previously) had considerable impact on the forms of cities. Suburban development increased and downtowns could draw on larger areas for labor and sales and service activities. In short, the centralizing/decentralizing forces that we usually associate with the automobile were quite strong before the automobile entered the city.

Streetcar service was highly desired. Cities were quick to issue franchises. There was overbuilding of lines, and some lines were not well connected to others. The opportunity, need, and ability to consolidate rail properties seem to have varied greatly from city to city. In Los Angeles some thirteen systems became the Los Angeles Railway Corporation. By 1890 there were four properties. Consolidation was complete by the time automobiles began to appear in numbers, from 1910 onward.

At about the time rail transit services became available, cities were growing very rapidly; the highest growth rates for cities occurred at the turn of the twentieth century. Making land available for many types of development, the transit services had massive off-system effects. The physical realizations of the impacts included streetcar suburbs and the decentralization of shopping from the central business district (CBD) to outlying retail centers.

The systems suffered from the ills we identified for the railroads (rail-itis). The problem of the 5-cent fare has been mentioned. Route and service rationalization was needed due to duplicating properties. Desirable network connections were needed because lack of physical connections and/or transfer rights thwarted end-to-end services. Congestion occurred during rush hours, yet low demand characterized some routes and times of the day. Importantly, the systems had lost much public support. In the late nineteenth century, transit was regarded as highly desirable from a social point of view. Transit-based developments reduced residential crowding and made job sites available. Yet by 1920, systems were regarded as poorly managed "rip-offs" (Barrett, 1983).

Problems became acute by the 1910s and 1920s when the car and truck began to provide competitive services and other factors affected the transit market. The truck eased the logistics problems of stores in decentralized locations that reduced CBD shopping activities. With auto mobility, such activities no longer needed to be on transit lines. The truck also enabled the decentralization of many kinds of manufacturing, especially the activities that had previously found their most desirable locations near the downtown rail freight yards and where labor could travel to work using CBD-oriented transit. With activities at decentralized locations, the automobile offered an option for the journey to work.

The adoption of electric motors and other factors began to favor single-store manufacturing establishments. Land requirements influenced the building of new plants on the outskirts of cities.

Actually, the early impact of the auto on transit was modest. At first, the automobile was used for recreation travel and was considered a rich man's toy. Only later did it begin to be used for the journey to work and for shopping as the sites of those activities began to shift. The competitive impact of the automobile differed depending on city morphology and type of transit. Today, for example, the CBD of Chicago continues to be served by transit in its historical forms (which Charles Yerkes [see profile below] helped establish)—commuter rail, subway/elevated, and bus (which substituted for the streetcar).

Other factors affecting the demand for transit included growth in real incomes and the shortening of the working week from six to five days. As a result of the factors at play, transit demand, which had been roughly evenly distributed seven days of the week, was reduced on Saturdays and Sundays. The morning and evening peaks of traffic became relatively steeper as off-peak CBD shopping and travel for warehousing and manufacturing work in the vicinity of the CBD decreased. Figure 11.2 shows loss of market shares.

All of these developments required planning. Most were like project planning in style and scope, and their first client was the city government because franchises were needed before work could go forward. The topic of how the system was to be operated (fares, schedules) was treated because it was of great interest to governments. Consolidation planning (or rationalization) had a different style. It extended to the best ways to combine properties and the appropriate treatment of stakeholders in the properties. These plans were developed by (relatively) famous consultants from out of town, and were usually sponsored by city governments.

Profile: Charles Yerkes

Charles Yerkes, a Philadelphia bond salesman, was perhaps the leading entrepreneur of the rail transit era. He moved to Chicago in 1881, and earned a shady reputation due to some poor economic transactions associated with the Chicago Fire. Nevertheless, Yerkes

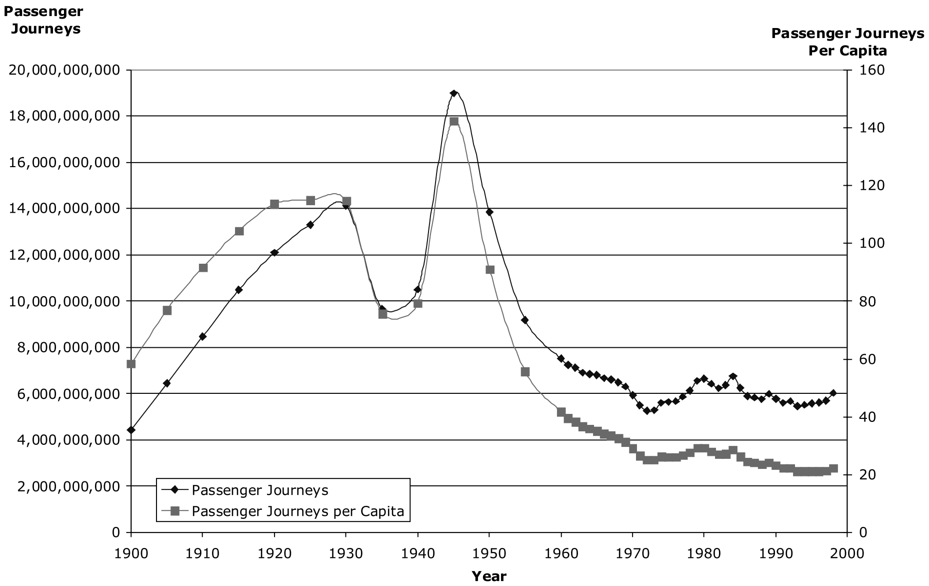


Figure 11.2. United States transit ridership trends. (Source: Public Purpose, 2000.)

was able to buy respectability, which was for sale in the Chicago of the 1890s, and was able to acquire most of Chicago's public transit system through bribery of pubic officials. Eventually he was driven out of town when the political winds changed and he was unable to obtain a fare increase (provoking riots in the attempt), and wound up in London, where he helped consolidate that city's Underground. Yerkes' life was fictionalized as the character Frank Cowperwood by novelist Theodore Dreiser in three novels *The Financier*, *The Titan*, and *The Stoic*.

Deterioration

Subway and elevated transit, streetcars, passenger railroad service, and ferry service were deployed in large cities prior to the coming of the automobile, and by the late 1920s the widespread use of the automobile in urban areas either brought the growth of ridership to an abrupt halt or turned it downward. Streetcar service was impacted the hardest. Views of the problem had several ingredients (Jones, 1985). One was that suburban areas not served by transit required transit expansion. Otherwise, market shares could not be maintained.

Another view said that the automobile was a superior vehicle, so transit vehicles of higher quality were needed. There were two responses to these views. One response was to deploy the bus. It could serve newly developing residential areas and serve as an economical substitute for streetcars on thinly traveled lines. Transit operators liked the bus because a one-man crew could be used, the bus was somewhat more maneuverable than the streetcar in traffic, and interruptions of power, fires on streets, and so on could be avoided. Additionally, many cities required that streetcar operators maintain the roadway occupied by streetcars, an expensive endeavor and one disliked by transit operators because those facilities were used by automobiles.

The other response was to develop a superior technology. The Presidents' Conference Committee (PCC) streetcar resulted. The story of the PCC car is an interesting one. The Electric Railway Presidents' Conference Committee (PCC) was made up of the presidents of the large transit properties. It examined the situation and published reports and recommendations, most of which were ignored. Many of the ideas developed are topical today, for example, the idea of having downtown activities (land owners) subsidize CBD transit services. It was claimed that transit service resulted in a socially desirable urban form.

The PCC undertook the design of a modern electric streetcar (the PCC car), which was built in small numbers just before World War II and greater numbers just afterwards. Several car builders were involved, and overseas builders were licensed to use the technology.[7] European designs now being deployed in the United States as light rail ventures are second-generation PCC cars (Carlson and Schneider, 1980). The PCC car was much improved over previous cars—better acceleration, quieter, better ventilated, better seats, stronger, and so on. Yet it could not undo the reshaping of demand and competition from the automobile.

The third perception of the transit problem can be summarized as "rationalization." In many cities there were several properties operating competing services and services were often not coordinated. Because the transit properties operated on franchises, matters of fares and service had often been politicized. Many properties were operated by electric utilities. Tackling these problems was the third challenge to transit planning. The rationalization issue was not new, of course, for consolidation of properties had been undertaken previously.

The transit properties were mainly private properties, so often planning studies were undertaken by the property owners. But in many cases problems were so blatant that municipalities sponsored studies. Also, the franchise, fare, and service leverage exercised by cities on the properties gave them a considerable involvement in problem solving. Many studies were made in the "great men" style during the 1920s and 1930s. One actor was Henry M. Brinkerhoff, who worked as an engineering manager in the transit industry in Chicago. During the 1910s, he was Chief Engineer of the Chicago Subway Commission and he developed Chicago's consolidation plan. He subsequently worked in Detroit, Cleveland, Philadelphia, and a number of other cities.[8]

Considerations of a more policy planning-strategic sort were treated by the American Electric Railway Association. Its publication, *The Urban Transportation Problem* (1933), reads very much like today's problem discussions. For instance, special assessment districts in downtowns were proposed for transit funding.

Using as the criterion for success whether the plans accomplished what they set out to do, transit planning worked pretty well. Buses replaced streetcars and offered service in suburban areas; the PCC car was quite a remarkable advance over previous technology. Rationalization was not as successful. In many places properties were not consolidated, and everywhere little progress was made on adjusting fares and service.

The transit context was the problem. The properties were either losing market share (subways and elevated lines) or losing in an absolute fashion (bus, streetcar). The problem was to manage stasis or graceful decline, and we have four observations on that problem.

First, we may observe that changes pose no special problems for individuals and institutions if the physical and psychological magnitudes of those changes are slight. An example is the switch from the horse-drawn tramcar to the cable car, which involved a familiar technology and not much new knowledge. It did require some change in behavior on the part of institutions as the use of horses was phased out and new investments made and as new kinds of people were brought on board to operate the cable works. The change from the electric streetcar to the bus was also manageable. However, suppose physical and psychological magnitudes are great. Consider the shift from the steam locomotive to the diesel. Traditional locomotive manufacturers had almost none of the relevant knowledge, and it was unthinkable that something so different could replace the iron horse that built the railroads. Those manufacturers are no longer in business.

The next three observations are also well known. We will follow Simon's (1959) wording of them:

- When an institution is not performing as well as it aspires to perform, search behavior is induced.
- The institution's level of aspiration drifts downward until it matches obtainable performance.
- But there is a catch. The level of aspiration may be so locked-in by peer group values and traditions that it does not drift down easily. Search behavior may be fruitless or only marginally rewarding. The mechanisms causing performance to fall short of aspirations may continue in place, and declining aspirations chase ever-declining performance possibilities. (So there may be a fast variable, slow variable situation where things get out of synchronization.)

If the latter situation holds, then the possibility of catastrophe looms. In the private sector this may mean bankruptcy, depending upon the structure of competition. In any circumstance, one observes rational adaptive behavior being pushed aside by apathy and/or aggression.

The transit industry seems to have maintained its cool. It searched for new options (e.g., bus, PCC car), lowered its aspirations, and acted in a rational fashion. Today, however, it has the problem that concerned publics have high aspirations for it—saving the city and eliminating congestion, among others. But those aspirations have not permeated the industry very deeply.

Motorization

One by one the properties began to substitute electric or motorbuses for streetcars and interurban services gave way to bus services. Public policy actions enabled and often encouraged the shift from streetcars to buses.[9] Policy allowed for some rationalization of properties and services, as well as fare adjustments. The industry muddled through the Great Depression. World War II saw great increases in ridership as employment increased and automobile production and use was discouraged. Many properties were flush with cash at the end of the war.

But it was not long after the war until trends dating from the 1920s again took hold. The fiscal problems of private operators called out for public actions in the larger older cities where the loss of transit services could not be tolerated (San Francisco, Chicago, New Orleans, New York, Philadelphia, Pittsburgh, etc.) and the cities began to take over services. The acuteness of problems, steps taken, and success in managing problems varied by venue. Seattle and San Francisco took over private services early on; some cities took over step by step. Chicago, for example, took over subway/elevated services first and bus and streetcar services later.

In general, the cities undertook modest downsizing, fare rationalization, and other efforts to improve the matching of services to markets. They did not experiment with deregulation in a full sense. However, in the 1950s and 1960s quite a few services in the metropolitan areas continued to be privately operated, typically providing small market niche services.

Several key points can be drawn from our history that relate back to the conspiracy. First, while General Motors' National City Lines was a private venture that converted streetcars to buses, a number of other cities, in which National City Lines was not a player, did so as well. Some of these cities made conversions while the city government controlled the routes, others while they were in private hands. These other (non-NCL) cities did not always make quite as extensive a conversion, but they did a conversion nonetheless. (Evidence for this includes locales beyond the United States, for instance London, which phased out electric streetcar and trolleybus lines for the ubiquitous double-decker motorbuses that are world famous.)

Second, the PCC car was promoted by private companies as well; General Electric, Westinghouse, and St. Louis Car were not nonentities in the business. If there was a good business to be made in selling modern streetcars, there were capitalists willing to give it a go.

Third, the NCL organization was profitable for many years. General Motors entered the business to make money by selling buses, not to destroy transit to increase auto sales, which were on an independent trajectory and did not need the assistance. While the business may not have been GM's most profitable, it was just an element of a large firm that diversified to spread risk and invest profits. Other GM subsidiaries at various times included appliances (Frigidaire) as well as bus, taxi, and rental car companies. The literature in the 1930s often refers to the saturation of the automobile market. Then as now, there was interest in the industry in growing through diversification.

Fourth, buses were at the time seen as the "new and improved" version of transit. Rational transportation planners comparing bus and streetcars would point to their flexibility, their ability to ride free on roads provided for other reasons (no maintenance of track or overhead electrical was necessary), the smoother ride, the ability to follow demand to the suburbs at relatively low cost, and so on.

At worst, the NCL conspiracy accelerated a trend already in place. We judge that the matter was not a big thing in the decline of transit. The market was the strong force at work. NCL may have yielded minor returns to the GM bus business, but as a diversification step it was not a very good idea. For another case that clearly did involve conspiracy, see box 11.1.

Federalization

The spread of slums in the inner cities of metropolitan areas, the relative decline of CBDs, and the relative or absolute loss of central city population, together with the

BOX 11.1 Twin Cities Transit

While there is clearly some dispute as to the importance of a national conspiracy in the shift from streetcars to transit, one should not dismiss the existence of criminals in the streetcar companies of the era (as in the rail era before them). A marked example is in the Twin Cities of Minneapolis and St. Paul, Minnesota. The streetcar lines in the Twin Cities were built by Tom Lowry in the nineteenth and early twentieth centuries, and like many cities were aimed in large part at land development. For the period between 1925 and 1948, fares held steady at 10 cents, leading to capital shortfalls. The Twin Cities lines were publicly traded and most shareholders were nonlocal. The conversion from streetcars to buses took place after a series of events helped drain the company of even more resources. In 1949, Charles Green undertook a hostile takeover. He asked for a fare hike, fired 25 percent of the workforce, and canceled capital investment. He was employing a traditional "cash cow" model, wherein new owners milked the system of resources to pay for its own takeover. A strange turn took place when Isadore Blumenfield, a.k.a. Kid Cann (a *rumored* gangster and murderer), and Fred Osanna (a *known* lawyer) tried to take the system from Green. The State Railway Commission made an investigation of bribery, embezzlement, kickbacks, and death threats. Osanna and company did successfully take over the Twin Cities Rapid Transit in 1951, and sold off the streetcars. It is reported that the vehicles are still running in New Jersey and in Mexico City, though while the shells may still operate, whether the mechanics in the vehicles do is unclear. Osanna claimed "the fastest and most massive streetcar-to-bus conversion ever undertaken in any major U.S. city." However, Osanna wound up in jail for fraud. The system was subsequently sold to Carl Pohlad (later owner of the Minnesota Twins), and was eventually sold to the public Metropolitan Transit Commission in 1970 for $7.9 million.

many social problems of the older low-income parts of central cities, focused national attention on urban problems. The federal government was asked to come to the rescue of the cities. It did so with a variety of crime prevention, health, welfare, physical redevelopment, and other programs. Included was action to aid transit—the creation of the Urban Mass Transit Administration (UMTA) in 1964.

The creation of the Urban Mass Transit Administration (now the Federal Transit Administration) and the working out of its relations involved a diverse group of interested parties outside government. Large rail operators in old cities, commuter bus and rail, the downtown business interest groups, and auto opponents all had their own interests. At the time there was no single voice for the operators, who were split between rail and bus. The National Conference of Mayors served the urban development downtown business interests. A crisis was sensed, but the crisis had many interpretations. Finally, there was no clear model or set of existing suitable institutions. The closest model was the Department of Housing and Urban Development's (HUD) programs. HUD knew how to work with the cities, and it had subsidy programs. It was chosen as the first home for UMTA, with a study of the advantages of remaining in HUD versus moving to the DOT to be made. The first home seemed to satisfy the urban development interests that had worked with HUD. However, at the end of the first year UMTA moved to the DOT. In the absence of a close model, there was the problem of figuring out a government role satisfactory to diverse parties. Charles Haar, a member of the Harvard Law School Faculty and the first UMTA Administrator, worked hard to establish an urban development role. Even so, the mood that prevailed was that better management and technology were needed, and that helped pull UMTA into the DOT sphere. (At the time, DOT was striving to play a major role in research and technology development, fallout from the "If we can put a man on the moon, why can't we . . ." thinking.) UMTA learned to work with the states and the cities, the American Public Transit Association (APTA) has emerged as a force in the industry, and it has learned how to work with other groups, such as the American Bus Association.

A national need for UMTA is arguable, but it is seldom challenged. Changed programs in HUD seem to have provided models for change in UMTA. For instance, change, such as that driven by emulation of the private sector in program activities, seems to be in the HUD model. The Americans Disabled for Accessible Public Transportation (ADAPT) fought for wheelchair lifts on all buses (see also box 26.4 for some consideration of the problem). UMTA accepted that in Section 405 of its regulations. APTA was forced into the role of protecting the capital-short operators who cannot afford lifts. APTA's interesting defense was that this is a local matter—the properties ought to figure out the mix of bus and special van services. That is interesting, because it departs from the "all issues are national" stance of APTA.

A good deal of what UMTA was to do was established in its organic legislation; bureaucrats worked out the rest. Steps taken early on had lasting impact.[10] Most of those steps were mandated by one or more of the interest groups that supported the creation of UMTA. We now list some decisions taken early on:

1. Students of urban affairs and government administrators had the notion that transit management was "up through the ranks" and unskilled—trained managers with business school backgrounds were needed. As a result, UMTA and local agencies did not take advantage of employees with a lot of experience and who knew what did and didn't work. "Political hacks" were also rampant in the industry.[11] This perceived need to turn over management resulted in lots of "know nothing" managers, especially at UMTA,[12] and political appointments at local levels.
2. The renewal of capital was urgent. Some thought that a one-shot renewal might be enough. Others had the notion that technological improvements were needed. Interest groups composed of traditional suppliers, aerospace, and engineering and contracting firms pressed this view, garnering public support. The Disneyland monorail was new, and that was the model in many minds.

   The capital grants program resulted. Another result was a round of new systems studies and the encouragement of defense contractors. This emphasis, together with the hoops one has to jump through in government procurement, put the traditional suppliers out of business, suppliers such as St. Louis Car and Pullman. Later, the aerospace industry found it couldn't make money. Lacking technology management capability, UMTA engaged in some disasters—its bus development program was an example.
3. People who wanted to manage the urban problem in a holistic way and those who wanted independent programs for UMTA were engaged in a behind-the-scenes tug of war. Do we combine transit with health, housing, education, and other urban social programs? UMTA kept its distance from those programs, and the void created was filled mainly by the then Department of Health, Education, and Welfare. School bus programs operated by local governments continued, of course. This debate continues today, pressed by those who want to coordinate public agency decision making about land use and transportation services.

4. Next was the question of the geographical organization of UMTA programs. Political realities said these could not just be big city programs.[13] When UMTA was created there were many central city transit agencies, both public and private service providers in the suburbs, and also a mixture of service providers in small towns and rural areas. How could UMTA interrelate with so many entities? How would it work with state and metropolitan area organizations? How would transit facility investments fit into transportation planning activities? By and large, UMTA was careful to fit in with existing arrangements, support both large city and other constituents, and go along with a large amount of congressional earmarking of expenditures and pressure for the expenditure of so-called discretionary grant funds.

   UMTA did adopt the public administration dogma that single public agency organizations were best for urban areas (they avoid duplication and obtain economies of scale), but that is very questionable.
5. Another question to be settled was that of the size of UMTA and whether it should be restricted to equipment-facility programs. Giving way to political pressure, subsidies have been made available for operations. The size issue remains a matter of debate, although transit has access to highway trust funds thereby partially relieving the funding constraint on program size.

Situation

Working out the matters just discussed partly describes the situation today; most of those matters are not completely resolved, of course. Conservative members of the national government question the federal role in transit, but we do not see that as much of a threat to the program, partly because conservative downtown property owners are supportive of transit.

As is well known, today there are subsidies covering fixed and much of the operating costs of transit. They run to about $70 per capita per year and are increasing. Although many who do not have automobiles available and/or lack the means to purchase and use private transportation are transit users, overall there is an income transfer to the wealthy—especially commuters. Box 11.2 illustrates the issues by investigating the San Francisco Bay Area Rapid Transport system.

BOX 11.2 San Francisco's BART

The Bay Area Rapid Transit District (BART) subway-elevated/commuter train system began providing service on September 11, 1972, and it is a Bay Area icon; although there is no place to take such a picture, one imagines sleek trains with the Golden Gate Bridge and palm trees in the background. Sponsored by central city politicians, property owners, and newspapers, it was the first new transit system in the United States after World War II. BART, and to a lesser extent the Washington Metro and Atlanta MARTA systems, served as a model for the wave of rail transit improvement projects promoted in subsequent decades, and that is why we emphasize it. Also, it illustrates that the gap between hype and reality can be great but invisible to publics and policy makers.

BOX 11.2 San Francisco's BART—cont'd

Centered on Oakland, BART service fans out westward under the Bay through San Francisco to its airport, north and south along the East Bay, and to suburbs to the northeast and southeast of Oakland. It is rather a skeletal mainline system, more so as extensions have been added over the years. It is essentially a commuter railroad serving San Francisco, Oakland, and other older centers of employment in the region. In a metropolitan area of about 6.8 million people, it serves about 300,000 one-way riders per day (about 150,000 people). BART actual weekday ridership in the 4th quarter of FY2003 was 291,011, http://www.bart.gov/about/reports/indicators.asp (accessed September 16, 2003), Since riders are one-way, and most people make round trips, the number of people served is about half the number of riders. Thus, in a region with about 20,213,000 total trips (MTC, 2003), about 1.4 percent of weekday trips are by BART. BART serves only a small fraction of transit trips in the Bay Area, which is about 1.1 million.

Initial investment capital was backed by imposts on property in three Bay Area counties, and funds for the completion of the system and for extensions have come mainly from the federal government. The operating budget is about $430 million per year; it is partially covered by fares. Capital costs are never mentioned except when extensions are considered.

As stated, BART is an icon. There is never a critical word in the newspapers, citizens assume that the service is essential, and although they are more than illusive to analysts, BART is assumed to have had great positive impacts on community and regional development. Ignoring the probability that, if desired, private sector investors and consumers would have long ago energized developments at BART stations, concentrated development near BART stations is high on Bay Area planners' wish lists. Moreover, there is clamor for extensions to swing BART through San Jose and complete connections around the South Bay.

Costs of BART

In today's contentious world, anyone questioning transit costs is taken to be ignorant and pro-automobile. Even so, let us do a bit of math on costs anyway. It will give a feel for magnitudes.

A recent article in a local large circulation monthly says that the BART extension to Pittsburg/Bay Point to the northeast of Oakland cost $505 million (Yamamoto, 2003), and it serves about 3,000 round trip riders daily. We do not know how many, but certainly many of these patrons are regular commuters to centers of employment.

Dividing capital cost by the number of riders says that about $170,000 has been invested per rider; considering interest in order to calculate annual cost, there is a capital subsidy of about $17,000 per rider per year. It is left as an exercise for the reader to compute the daily subsidy per one-way trip per rider. Moreover, there is an operating subsidy applying to each rider, so the total subsidy is somewhat higher. Numbers in this range apply to many transit investments, especially rail investments.

The $505 million divided by the 6.8 million people in the Bay Area works out to about $74 per person in the Bay Area, but that is ignored because much of the money went to Washington and came back as free money. An irony is that the Yamamoto article highlighted BART Board Director Roy Nakadegawa, who is a transit supporter but questions the wisdom of BART expansion. If no one pays attention to him, what is the use of our math?

Ridership has declined to the point where about 2 percent of all trips are by bus and streetcar and about 0.3 percent by rail. Thirty-five percent of all transit trips are in New York City and over one-half are in New York, Philadelphia, Boston, and Chicago. Cities are planning new systems or expansions of old ones, and vast funds will be required for these. The experience in rail transit projects says that projects will come in over budget and will not meet ridership projections (see table 11.1 from a study by Don Pickrell). Observing that subsidies are highly concentrated, ridership is limited, and new facilities very expensive, one pundit commenting on the Los Angeles subway observed, "Never will so many have paid so much for so few."

Incomprehension

It seems clear that we need to preserve and improve services in urban environments such as those found in San Francisco and other old, densely populated cities. Citizens who do not have access to private automobiles need services. But nowhere is it carved in granite that the federal government was the way to achieve these goals and that its programs should be continued. One might say that federal transit programs are a success because transit service has been preserved, but might there have been other, better ways to do that? Might downsizing and market specialization as illustrated by the U.S. freight railroad industry have served better?

Applying Occam's Razor

The observation that government steps in and does what systems cannot do for themselves is perhaps the simplest explanation for the situation in mass transit. The observation applies worldwide. Straitjacketed by high fixed costs, militant labor organizations, and regulatory constraints, by the 1920s systems were having difficulty adjusting to changes in competition and markets. So local and/or national governments began to acquire ownership to maintain the status quo.

In the United States, local actions gave way to federal. This follows from the federal taste for large programs acquired when water resource, agricultural, and defense programs increased in the 1930s and 1940s. With its monetary resources and the tilt to urban-based power in the Congress, urban programs followed. With clamor from large city business, political, and transit labor interests, transit was there for the taking. Along with urban freeways and airports, it became one of several national programs leading to megaprojects. Altshuler and Luberoff's (2003) analyses of such projects include reasoning about federal involvement similar to ours (pp. 249–251).

So far, William of Occam's Razor, "One should not increase, beyond what is necessary, the number of entities required to explain anything," holds very well.

It is also easy to provide explanations for distorted project costs and ridership projections, the sometimes venomous antiautomobile, transit-first clamor, the willingness to use urban planning to (try to) control urban travel, and the use of "ends justify means" lines of pro-transit reasoning and analysis. (It might be worth noting that highway builder Robert Moses once said "If the ends don't justify the means, what does?") People value the status quo. Explanations that involve human avarice and efforts to impose planners' values on others are supplementary.

Table 11.1 Forecast and Actual Cost per Passenger for Recent Rail Transit

	Heavy rail transit projects			
	Washington	*Atlanta*	*Baltimore*	*Miami*
Weekday Rail Passengers (thousands)				
Forecast	569.9	NF	103	239.9
Actual	411.6	184.5	42.6	35.4
% difference	–28%	—	–59%	–85%
Rail Project Capital Cost (millions of 1988 dollars)				
Forecast	4,352	1,723	804	1,008
Actual	7,968	2,270	1,289	1,341
% difference	83%	58%	60%	33%
Annual Rail Operation Expense (millions of 1988 dollars)				
Forecast	66.3	13.2	NF	26.5
Actual	199.9	40.3	21.7	37.5
% difference	202%	205%	—	42%
Total Cost per Rail Passenger (1988 dollars)				
Forecast	3.04	NF	NF	1.73
Actual	8.75	5.93	12.92	16.77
% difference	188%	—	—	872%

	Light rail				Downtown people mover	
	Buffalo	*Pittsburgh*	*Portland*	*Sacramento*	*Miami*	*Detroit*
Weekday Rail Passengers (thousands)						
Forecast	92	90.5	42.5	50	41	67.7
Actual	29.2	30.6	19.7	14.4	10.8	11.3
% difference	–68%	–66%	–54%	–71%	–74%	–83%
Rail Project Capital Cost (millions of 1988 dollars)						
Forecast	487	699	172	165	84	144
Actual	722	622	266	188	175	215
% difference	51%	–11%	55%	13%	106%	50%
Annual Rail Operation Expense (millions of 1988 dollars)						
Forecast	10.4	NF	3.8	7.7	2.5	7.4
Actual	11.6	8.1	5.8	6.9	4.6	10.9
% difference	12%	—	45%	–10%	84%	47%
Total Cost per Rail Passenger (1988 dollars)						
Forecast	2.15	NF	1.68	1.53	0.9	1.14
Actual	10.57	7.94	5.19	6.53	7.11	10.21
% difference	392%	—	209%	328%	693%	795%

Source: Pickrell (1992).

Cognition

How did we get into this situation? We are there because of lack of *cognition*. One meets with policy makers, and discusses modal costs and services.[14] It is stressed that fixed rail, people movers, and monorail are off the chart when cost effectiveness is considered. Alternatives such as improved bus services, or even buying used vehicles or paying for taxis for those who can't drive, is now seldom considered. Real improvements, those that make a factor of two or better changes, should be tried.

But policy makers pay no attention to such suggestions. They have already decided that autos and buses are nonfeasible solutions to problems. Rail is the only answer. Exactly what the problem is not always clear. In cases with which the authors are familiar (Denver, Minneapolis, Chicago), CBD access was the main issue. In other cases, congestion generally and air pollution have been at issue. There also seems to be the feeling that modern cities have streetcars; what else is there to discuss, especially since the feds will pay much of the bill? Expressions like "Minneapolis–St. Paul is the largest city in North America without rail transit" have been bandied about, illustrating the competitiveness question; to be a world class city one must have a new rail system, a new baseball stadium, a new football stadium, a new basketball arena, a new hockey arena, a beltway with three lanes (Minneapolis–St. Paul is apparently also the largest city in North America with a two-lane beltway), a convention center, a festival marketplace, and so on (and in Minneapolis–St. Paul, if Minneapolis has it, then St. Paul needs it as well). Transit is just one more instance of feature-itis.

We judge that policy makers, newspapers, and others see transit as the only solution, and rail transit as the superior choice. We think that is because they can't imagine seeking new solutions.[15]

Assumption

The conspiracy is clearly the most popular view of why transit failed. Milder "devil" theories have to do with tax subsidy for suburban family homes and subsidies for the automobile. Sometimes it is said that mortgage insurance offered by the federal government influenced development, but such insurance was available for many kinds of residential development. One gets the impression that somehow the devil made otherwise good people make bad decisions about auto ownership and suburban development.[16] Devil theories go a little way but end up as not very consequential. Angel theories give the same impression.

We have already mentioned some angel theories: We would be in heaven if smarter, better trained managers were hired, if new equipment was purchased, if new systems were developed, and so on.

A couple of cost-related angel theories are that transit is inherently less expensive than the auto alternative. Intuitive clarity takes over—moving a bunch of people in a vehicle is relatively inexpensive. That extends to the notion that the higher the capacity, the lower the cost; for example, BART-like heavy rail systems are lower cost than light rail, and light rail is lower cost than bus.

It is easy to demonstrate that this is not the case. The best-known work was done by T. E. Keeler in the early 1970s and published by M. Webber (1976) in *Public Interest*.[17] Figure 11.3, adapted from that publication, compares automobiles, bus, and BART. It needs to be remarked that this service niche is favorable to the bus. Bus service in thin,

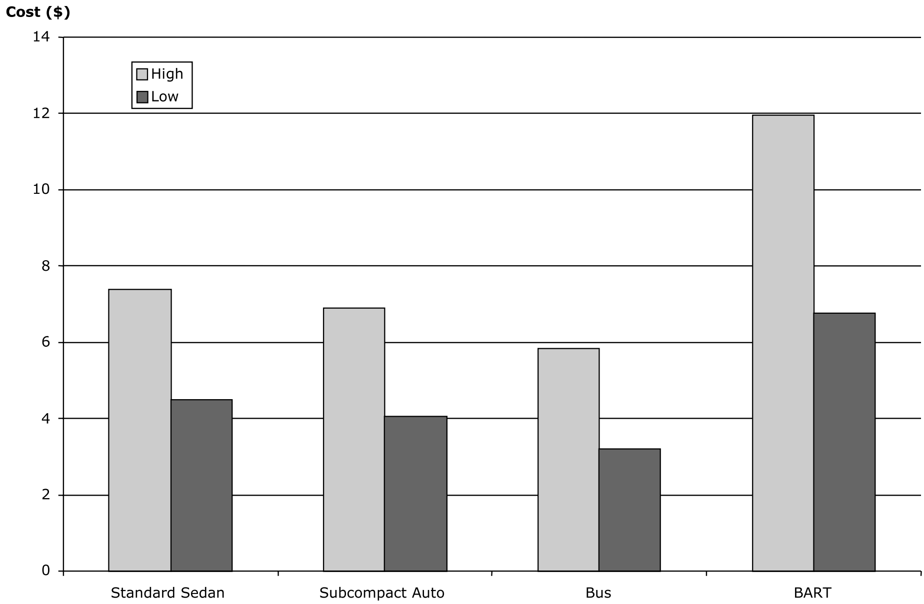


Figure 11.3. Cost of a Transbay trip on BART. Note: Bus and auto; 8,000 trips per hour. October 1975; peak hour trip from Orinda to Montgomery Street. High estimates based on reasonable assumptions, but less favorable to BART. Low estimates expected to be most favorable to BART. (Source: Webber, 1976.)

collector-distributor markets is quite costly. This mythology is important for present transit advocates, because if the devil, rather than economic forces, caused transit to disappear, the good angels can bring it back. It is the comparison that is important—rail is expensive compared to the bus. Costs would be much higher if services were provided in thin markets and the situation much more favorable to the bus.

Another angel theory is that of avoided cost—providing transit is much less expensive than providing for increased automobile use. That is a very situation-specific assertion, and work that we have seen says that it does not hold very widely. At any rate, it makes assumptions about market growth and about unchanging spatial patterns of demand that are not very tenable.

Somehow we went from this assertion to the conclusion that we ought to be concerned only with transit operating costs (fixed costs are of no concern because we would have had to spend at least that amount of money on auto facilities). This kind of thinking leads to the conclusion that BART is more efficient than bus because the fare box covers more of its operating costs and in general the nonsense that high fixed cost, low variable cost systems are always superior. Amtrak has taken such thinking one step further. At one time it treated its subsidy as income on its books, and claimed to make a profit.

The notion arises that highly desirable (angelic) urban lifestyles and urban forms will be achieved by transit development. Because of market segmentation, at some level the notion has to be true, and the issue becomes "For how many?" If there were lots of people that find that to be true, then ridership growth would reflect it. Alternatively, changes in urban land uses and urban form would reflect it.

Urban transit was pretty well deployed by the 1920s, and subsequent further deployment has had marginal impact on urban land uses. Edwin Spengler noted as early as 1930 that when transit services were provided, areas that were declining continued to decline; where there was little change, little change continued, and growing areas continued to grow.

Even so, transit's favorable impact on urban development is the Holy Grail of transit advocates, and they continue to look for it. Federal transit agencies funded study after study, and the Transit Cooperative Research Program (TCRP) has begun work in the area, so far to no avail.

A variety of views exist. Some hold that transit and walking neighborhoods might be created with desirable social values. Demand is diverse, so there is certainly a market for such neighborhood developments. Issues are those of the size of the market and why private decision making has not cleared such markets. If there is a market and there is some dysfunction constraining it, there might be room for policy actions.

At a much broader view, there are those who advocate return to transit-like cities in order to improve the quality of life and, in particular, deal with energy use and sustainability problems. Newman and Kenworthy (1989) have pointed out that dense, transit-dependent cities use less gasoline than "auto cities." The Newman–Kenworthy policy of returning to transit-served cities has intuitive clarity to many, but it is not sensible.

Why? As discussed, transit served the city of the year 1900 very well. Subsequent development of economic and social activities saw cities taking on more of an "auto" structure. The Newman–Kenworthy policy is much more than just a matter of substituting one mode for another; it has to do with reversing social and economic trends. They are tilting at windmills, trying to put Humpty Dumpty back together again. History does not repeat itself.

This listing and debating of angel theories could go on and on. Important items to be included are reduced negative externalities (compared to autos), reduced space utilization, favorable social impacts of an "enabling the transportation disadvantaged to enter into societal activities" type, and expanding the energy efficiency discussion.

Discussion

Mass (or public) transit receives much attention from political actors and the press, and many professionals think transit is where the action is and will be so in the future. This chapter traced the history of transit and transit usage, and discussed the recent and current issues facing transit. While in a later chapter we cite a book on the "Rise and Rise of the Automobile," we might call this the "Decline and Fall of Transit."

The argument of the devil versus the angels is very much one of style versus substance. By demonizing their opponents, angelic transit supporters aim to seize the moral high ground. Yet their arguments and facts are as mythic as their styles. This raises an important issue about the ethics of advocacy planning. If the supporters of the conspiracy know that the conspiracy is not really to blame for the loss of the streetcar (and we would venture that some of them do), then they as planners are behaving unethically in using that story as the cornerstone in their arguments for new rail transit investment.

Simplifying the broad sweep of history, we imagine for passenger transportation a walking (and draft animal) society, a transit (and electric interurban and intercity passenger train) society, and the auto society. Walking gave way to transit, and transit gave way to the auto. In each case the transition was not graceful. It was costly to fixed investments and to those for whom lifestyle changes were not easy or desirable. "Gave way" was destructive of desirable aspects of life such as the activities best served by walking and transit.

With this preamble, we may state that the transit and walking problems are a failure of automobilization. The automobile system innovation failed to the extent that it could not fully replace transit or walking. The response to the transit (and walking) problem is apparent: tweak the automobile highway system so that it can effectively substitute for transit and walking.

One option is the devolution of federal activity in the transit area. The reasoning behind one objection to devolution runs this way. Healthy cities are in the national interest. Therefore, a federal role for transit is in the federal interest. That claims too much, and it ignores the question of whether the federal government has or could create an effective role. Another objection is on equity grounds. Some cities are not as wealthy as others and it is only fair to send money from here to there. However, in conflicts between the central city and its suburbs, state governments can and do deal with such issues.

Overall, we see transit as a niche market business, one that should be more focused on serving those without choices (the transportation disadvantaged such as the poor, elderly, disabled, and children) rather than providing additional, and largely worse choices to those who already have options (the car). Policy ought to treat it that way. It should recognize that in spite of enormous expenditures, the transit market is not expanding. Niche markets offer appropriate environments for innovation and system improvements where lessons from other modes, especially the railroad, might apply.

12

Turnpikes

The Long Island Motor Parkway will supply an uninterrupted route across the Island that, owing to its proximity to the metropolis, is destined to be the home of millions with business and social interests in New York City. Someday the state will supply such motorways.
—*Automobile* magazine (1908)

Introduction

To break the monopoly of the dominant Pennsylvania Railroad, the Vanderbilts, who owned what became the New York Central Railroad, initiated the South Pennsylvania Railroad from Harrisburg to Pittsburgh, Pennsylvania. (The New York Central already faced competition from the Erie and related railroads.) Construction began on tunnels in 1884 and continued through 1885. However, while competition may be good for consumers, it is anathema to capitalists. Financier J. P. Morgan won a seat on the New York City and Hudson River Railroad and gained sufficient control to force the Vanderbilts to sell the unfinished line to the Pennsylvania Railroad. Although $10 million was spent and 26 workers died, "Vanderbilt's Folly" remained dormant for 50 years.

In 1935, the Pennsylvania legislature authorized a feasibility study of building a new toll highway using the old, unutilized South Pennsylvania Railroad right of way and tunnels (Cupper, 1990). Construction started in 1937, and the road opened in 1940. This was the first significant new turnpike for over 40 years, as the old turnpikes had reverted to free roads in the late nineteenth and early twentieth centuries. Moreover, it was the first of a new generation of limited access highways, generally called superhighways, that came to transform the American landscape.

Why was a model of road financing (the turnpike or toll road) that had been largely discarded half a century earlier revived? Or perhaps more to the point of this chapter, why was a model that had clearly once been successful (in the early nineteenth century), and again successful (in the 1940s and 1950s), largely discarded at the turn of the twentieth century?

This chapter ranges from Ancient Rome to the beginnings of the industrial and commercial revolutions, and we shall see the emergence of policies that continue today.

However, much of the road-building knowledge of the Romans was lost and had to be relearned. The rebirth of advanced road systems began in Western Europe as commercial activities began to expand during the Renaissance, and it is sufficient to our study to take these births as baselines. Transportation knowledge—how to build, control, and operate transportation—has accumulated from experience (see Lay, 1992, for a sweeping history of roads).

The discussion will put the English early parish and toll road systems in place. We want to know what services were in place at the beginning of the industrial revolution and, in particular, what polices had evolved that served as building blocks for modern transportation systems generally. Why England? Ultimately England was to lead the industrial revolution, though that was not obvious to an observer in the 1650s as the turnpike era began. Arguably the turnpikes enabled that revolution (Szostak, 1991). One could start this discussion by looking at France, the Low Countries, and North Italy. The precursor systems were developed earlier in those areas. Paris had grown to be the largest city in Europe, while France was politically integrated. Paris, the Italian cities, and Brussels were centers of European science and technology. Even so, we begin with England because its story seems more sweeping and consequential. Although London was a world city, England was on the undeveloped fringe of Europe.

This chapter asks what were the chief features of the baselines and then traces these through to the modern world. It follows the corvée experience in several countries. It then shows how experience has built on experience and how the trail of and accumulation of experience is used today. The trail is crystal clear.

Roman Roads

Despite evidence of roads elsewhere, we begin by touching on the development of Roman roads, a system built over a 500-year period, with mileage about the same as that of the U.S. Interstate Highway System. Except for bridges, Roman engineering seems not to have been emulated very much. Reverse engineering on the Roman roads tell us how they were built—they were stone structures made of polygon-shaped rock bound by mortar (see figure 12.1). The roads comprised long straight segments with stiffer grades than those allowed in later road building; curvature was avoided except where necessary (mountain passes, natural places to ford or bridge rivers). Comparisons of Roman road mileage between places and modern roads find that the Roman roads were shorter than modern roads.

It may have been that straight and sometimes steep roads allowed for rapid movement of marching troops. Wagons, which would have liked low grades, were not so common. Without front axles that turned, Roman wagons worked best on straight roads. The typical load seems not to have been more than 225 kg (500 lb). Some evidence exists that the right of anyone to use a road dates from Roman times, as does the idea of the common carrier. A good part of Roman design was symbolic—a strong, powerful artifact ignoring terrain and pushing straight ahead: Roman roads equal Roman power.

Roman roads accommodated carts, but by about 1600 the population, and military and church institutions, were mainly served by ways, trails, traces, or paths along which people could walk, ride on horses, or drive animals (Geoffrey Chaucer provided

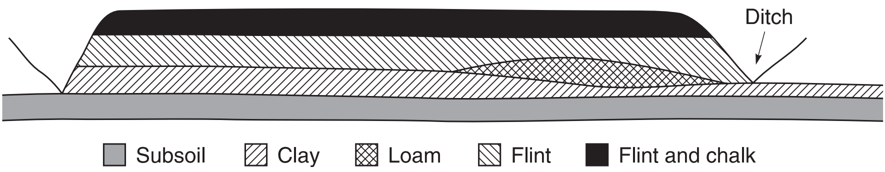


Figure 12.1. Construction of a Roman road. (Source: Margary, 1993.)

descriptions *ca*. 1380). Like the Roman roads, these routes had an "as the crow flies" character; they were paths and often had fairly steep grades, with route orientation tempered by the location of mountain passes and fords.

Renaissance Roads

Today's road system began to emerge with the growth of trade in the Mediterranean area and the spread of the commercial revolution to the remainder of Europe, North America, and the parts of other continents accessible by sea and with a basis for trade. The growth of wealth and communications created and expanded carriage traffic. Wagons began to be used to move commodities to growing cities and between ports and points of origin for the distribution of commodities, and there was a concomitant growth of institutions supporting all facets of trade.

We are also interested in the ways in which transportation developments led or followed other developments. One view is that the constraints on trade among the isolated feudal economies of Europe began to be destroyed in the eleventh century by the Crusades, which lasted into the beginning of the thirteenth century. A new trade-based empire centered on Venice began to emerge, soon followed by centers in favored crossroads—Brussels and the towns of the Hanseatic League; specialized manufacturing began to emerge in Flanders and Florence. These developments were well under way by the end of the thirteenth century. Over the next four hundred years there were dramatic increases in trade, specialized production, middle-class wealth, commercial towns, and so on.

This way of thinking says that the Crusades destroyed barriers, and opportunities for production and trade were grasped. Other ways of thinking emphasize the window to the knowledge of the East opened by the Crusades. The development of transportation means was not causal, for the means were there, just little developed—pack animals, coastal shipping, light wagons.

A next round of development emerged in the seventeenth century with the innovation of the private banks of Amsterdam and London and state banks. This certainly accelerated the growth of trade; it exploded. Power and wealth moved to those engaged in trade and away from the crown and the church. Large cities began to emerge, especially London, Paris, and Amsterdam. Transportation was gradually improved during the period, and the amount of work it was called on to do increased greatly. Again, however, we would not want to say that transportation played an important causal role.

Why make the above remarks on whether transportation played a causal role in development or not? We have made them as "straw man" remarks, for the conclusion one reaches depends on how transportation is viewed. If we say that transportation is something hard and physical, then the remarks hold. If we take a "transportation-as-transactions" view, then we conclude that advances in transaction capabilities triggered the developments.

The Corvée in England

England's longstanding parish road system used (one hesitates to say employed) statute labor (the corvée system) geared to local needs, and relied on manorial organization. The system of statute labor seems foreign to the twenty-first century, especially in a United States without a military draft. The idea is similar to taxation, except that residents were taxed their time instead of their money. The difficulty is ensuring quality control; a dollar is a dollar (a pound is a pound), but an hour from a productive individual is very different than an hour from an unproductive one. The system began to be strained in the sixteenth century because of the growth of through traffic (roads were no longer a local matter) and the breakdown of the manorial organization of life. This also introduces the free-rider problem. Local residents have little incentive to maintain roads for nonlocal (through) travelers. Moreover, the substitution of the Church of England for the Roman Catholic Church eliminated a major source of road maintenance—monks aiding those on pilgrimages.

The decline in quality of the roads led to a revision of the early sixteenth-century system. Bridges were a technical and fiscal problem, addressed by the 1537 Statute of Bridges. This was followed by the Highways Act of 1555, resulting in the election of surveyors to plan and supervise the four days of statute labor per year (which was soon raised to six days). With revisions, this system served until the 1830s. Surveyors were assigned to the Quarter Sessions (the county's quarterly meeting of justices of the peace—the predecessor to the modern County Council), they were given powers to requisition materials, and parishes were empowered to tax for road improvements. Moreover, labor could be hired—which was important, because hired labor has more incentive to be productive than statute labor.

However, the mismatch between regional travel and local responsibility remained, and policy had not responded to technical questions, for example, how to build roads. Radical changes began to emerge as the local Quarter Sessions attempted to deal with those problems. Some started charging tolls on heavy vehicles to raise money for repair; others set maximum weight limits for vehicles. Several Quarter Sessions worked together to develop toll and road programs. Others wanted to increase the widths of wheels on large vehicles. (Narrow wheels place more of the wagon's load on a smaller space, creating rutting, while distributing the load across wider or more wheels increases the life of the road.) In the meantime, traffic of all types continued to grow; stagecoaches and mail wagons emerged in the early seventeenth century. Packhorses and mules were less and less used; wagons increased in size and weight.

The bridge problem became acute. The Act of 1537 simply put the responsibility for bridge maintenance on the parishes, and it had few teeth in it. Technical problems had to do with the narrow width of bridges, unsuitable timber construction, and steep access and egress.

The stage was set for considerable revision of highway policy. One revision allowed and encouraged turnpike developments, beginning in about 1650, but taking off in about 1700. Another was a restatement of the responsibilities of the parishes.

The parishes' first policy emerged in the 1760s and 1770s with a rationalization tone. They attempted to define the technologies needed; town access roads were to be at least 6 m (20 ft) wide. The effort to control weights and vehicle configurations continued: six-horse teams hauled wagons with wheels 15 cm (6 inches) across; more horses, wider wheels. Little used routes could be abandoned. Fees were graded so that those who used the roads the most paid the most. Some ills were cured, but poor construction, drainage, and bridge problems remained.

Another round of road development occurred prior to the development of the railroads. The evolution of toll roads built in part from the canal experience, which is discussed in a later chapter; the stories are intertwined. The role of "tolbooths" in Scottish culture is illustrated in box 12.1.

The Corvée in France

The French government had been exercising considerable taxing powers, in part because of the military needs of the central government. The vision and power were there too. In the seventeenth century Jean-Baptiste Colbert, Louis XIV's minister of finance, developed a plan for the orchestration of national life through the use of canals and roads for commercial and military purposes. A vision sometimes called Colbertism emerged—in essence, the belief that the state has the wisdom, resources, and power to do the best and most just things. The vision is sometimes referred to as a tradition of the *ancien régime*.

Beginning in 1716, state highway engineers, the Corps des Ponts et Chaussées,[1] prepared standardized maps for provinces, with centralized planning of roads beginning in 1747 (the year the school for roads and bridges was established). Between 1720 and 1770 the road construction budget increased eight-fold. Plans were implemented using public capital. In addition to capacity expansion plans, standards were developed for bridges and other aspects of the physical plant. For instance, all roads were to be 18 m (60 ft) wide. By 1789, the year the French Revolution began, the country had a 27,000 km (17,000 mile) road network. The state engineers had maps for the entire country, and they saw the need for a plan with standardized facilities, regardless of local physical conditions and markets.

BOX 12.1 The Heart of Midlothian

The center of activity in any significant Scottish burgh was the "tolbooth" [*sic*]. As might be expected, this is where tolls were collected, but as a small well-organized financial center, these tolbooths came to be administrative centers, with courthouses, and then prisons, and police and fire stations. In Edinburgh, for instance, the Canongate Tolbooth dates from 1477, the present structure from 1591 (Clark et al., 1991). Canongate was a burgh, just down the Royal Mile from the Edinburgh Castle, eventually incorporated into the larger city of Edinburgh. The 1737 Tolbooth Riot (in which the mob aimed to free a prisoner jailed at the Tolbooth) was fictionalized in Sir Walter Scott's *The Heart of Midlothian* (1818), a novel in which the Tolbooth was the Heart.

A high-quality, state-planned, financed, and operated, free road system centered on Paris had been developed prior to the emergence of the railroad. That was at a time when English major roads were toll roads improved by local capital and managed locally, and the United States had not much more than strips of mud. Despite its praiseworthiness as an engineering feat, the road network was burdensome to the poorer farmers. Roads require resources. The king appointed tax collectors to raise money, and those who could not pay often saw their land confiscated. Further, from 1737 the roads were maintained by a special road tax, but those who could not pay were required to contribute 30 days of labor per year on road crews. Farmers were inspired to overthrow their oppression of forced labor of the corvée and join the Revolution. Ultimately, the Revolution nationalized what private toll roads there were as well as the king's royal roads. However, by eliminating the dedicated sources of financing and maintenance, roads became a general public service.[2]

The Begar in India

In India, a monthly one- or two-day corvée (during Mogul times this uncompensated contribution of human and animal labor was called Begar) was often exacted from artisans, mechanics, and sudra laborers according to surviving legal texts from very early times. The Begar was more severe in India than the corvée in Europe, as some persons were required to bear loads, not merely maintain roads. How early this began is unclear, but the corvée was mentioned in the Code of Hammurabi (*ca.* 1700 B.C.E.), though that document mostly deals with exemptions. The Laws of Manu (*ca.* 1500 B.C.E.) permitted the sovereign to demand temporary services (DeLoche, 1993). It was noted in the seventh century by Hsüan-tsang in his *Travels*. It was established at different times in different regions, for example in the thirteenth century in the Hoysala kingdom, and later by Muslim princes. It came and went; for instance, in the Mogul dynasty (starting in the sixteenth century) Akbar eliminated Begar, but Jehangir reinstated it and Shah Jahan abolished it again. It was widespread in places, especially near the Himalayan border. In some areas, for some persons, this lasted through the first part of the twentieth century (Mishra, 2000), and was not legally abolished until Indian independence in 1947. Despite the relatively poor quality of humans as beasts of burden, this practice was an important element of transportation as well as construction and maintenance in India.

The Corvée in Japan

Gishi-wajin-den, a Chinese history from the third century, provides the earliest record of Japanese roads. From this period through the Meiji Restoration in the late nineteenth century, roads served pedestrians and animal-powered transportation. As a result, maintenance was simplified and reduced, since humans and animals do not damage roads nearly as much as wheeled vehicles. The mountainous terrain was not conducive to wheeled traffic, which did not develop as it had in China and Europe. As with the islands of Greece, sea routes were more prominent than land transportation, especially for bulk cargo.

Major overland routes were reported in the Chronicles of Japan, *Niho Shoki*.[3] After the Taika Era Reformation (645), a central government modeled on the Chinese Tang dynasty reorganized the governance of Japan. A system of *Seven Kaido* (*Roads*) was established connecting Honshu, Shikoku, and Kyushu islands. These roads, centered on Kyoto, were the Tokaido (eastern route), Tosando, Hokurikudo, San-indo, San-yodo (western route), Nankaido, and Saikaido. The backbone provided by those roads remains, and modern superhighways in Japan use roughly the same routes that were established when they were originally constructed.

The Seven Roads were used for domestic communication, and a postal courier system, the "Ekiba, Tenma," modeled on a system in China and similar to the later Pony Express in the United States, was established. Every 16 km (10 miles or 30 *ri*), stations were placed to provide roadside services and to allow riders to change horses. The corvée was imposed to construct postal stations, and a rebellion against the corvée broke out in 1764 (East Asia in the World, 2004).

Roadside beautification, later to be popularized by Lady Bird Johnson in the United States, was established in the mid-eighth century with the planting of fruit trees along the Seven Roads. Road signs, or *Ichirizuka*, were mileposts, similar to those constructed on Roman roads, providing navigational information for travelers, and were popularized in the mid-seventeenth century. Road standards were put in place. At the beginning of the seventeenth century, the Edo Shogunate specified that major highways would be 11 m (36 ft) wide, secondary routes would be 5.5 m (18 ft) wide. The roads were to be gravel, and covered with sand. Residents who lived alongside the road through the Shogunate era performed road maintenance.

Walking with its overnight stays had a social side. A 1952 translation of Ikku Jippensha's *Hizakurige* (*ca.* 1800) provides a humorous description of travel events. During Japan's great modernization, the Meiji Era, wheeled vehicles such as carts and carriages began to be used on roads. This caused roads designed for people and animals to deteriorate. Crow (1881) described the Tokaido as having much traffic yet having ruts and holes large enough almost to swallow a cart. The condition of roads was exacerbated as the Meiji government privileged rail and sea travel to road travel.

The Fukushima incident of 1882, in which advocates of the Japanese Freedom Party were suppressed by the prefectural government, resulted from a local rebellion against the corvée labor tax imposed by the government to build roads (Mainichi Newspapers Co., 2002). In response, road construction subsidies (from monetary taxes) were imposed. However, it was only after World War II that Japanese roads were truly modernized.

After World War II, the use of the automobile in Japan took off, as seen in figure 12.2. The number of vehicles rose from about 142,000 in 1945 to 922,000 in 1955. As late as 1955, the main road between Tokyo and Osaka was unpaved for one-third of its length (see, e.g., figure 12.3). The first expressways were not opened until the Meishin Expressway in 1963 (shown in figure 12.4). Clearly the vehicles drove the demand for expressways, which can be seen to be lagging vehicle growth significantly.

Profile: John Loudon McAdam

John Loudon McAdam, dubbed the "Colossus of Roads," was born in 1756 in Ayrshire, Scotland. As with many innovators, his interest began young; while at school he built

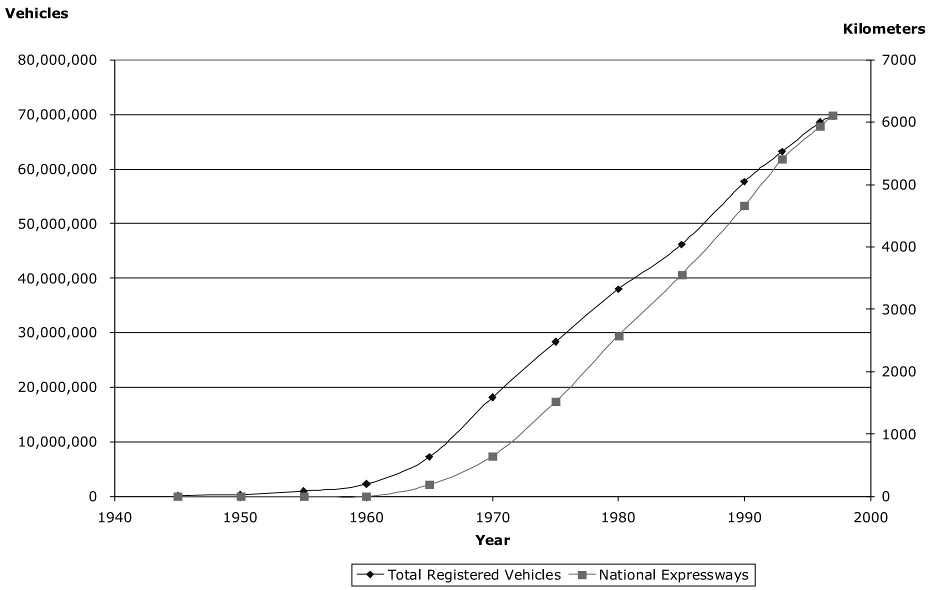


Figure 12.2. Japanese vehicle highway system, 1945–1997. (Source: Road Transport Bureau, 1959, 1960, 1970; Statistics and Survey Department, 1964, 1966; Regional Traffic Bureau, 1992; Japanese Automobile Inspection and Registration Association, 1991.)

Figure 12.3. Condition of roads in Japan in the 1950s. (Source: MLIT, 2003.)

Figure 12.4. The Meishin Expressway (1963).

a model road. At the age of 14 he went to America to work for his uncle in New York City as an “agent of prizes”—a legal form of dealing in prize ships and cargos captured by the British prior to the end of the American Revolutionary War. By the time he returned to Scotland in 1783, he was wealthy, and became a road trustee for his district. Noticing the poor quality of the roads, and this being the era of the amateur scientist, McAdam pursued a number of techniques to improve the quality of the road. He later moved to Cornwall, and received a government grant to continue the work. His conclusions, documented in two books, *Remarks on the Present System of Road-Making* (1816) and *Practical Essay on the Scientific Repair and Preservation of Roads* (1819), called for roads that were elevated compared with the adjacent ground, and covered first with large rocks, then smaller stones, and finally bound with gravel—all to improve drainage, which he identified as the major destroyer of roads.

Following a parliamentary hearing on road building, “macadamization” was adopted as the standard for construction, and McAdam was appointed Surveyor-General of Metropolitan Roads in Great Britain and was compensated for his expenses in researching the issue. The technology was adopted elsewhere, as illustrated in figure 12.6 (see page 159).

McAdam’s system, while more expensive than the dirt roads it largely replaced, was much cheaper than the similar quality of road inspired by Roman road building, the use of stone slabs carefully laid by masons.

Richard Edgeworth improved the “macadam” method by using stone dust and water (a form of cement) as a binding agent (though this was opposed by McAdam himself).

In 1854, the technique was further improved in France by using bitumen (asphalt) binding, to ensure a smoother surface than simply gravel and slag could provide. This "Tar-Macadam," abbreviated "tarmac," was very much the forerunner of the blacktop common today. For his efforts, McAdam was offered a knighthood, which he declined before his death in 1836.

Profile: Thomas Telford

Thomas Telford was born in 1757 near Westerkirk, Scotland. After spending his youth aiding his uncle as a shepherd, at the age of 14 he was apprenticed to a stonemason. In 1780 he left for Edinburgh where he gained work as a mason, and by 1792 he was among the elite of his profession, working in London on Somerset House. As a supervisor of construction, Telford's first bridge was in Montford across the River Severn. His other works include designing and building churches.

An interesting project was a canal that was on an aqueduct across the River Dee. Rather than using clay to form the edges of the canal, which would have been too heavy, he innovated design by fixing troughs made of cast-iron plates in masonry. In this era of the engineer, it was not uncommon for an engineer to work on structures, waterworks, and highways. He aided in the professionalization of civil engineering by founding the first Institute of Civil Engineers.

He is perhaps most famous for his suspension bridges, such as the Menai Bridge linking the isle of Anglesey with Wales. He also built cast-iron arch bridges and turned them into works of art.

In 1803 Telford was hired to help develop the Scottish highlands. He was in charge of rebuilding the roads from London to Holyhead and from Shrewsbury to Holyhead, as well as others, totaling 1450 km (900 miles). He set standards for maximum grades among others.

Telford's method differed from McAdam's. First McAdam wanted 25 cm (10 inches) of graded broken stone above the ground, while Telford used an 18 cm (7 inch) foundation base of larger stones, laid in a trench (rather than on top of the ground). McAdam argued that Telford's method was costlier and required more maintenance, and that well-drained ground would be an adequate foundation. In a sense their dispute was the first salvo in the battle between asphalt (which most resembled McAdam's method) and Portland cement concrete (which is somewhat closer to Telford) that still rages today (see Chapter 13). Concrete still is more expensive and takes longer to repair, but is thought to be more durable under heavy loads.

Telford died in 1834 and is buried in Westminster Abbey.

Turnpike Trusts

The parish roads were handled as if they were local roads serving local landowners. But the growth of mail, passenger, and freight traffic, many with nonlocal origins and destinations, was imposing costs on the locals. Nonlocal and heavy local users were demanding improved facilities. The parish system had problems enough dealing with strictly local demands.

The toll road or turnpike was the answer. Such roads predate the canal era, and early ones (e.g., in the seventeenth century) were ad hoc extensions of the parish system—several parishes would work out a joint project.

Of course tolls were not invented in the seventeenth century. Precursors to tolls date to the mythological world, with Charon charging a toll to ferry people across the river Styx. It was easy enough to transfer the idea of tolls for service from ferries to bridges, and then from bridges to roads. Other early examples include mentions of tolls in Arabia and other parts of Asia by Aristotle and Pliny. In India, the *Arthasastra* identifies tolls prior to the fourth century B.C.E. Tolls were also known among the Germanic tribes in Europe during the late Roman Empire, who offered to guide travelers through mountain passes (let us call it a protection payment) for a fee. Later tolls were widely used in the Holy Roman Empire in the fourteenth and fifteenth centuries, and were thought to be interference in commerce.

Returning to the early eighteenth century, the idea of local administrators seeking permission for tolls from Parliament met much opposition. By and large, it was regarded as attempting to foist local responsibilities onto others. The locals objected to paying tolls on roads on which they labored and which they had to use.

This combination of opponents prevented many schemes from going forward. While some schemes were accepted, Parliament turned many down. When approved, there were often concessions for local traffic. Even so, there is a record of local uprisings against toll roads, riots, destruction of gates, and so on. This reflected a larger conflict; toll roads are in a sense the network analog of the enclosure movement facing England at the same time. Fenced fields and tollgates were redefining property relationships and class rights.

Although development of turnpikes was slow in the first half of the eighteenth century, a pattern of development had emerged by about 1750. "Town centered" sums it up. The effects on roads of traffic to London and provincial centers required action, and successful acts and schemes prior to about 1750 yielded a map of rather disconnected, urban-centered routes with 143 trusts managing about 4,800 km (3,000 miles) of road. By 1770 the network was better connected (figure 12.5). Later acts then filled in the map—by 1830 there were more than 1,000 trusts and 32,000 km (20,000 miles) of road.

Road trustees were local men (and they were almost always men) of substance. Enabling acts specified powers, accounting and meeting requirements, and provided for posts of treasurers and surveyors. The early pattern was for tolls to be collected at gates (by toll farmers), and after expenses were met, reinvested in repair. After experience, mortgage funding, guaranteed by gate income, began to be common.

Toll schedules were very complex. They reflected geographical (or spatial) equity, the principle that those who impose costs ought to pay (see, e.g., box 12.2). The tolls thus aimed to protect roads from damage, by placing high charges on excessive loads and on vehicles with narrow wheels. The technical view was that roads needed protecting. At the national level, the General Turnpike Act of 1773 contained 28 clauses relating to wheels, weights, and so on.

Thomas Telford became involved with the technology of road construction in 1803 when Parliament considered the problem of roads in the highlands of Scotland. A development scheme was initiated—Parliament would pay one-half the costs if local politicians would propose schemes and pay the remaining costs. That is the first use of a financial matching scheme we know of. John L. McAdam obtained experience serving

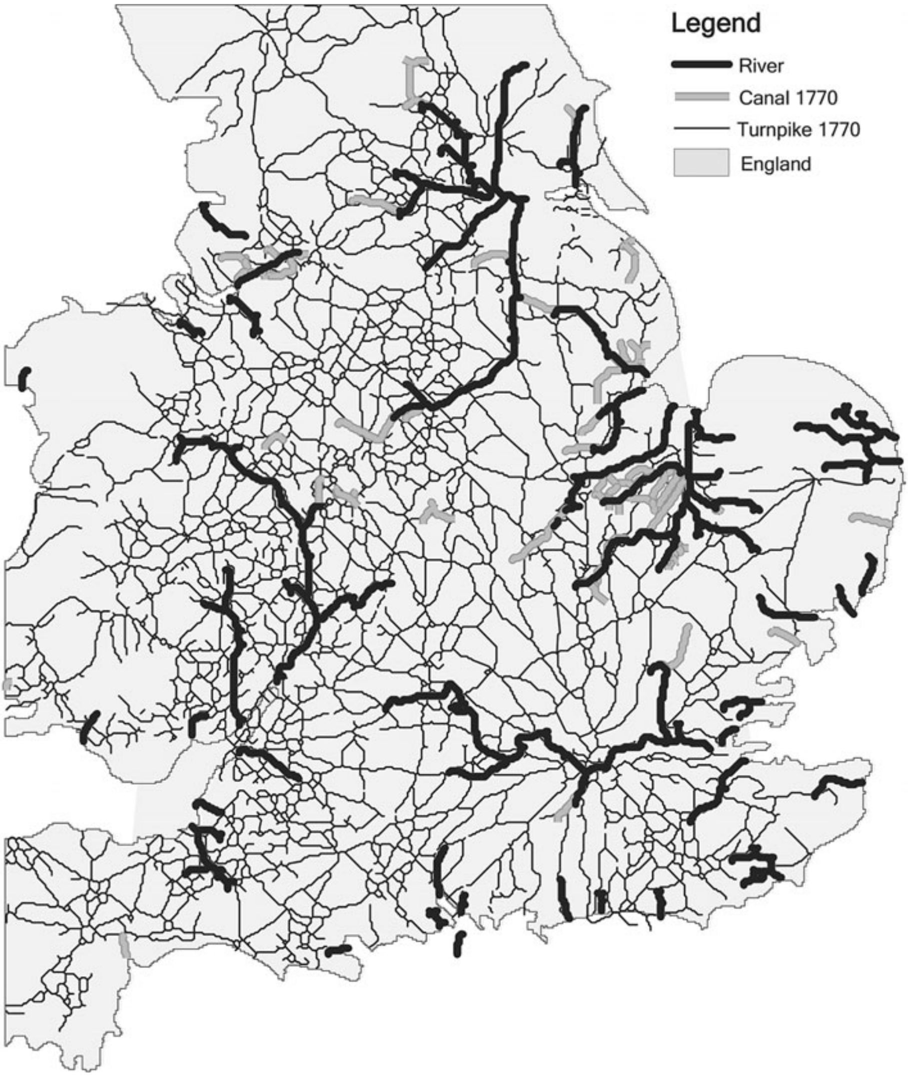


Figure 12.5. The turnpike and canal network of England and Wales in 1770. (Source: Pawson, 1977.)

on trusts in the 1790s and 1800s, and he interested himself in both technology and administration. Figure 12.6 shows the first macadam road in the United States that was constructed on the Boonsborough Turnpike in 1823 outside Hagerstown, Maryland.

By the 1820s much of the road system had been improved to macadam standards. Extensive, organized coach service operated at 16 km/hr (10 mph), there were mail wagons and mail service, and freight had emerged in two classes of service—fly wagons or vans for fast freight and heavy, slow wagons, of about 10 tons.

Yet, in an 1816 editorial, *The Times* of London described toll collectors as "men placed in a situation unfavourable to civilized manners, and who might be usefully

BOX 12.2 Levy of Tolls Using the Dartford to Northfleet Turnpike Road, 1760

For every Coach, Berlin, Landau, Chariot, Chaise, Calash, Caravan, Hearse, Waggon, Wain, Cart, Dray, or other carriage, drawn by six horses, or other cattle, or more, the sum of one shilling.
If drawn by two horses, or other cattle, the sum of six pence.
If drawn by one horse, or other beast, the sum of four pence.
For every horse, mare, gelding, mule or ass, laden or unladen, and not drawing, one penny.
For every drove of oxen, cows, or neat cattle, eight pence by the score, and so in proportion, for any greater or lesser number.
For every drove of calves, sheep or lambs, five pence by the score, and so in proportion, for any greater or less number.
For every drove of hogs, six pence by the score, and so on in proportion.

(Source: Dartford Grammar School, 2003)

employed in mending the roads which they now obstruct in a most disagreeable manner," giving evidence that tolls were not held in universal acclaim (Albert, 1972, p. 65).

Figure 12.7 shows how investment in turnpikes tapered off even before investment in railroads increased. After the railroads, some turnpikes failed financially and were taken over by local governments, which converted them to free roads. Others simply had their franchises expire and not be renewed. In any case, turnpikes were merged with the parish road system as the trend toward a nationally controlled and financed system was strengthened.

Turnpike Companies

In contrast to France, road and canal development in the United States had lagged behind that in England. Instead of being already ahead, the United States was rushing to catch up. Also in contrast to France and England, the United States at the time was a federation of states with a weak central government. Hierarchical governments needed to learn roles. The main American turnpike experience differed from the British experience in several other ways. It began later (in the 1780s) and ended later (at the onset of the twentieth century). But the organizational form also differed. In the United States, private corporations held most turnpike charters, while in Britain, the turnpike trusts were institutions with more public control. The private turnpike companies were regulated, and often, especially in the early years, had some local government (public) investment, so we are speaking of degrees of public and private, not absolutes, when we talk about road networks.

The first authorized turnpike in the United States was from Alexandria to Berryville, Virginia, in 1785, though the road was a public tax-funded road. Maryland followed in 1787. However, the 100 km (62 mile) Lancaster Turnpike in Pennsylvania (with nine toll gates), chartered in 1792, with land donated by the state, was the first notable turnpike company. As can be seen in figure 12.8, 69 turnpikes were charted in the 1790s, rising to 398 by 1810.

Figure 12.6. First American macadam road (1823). (Source: Rakeman, 1823.)

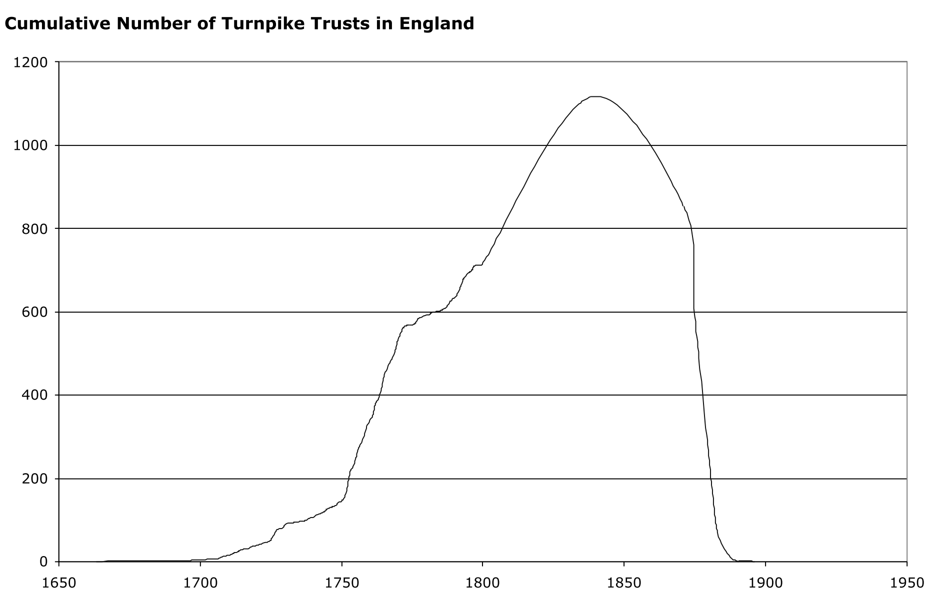


Figure 12.7. Turnpikes in Great Britain, 1650–1800. (Source: Pawson, 1977; Webb and Webb, 1913.)

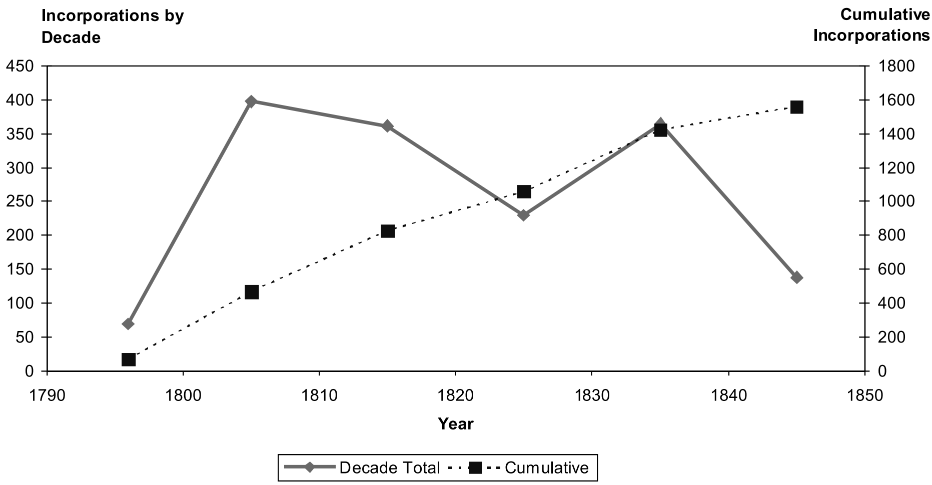


Figure 12.8. Turnpikes incorporated in the United States, 1790–1845. (Source: Fielding and Klein, 1993.)

The logic behind the turnpike boom is in many ways that of an arms race, though more productive. Turnpikes increased accessibility. With a turnpike (shown in figure 12.9), Lancaster residents could now get to Philadelphia quickly on a broken stone and gravel road. This improved overall welfare (absolute accessibility). But perhaps more importantly, it improved Lancaster's position with respect to competing towns (its relative accessibility), whose inhabitants could only get to Philadelphia on slower dirt (and mud) trails. It was a mixed bag for Philadelphia; while it made the west more accessible and helped spark the western migration, it brought Lancaster into Philadelphia's orbit and away from Baltimore's. Thus, it improved Philadelphia's position with respect to its rivals (Baltimore and New York). Moreover this turnpike was profitable, paying up to 15 percent annual dividends to shareholders.

A map of the Lancaster turnpike is shown in figure 12.10. Over time, Lancaster positioned itself at the center of a web of radial turnpikes, in addition to the route to Philadelphia: the Lancaster/Columbia Turnpike, the Lancaster/Marietta Turnpike, the Lancaster/Millersville Turnpike, the Rockville (now Rock Hill) Turnpike, and the Stumptown Turnpike (now Old Philadelphia Pike). As a side note, the Lancaster turnpike also helped birth the Conestoga wagon as a major vehicle type (which can be seen heading away from the inn, in figure 12.9).

A U.S. critic in the early 1800s might have said that the central government was destined to play only limited and rather ad hoc roles in transportation development. Secretary of the Treasury Albert Gallatin's report to Congress of 1808 had recommended an extensive set of canal and road improvements. But no action was taken. It was claimed that the Constitution did not provide for federal activities. Was that an excuse or reason for inaction? The real obstacle to action may well have been the regional jealousies of the times.

As a result (we think mainly of the problem of consensus about activities), federal government activities were small and scattered. The Ohio Statehood Act of 1803 set aside 2 percent of the proceeds of public land sales for building the Cumberland

Figure 12.9. The Philadelphia and Lancaster turnpike road (1795). (Source: Rakeman, 1795.)

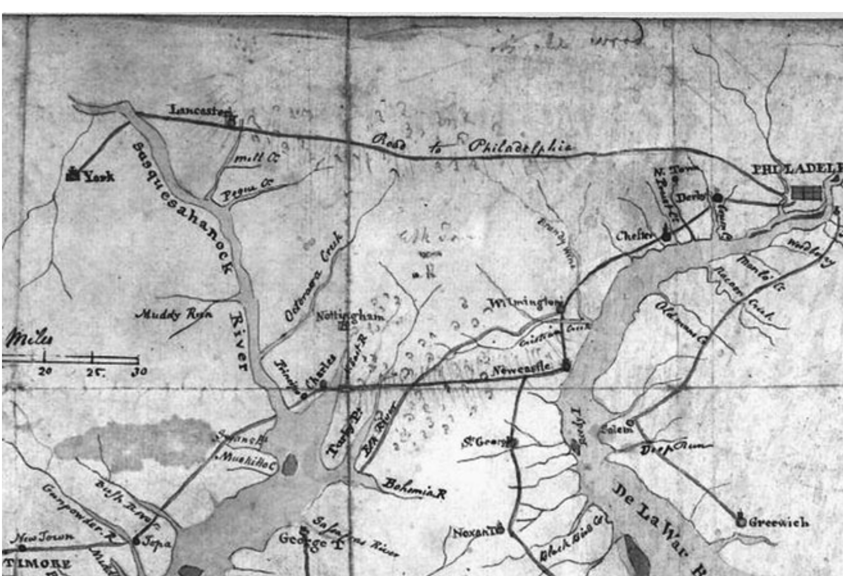


Figure 12.10. 1796 map of Lancaster turnpike. (Source: Cramer, 2004.)

Road—the first interstate highway—constructed by the U.S. Army Corps of Engineers (Raitz, 1996). Those monies got the road built but did not provide for maintenance. An Act was passed in 1822 permitting the collection of tolls for maintenance, but was vetoed by James Monroe on the grounds that the federal government lacked the necessary jurisdictional power. Not many years later, in 1830, Andrew Jackson vetoed a bill funding the Maysville turnpike in Kentucky on the grounds that the support of small local projects created "disharmony among the states."

Opponents to the turnpikes were in part easterners, who objected to increasing the accessibility of the west (and thus the migration to the west), and those who opposed any federal involvement. Rival modes (canals and later railroads) also opposed government support for their competitors. Aside from the Cumberland (or National) Road (today's U.S. 40), federal involvement in road building was limited.

While the federal government was in general out of the picture, many states participated in private turnpike construction. Virginia, for instance, saw a network of toll roads emanating from Alexandria sponsored by local merchants. Alexandria is just across the Potomac River from Washington, and was part of the District of Columbia from 1800 to 1846 before being retroceded back to Virginia. Local rivalries were intense;[4] sometimes opposition was too (Jones, 1990) when local and town interest conflicted.

Box 12.3 shows the quick rise and even quicker fall of privately constructed plank roads.

Fin de Siècle

Our discussion of the decline of turnpikes contemporary with the rise of railroads may imply that regional roads disappeared as railroads were deployed. That is too simple

BOX 12.3 Plank Roads

Turnpike incorporations slowed with the beginnings of the railroad in the 1830s. Aside from the plank road boom, turnpikes grew less and less important as an element of the American transportation network. By 1910, almost all turnpikes were assumed by state governments.

The plank road boom deserves some discussion. Wood planks provide a much smoother surface than gravel, and prior to concrete and asphalt would enable the fastest off-rail transportation by wheeled vehicles. In the 1850s, especially in the timber-rich states, a boom in plank road construction took place, as shown in table 12.1.

Table 12.2 shows a regression of the plank road data. The greater the rank in lumber production (i.e., the less lumber produced), the fewer plank roads built. Similarly, the greater the population, the more roads built. So construction was a function of both material supply and travel demand.

The plank road boom ended as the first plank roads deteriorated. Wood planks typically last 8 years in road use. As the planks went bad, they either needed to be replaced (which was costly) or abandoned, either of which would raise the cost of operation, and if passed through as tolls, the cost of travel, and make plank roads much less advantageous than they had seemed 8 years earlier.

Table 12.1 Plank Road Data

State	Rank in lumber production	1850 population	Plank roads
New York	1	3,097,394	335
Pennsylvania	2	2,311,786	315
Ohio	4	1,980,329	205
Wisconsin	11	305,391	130
Michigan	5	397,654	122
Illinois	10	851,470	88
North Carolina	16	869,039	54
Missouri	9	682,044	49
New Jersey	13	489,555	25
Georgia	18	906,185	16
Iowa	23	192,214	14
Vermont	20	314,120	14
Maryland	21	583,034	13
Connecticut	22	370,792	7
Massachusetts	7	994,514	1
Rhode Island	26	147,545	0
Maine	3	583,169	0

a view. Many local roads survived very well. They served feeder functions to railroads. Local governments provided local roads, and property taxes (or contribution of labor in lieu of taxes) help kept that part of the road system viable.

There were increasing demands on the local road system as cities grew and as rural economic growth proceeded. With city growth, there were local markets for products of farms, and as grain, fiber, and meat production increased, specialized products were shipped from the farm via railroads to distant markets. These demands emerged in different ways in different farming communities. For example, the demands on the local road system for daily movement of fresh milk to the urban market were quite different from the demands of crops such as grain or cotton.

Improving the rural local road system began to be a matter of state concern during the latter part of the nineteenth century. The State of New Jersey, for example, passed legislation permitting the counties to issue bonds for improvement of the local road system. A plausible explanation was the rapid growth of Philadelphia and New York providing for market-garden-type agriculture in New Jersey. Emulation may have

Table 12.2 Regression Results of Simple Plank Road Model

Variables	Coefficients	*t* Stat	*P*-Value
Intercept	133.91	2.90	0.01
Lumber rank	–7.19	–2.88	0.01
1850 population	0.000040	1.90	0.08
Adjusted R^2	0.51		
Standard error	75.61		
Observations	17		

played a role. References were made at that time to the lot of the European farmer with his somewhat better government-supplied road system. The spread of bicycle technology also played a role. Growing, wealthy urban areas demanded improved roads. Facility improvements—improved drainage, sidewalks, bridges, pavements, for instance—were regarded as highly desirable.

Turnpike Authorities

This chapter opened with discussion of the Pennsylvania turnpike. It was the forerunner of another major turnpike boom lasting from 1940 to 1956. During this period (and counting projects initiated in this period), some 6,400 km (4,000 miles) of freeway class turnpikes were built in the United States (Levinson, 2002). In 1956 the interstate highway program was established, giving states 90 percent of the money toward construction of freeways, provided they were “free,” or untolled. While turnpikes are a great way to collect revenue from nonresidents, who may not pay a state’s gas tax, an even better way is to get federal cost sharing of this magnitude. Thus the era ended shortly after it started.

However, by the end of the twentieth century, with the interstate era ended, local governments again viewed toll roads as a reasonable way to finance roads. New toll road projects were begun in a number of cities, largely as suburb–suburb connectors, though with some suburb–city routes as well.

Discussion

There were two styles for road planning. On the Continent, and especially in France, central governments took responsibility for road development. In England (and places under English influence) road development was a local affair. As traffic between towns increased, enabling legislation was sought so that private organizations could improve roads and fund improvements from tolls. Mostly, short stretches of roads were developed, and the network evolved as links were improved end to end. To the extent that there were plans, they were business plans formed for the development or maintenance of an existing link.

The use of wagons and coaches required facilities quite different from precursor facilities. The requirement to reduce grades often called for new route locations. Pavements and drainage were used; bridges, inns and warehouses were constructed (Parnell, 1833). Requirements for investment and maintenance placed new demands on governments and for the development of capital markets, construction technologies, and management capabilities. These developments set the stage for the subsequent creation of canal and railroad companies.

Turnpikes emerged as a financing mechanism in the presence of free-rider problems facing the existing road network. There were several free rides being taken. Laborers in the corvée/statute labor system were not putting in a full effort—they were shirking their taxes. Users were riding on nonlocal roads without compensating the locals who were responsible for them. A toll system remedied both of these problems. The remedies came at a cost, frequent stopping to pay tolls and high costs to collect tolls.

Nevertheless the system worked for almost 200 years before collapsing with the onslaught of intercity railroads, which were faster, better organized, and cheaper. Railroads avoided the free-rider problem from the start. Toll roads reorganized in the United States as feeders to the railroads, rather than competitors, but the long-distance roads collapsed into bankruptcy. By the end of the nineteenth century, and just before the widespread adoption of the automobile, those routes, as they had been in Britain, were taken over by local government and disturnpiked.

13

Rural and Intercity Highways

There was Anthony Stracci, who controlled the New Jersey area and the shipping on the West Side docks of Manhattan. He ran the gambling in Jersey and was very strong with the Democratic political machine. He had a fleet of freight hauling trucks that made him a fortune primarily because his trucks could travel with a heavy overload and not be stopped and fined by highway weight inspectors. These trucks helped ruin the highways, and then his road building firm, with lucrative state contracts, repaired the damage wrought. It was the kind of operation that would warm any man's heart, business of itself creating more business.
—Mario Puzo, *The Godfather* (1969)

Introduction

The official website of the Concrete Paving Association of Minnesota resides at www.concreteisbetter.com. On this page the reader learns that, versus asphalt,

Concrete costs less in the long run!
Concrete lasts longer with less need for maintenance and repair!
Concrete is quiet!
Concrete is safer!
Concrete is environmentally friendly!
Concrete is aesthetically pleasing!

Of course, asphalt does have its proponents, such as the Minnesota Asphalt Pavement Association who in response claimed the domain www.asphaltisbest.com.[1] They promote asphalt's "Quick easy construction, easy design capabilities, outperforms competitive materials." They ask, "Doesn't your community deserve smooth, attractive, asphalt roadways? American's best communities choose asphalt, shouldn't it be your choice?" They taunt, "Don't be Rigid in Your PAVEMENT Thinking. Choose asphalt, the Versatile Paving Material." The virtues of asphalt seem similar to those of concrete: "Customer satisfaction, economical, speed of construction, durability, versatility, recyclability, smooth & quiet, maintenance application."

Flexible asphalt versus rigid concrete—it seems a strange battle, even to those of us steeped in transportation. In many states, consolidated pavement manufacturers sell the appropriate material for the job. However, for whatever historical reason, in Minnesota the producers remain small and their associations have chosen to compete over the fixed pie of pavement surfacing and resurfacing rather than coalesce to increase the amount of pavement available. They promote competing studies arguing in favor of their material. Historically, low-volume roads have gone asphalt and high-volume roads have gone concrete, and they compete at the margins. Since there are many more miles of low-volume roads, there is a great deal more asphalt on the ground.

Pavements are of course but one aspect of rural highways, an aspect that makes little difference to the transportation itself, aside from minor adjustments to costs and delays during construction, yet in the aggregate, pavements are a huge industry, and a large element of the transportation experience that we would be remiss to omit. Like the debate between Telford and McAdam in the early nineteenth century, the battle between asphalt and concrete is both slow, puerile, and futile. A combination of the two (e.g., concrete with asphalt overlay) often makes the best technique, though the sides are too competitive to see it.

In response to pavement advocates, Francis Turner, a former head of the Federal Highway Administration, would sometimes close the debate by jesting, "The Interstate is a balanced system, one-half of the mileage is concrete, and the other half is asphalt." But there is more to be said about rural and intercity highways and this chapter explores their policy, planning, deployment, and management. Although some aspects of state activities are treated in the discussion of the evolution of the modern urban transportation planning system, the present discussion will begin around 1900 in order to provide a coherent view of modern rural highways. We shall see that three levels of policy and planning evolved: federal, state, and local.[2] In some states there is a fair amount of articulation between county and state planning, in others there is not.

The Birth of Highways

In the United States, the auto-highway system dates from the mass-produced automobile, that is, the Ford Model T, around 1910. The current realization of the truck-highway system also dates from 1910. Alternatively, one might say that steam, electric, and internal combustion engine vehicles triggered a new realization of old systems, though their birth dated from many centuries ago. The automobile and truck offered increased performance (higher horsepower per ton) and, eventually, lower costs compared to animal propulsion systems. This enabled a renewal or transformation of the precursor system or, if you wish, the birth of the modern system. The title of Barker and Gerhold's *The Rise and Rise of Road Transport* (1993) mirrors the renewal situation.

Much has been accomplished since the early twentieth century. It was decided what governments would do as against what private actors would do, funding responsibilities were set, learning about system capabilities occurred, and the system was deployed.

Some key matters in automobile development were the availability of high-energy fuels, the shift from the steerable front axle to steerable front wheels, the use of specialized labor and Fordist mass production, and the adoption of interchangeable parts. Interestingly, it took until the 1930s for the predominant design of the automobile and truck to emerge. Process of production technology was also well developed by about that time. Development took off in the United States. It is said that circumstances were first ready in the United States, where incomes and preferences supported the development of mass markets and enabled mass production.

It is instructive to compare the time constants describing market penetration in various environments, say, the time required to go from 5 percent to 95 percent of market saturation. This required about seven decades in the United States, two to three decades in Western Europe, and a little over one decade in Japan. That partly has to do with the rise of incomes in those areas.

We might expect places that began to automobilize after the United States to automobilize faster than the United States did. Because the technology had been standardized, only emulation was required. But the notion that the environment was somehow ready in the United States and not in other places is harder to explain.

The time constants for vehicle market saturation compare in an interesting way with deployment of improved roads. Comparison of the S-shaped deployment curves for roads and vehicles (figure 13.1) suggests that road improvements led and vehicle populations followed. In fact there were many roads before motor vehicles. That observation raises an interesting question about causality in system deployment.

The automobile and truck appeared in environments where road improvements were under way. Motorized vehicles begged incremental changes, including pavements to keep down dust and protect the road surface (and stronger pavements to carry loads), bridge improvements, increased capacity, and design changes to allow for higher velocities.

Many preautomobilization design protocols were unchanged. For example, the higher horsepower per unit of weight of motorized vehicles would have enabled much

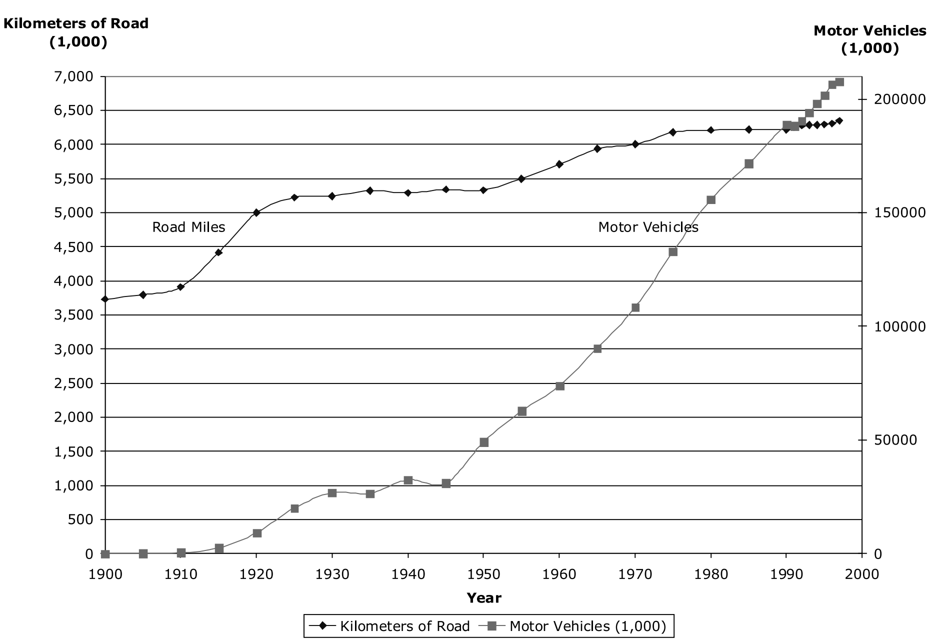


Figure 13.1. Kilometers of road and number of vehicles in the United States (1900–1997).

steeper grades. (The critical road grade for a wagon was downhill. The then current brake technology allowed for a grade of about 2 percent, which was the maximum load that horses or mules could hold back). Although special facilities for heavy vehicles were discussed in the early nineteenth century (the idea of iron roads), the protocol of limited specialization of the road to vehicles and operations continued. Specialized designs (truck-only or auto-only highways) were discussed in the 1920s and 1930s; but, except for a few parkways (such as those developed by Robert Moses in New York, discussed in the next chapter), those designs were never adopted (see box 26.1 for a discussion of the topic).

The system characteristics of automobiles, trucks, and of highway facilities were frozen when the predominant technology hardened in the 1930s. The roads, vehicles, and operations developed by the end of the 1930s have been deployed, and today only modest "polishing" changes are under way. That is true in the sweep of history in spite of, if not because of, the increasing number of regulations affecting vehicles and highway designs.

Demand for Road Improvements

Pressure to improve the rural road system intensified after 1900 as farmers began to purchase and use automobiles and trucks. There were sharp imprints on rural activities as a new spatial arrangement of activities (market, recreation, religious, school, etc.) emerged. For instance, small, local hamlets withered as commercial and social activities increased at larger centers.[3]

Rural residents claimed a right to an improved road system. Necessary governmental institutions were in place (township, county, and, later, state agencies) and technology (knowledge of how to construct roads and bridges) was available and/or could be evolved. Authority and power were in place, too, lending political interest and support; at the time, rural interests dominated the state and federal governments. However, money was a problem.

Federal Actions

Roads were popular, and the popularity of road improvements was pushed even before the auto by the need to get farm products to railheads and by use of bicycles. In addition to state and county initiatives, national level legislators responded warmly to needs for funds. Table 13.1 gives a partial list of national legislation.

The legislation framed the context of road planning. The 1916 Act referred to post(al) roads as a way to designate routes to be improved. The Act contained an interesting equity-oriented statement of purpose, including the need to decrease the isolation of rural settlements. Rural facilities were poor relative to urban.

The 1921 Act had concentrated resources and triggered the establishment of state highway departments where they had not already been established. It also gave those departments specific turf, the 7 percent of all rural highways that would be on the ABC system. ABC refers to a classification of state highways eligible for federal funding. Planning came along in 1934 following BPR experiments with state planning.

Table 13.1 Timeline of Federal Road Legislation

Year	Action
1916	PL-64-355 First Federal Aid Road Act set a precedent by allocating $5 million in federal funds to be matched 1:1 by the states for construction of rural roads. The Bureau of Public Roads (BPR) administered federal aid to state highway departments
1921	PL-67-212 Federal Highway Act required state highway departments with BPR to designate a system of state ABC roads
1934	PL 73-393 Federal Aid Highway Act (Hayden–Cartwright Act) authorized funds for highway planning
1944	National Interregional Highway Committee recommends a 55,000 km (34,000 mile) system
1944	PL 78-521 Federal Aid Highway Act created a national system of interstate highways, not exceeding 64,000 km (40,000 miles), no funding authorized
1955	Clay Committee (President's Advisory Committee on a National Highway Program) recommended $22.5 billion bond-financed interstate highway program
1956	PL 84-627 Federal Aid to Highway/Interstate Highway Act, Highway Revenue Act creates Highway Trust Fund[a]
1958	PL 85-625 Transportation Act
1965	PL 89-285 Highway Beautification Act
1966	PL 89-670 Department of Transportation established
1973	PL 93-87 Federal Aid Highway Act
1980	PL 96-296 Motor Carrier Act
1982	PL 97-424 Surface Transportation Assistance Act
1987	PL 100-17 Surface Transportation Act
1991	PL 102-240 Intermodal Surface Transportation Act
1998	PL 105-178 Transportation Equity Act for the 21st Century

[a]For a discussion of federal legislation close on the heels of the interstate program, see *Highway Assistance Programs: A Historical Perspective*, Congressional Budget Office (1978).

During this period and into the 1940s, the rural emphasis of state programs continued. In 1928 there was an Act allowing expenditures in the sparsely settled parts of cities, but such areas were essentially the rural parts of cities (the Acts listed in table 13.1 are not exhaustive). The 1934 Act extended federal aid to cities, a response to the depression and unemployment problems of the times. The 1932 Act had stressed the same reasons in its emphasis on farm-to-market roads.

The concentration on high-quality design can be traced as far back as the 1920s; further, the acts leading to the interstate reflect the interest in high-quality design.

Bonds had been proposed to fund the interstate, but the 1956 Act adopted the fee and fuel tax protocols used by the states. The subsequent evolution of state/federal protocols is rather complex; chapter 20 gives a modern snapshot of the situation.

Bureau of Public Roads

The BPR was established in the Department of Agriculture to "aid in the improvement and construction of public roads and to promote better agricultural engineering work" (Holt, 1923). Originally founded as the Office of Road Inquiry in 1893, the function of the Office from its founding to 1912 was primarily educational, conducting studies and disseminating information through lectures and publications. From 1912 onward, the agency expanded its power to include the construction of post roads (as authorized by the Constitution) and the administrative responsibility for federal aid programs.

In the early part of this century, the Bureau of Public Roads encouraged states to develop statewide plans for the growing network of roads and highways. It is important to note the motive for these plans. Washington politicians made a commitment to assist highway development in the states, and significant funding became available. But there is never enough funding, and the BPR's response was to concentrate resources on through and important collector routes. Indeed, one of its first actions was the "7 percent solution": only 7 percent of the state mileage was to be eligible for federal assistance. As we shall see, the strategy to *concentrate resources* permeated the subsequent BPR freeway programs.

In the early days the BPR had a role limited to working out techniques and designs, demonstrating roads, and encouraging states to act. The result was a number of BPR type roads. These roads failed badly under the traffic demands of World War I, indeed, so badly that there was a political backlash against the Bureau. In response, and adopting the "science is good for the country" thinking after World War I, the Bureau adopted a "rational" *scientific method* approach in the 1920s. This orientation was successfully applied first to soil mechanics.

In the 1920s and 1930s the Bureau was finding that facilities were becoming obsolete before they wore out. With higher velocity traffic, designs needed upgrading. Also, traffic growth was pressing capacity. In response, the Bureau became involved in getting the travel and traffic facts to support planning and design. It began to go beyond recommending, and required that states develop state plans as a condition for federal aid funding.

The state surveys of transportation in which the Bureau participated were essentially identical in their organization, data analysis and findings.[4] The surveys aimed to provide not only a detailed description of the existing network, but also a plan for future highway development. Each survey contains a background description of the history of roadway development in the state, the organization of the individual state highway department, highway revenues and expenditures, and methods of state aid and supervision. There were minor variations among the plans, for instance a discussion of significant geographical features in the New Hampshire survey and a greater discussion of the urban needs and the state role in the Ohio survey.

Methods used in the surveys were stressed. Data presented include descriptions of existing roadways by roadway type, measures of traffic density, truck and bus traffic, traffic composition and classification, and forecasts of highway traffic. Traffic density was measured as the number of motor vehicles that passed a count station during a 24-hour period (ADT, average daily traffic), and were classified as light (less than 200 ADT), medium (200–499 ADT), and heavy (500 and more ADT). Truck traffic and density, motorbus routes, interstate travel, and trip length data were also presented. Forecasts of future traffic and future motor vehicle registration were also developed.

The final sections of the surveys proposed plans for future highway improvement (for example, five-year plans for Ohio and Vermont, a ten-year plan for New Hampshire). These plans outline the extent of roads needed to meet future demand, provide estimates of the cost for the proposed improvements, and discuss safety concerns, areas of growth, and special study needs.

There was nothing radical or of a breakthrough nature in these early surveys. They scaled up project type work and used the conventional engineering standards of the day

(Blanchard, 1919). They illustrate the emerging relations between the Bureau and the states: the investing of primary responsibility in the states for development and maintenance of the highway network, with the federal government serving to establish both uniform standards and financing. A kind of partnership emerged which is still a fundamental part of U.S. road transportation administration. The roles of the states and of the federal government have remained substantially the same.

The plans also indicate a change in the role of the roadway network. Then primarily established as roads to move agricultural products to rail facilities for long-distance travel, the surveys point to the development of a network that serves additional needs, including social, economic, national defense, and long-distance transport. The increasing roles of the automobile and truck were recognized—the role could hardly have been overlooked at the time. But it is interesting that long-distance truck transport was not much emphasized. The plans are key documents for the time, indicating the change and how it came about.

In addition to the concentration of resources theme and the fact-based partnership themes, the BPR was very much a product of *progressive government*, professional leadership thinking in the early decades of the century. The long-time Chief of the Bureau and Bureau staff personified progressiveness (Lind, 1965). The progressive movement affected state and local government, of course, but its impact was concentrated in the Midwest and western states. As previously mentioned (in chapter 3) and as discussed by Coke (1968), engineering studies and management confronted the city beautiful movement.

With the growth of motor vehicle use and the importance of the highway network, the role of the federal government expanded. The BPR, as part of its responsibility for administering federal aid for roads, required the states to submit plans for the existing road network, the organization of the state highway departments, and the method for securing the necessary finances for road construction and maintenance. The state surveys were further developed as part of this process.

The Bureau also began to make resources available for planning. Weiner (1983) remarks that the Federal Aid Highway Act of 1934 authorized expenditures of 1.5 percent of federal monies made available to states for surveys, plans, engineering, and economic analyses of projects for future construction, and that by 1940 all of the states had created highway planning surveys.[5]

The Bureau began to tiptoe into the urban areas. Holmes and Lynch (1957) remark that urban area travel studies were not included in the highway planning surveys until 1944, because it was not until the 1944 Act that appreciable federal funds were made available to urban areas. They also remark that in anticipation of that Act, the Bureau had "developed a method to give the needed information," and refer to origin and destination of trips, mode of travel, and trip purpose.[6]

Holmes and Lynch (1957) discuss the strong nonurban priorities during the 1930s. As mentioned, there was the problem that early road designs were inadequate to the growth of traffic (number of vehicles, size of trucks, etc.), and a modernization and replacement program was needed. Local agencies were making claims on highway user taxes. Should trucks pay higher taxes? Finally, the state secondary road system, for which funds were beginning to become available, needed to be identified. These problems called for "facts," and the highway planning surveys responded. Study techniques were honed, and began to include financial topics and road-life analyses.

Business versus Touring Roads; System Size

One issue debated in the early twentieth century was the emphasis to be given to business roads versus touring roads. In the days before the Model T, autos were expensive and used mainly by the upper classes. Touring was an important leisure-time activity for the idle rich and those aspiring to that job, so they asked for touring roads, as did the auto manufacturers who thought touring roads would increase the market for vehicles. As less expensive vehicles came along, there was a great touring boom. Along with the development of National Parks and as interest in the great outdoors increased, there was a strong basis for a touring road emphasis. The debate lasted about ten years. The pragmatic business road concept won the day (U.S. FHWA, 1977), although the business promoted was often tourism (Preston, 1991).

Though the scope of the state versus the county road systems and how federal money would be divided was debated, the 7 percent solution for the allocation of federal money in the 1921 legislation coopted some of the debate. Also, states worked out different solutions for allocating dollars between the counties and the state systems. The give and take of state politics managed the county–state issue.

An issue that should have been debated was the matter of rational shifts in the road pattern given changes in the ratio of fixed to variable costs. In the horse and mule days, variable costs were high relative to fixed costs when compared to the case once autos and trucks came along. Consequently, there was an opportunity to reduce road mileage while providing improved quality roads. James (1916) pointed out that the rural system would be improved by mileage reductions and concentrating investment on remaining roads. Just as there was a rationalization of the railroads, a rationalization of rural roads would be desirable.

Needs for Highway Improvement

The word "needs" is a tough one to work with: how do we establish need for a highway improvement? Needs were operationalized by the 7 percent solution in the 1921 Act, and that was tempered in 1932 by legislation that said that states could increase their mileage by 1 percent per year when the original 7 percent was 90 percent complete and well maintained. In other words, there is no limit to needs; they grow 1 percent per year.

Despite the emphasis on business roads, the interest in touring did not die. Henry Joy, for example, pushed for the Lincoln Highway. It was to extend from the Atlantic to the Pacific, be built of concrete, and be free to any users. Lots of highways of this sort were "needed," some were park-to-park roads to assist visitors visiting the western national parks (and of course in urban areas like New York different sorts of parkways).

The 1934 legislation provided for state highway planning, and the states gradually built up planning capabilities. Although the BPR suggested procedures and the contents of plans, those plans varied somewhat from state to state and yielded no results in the rationalist *facts* style desired by the Bureau. At the end of World War II the Automotive Safety Foundation undertook some needs studies for several states, and these yielded *facts*. The Bureau recommended the study strategy to the states, calling attention in particular to the Automotive Safety Foundation study in California.

At first, the needs studies that followed BPR urging were made on an episodic timing, and were sponsored by legislators. A study commission was established with advisory committees. A sizeable staff, budget, and block of time were devoted to the work. Staff was largely engineering but included legal and fiscal specialists. The resulting needs were then considered by the legislature.

Currently needs studies respond both to local interests and to the Congress. The Congress requires that the USDOT report to Congress on the "condition, performance, and future capital investment requirements of the Nation's highway and transit systems." This report is carried out every two to three years. The highway condition information is drawn from the highway Performance Monitoring System (HPMS), which is a federal database fed by state DOTs.

The cost to improve highways and bridges is developed from the FHWA's Highway Economic Requirement System (HERS) and the National Bridge Investment Analysis (NBIA). HERS determines investment requirements by using the HPMS data on pavement, geometry, traffic volumes, vehicle mix, and other characteristics at the road segment level and making changes to the road segment to evaluate the benefit–cost ratio. It chooses the improvements that produce the greatest benefit for the purpose of estimating recommended improvements. It aggregates the results over all the road segments and statistically adjusts the results to get a national estimate. It thus approximates local decision-making (though of course each project still has its own much more detailed analysis before it actually gets funded).

Roads can be improved in a number of dimensions, including the capacity of the road, the strength of the pavement, and the strength of the bridges. For pavements, a *serviceability index*, which depends on cracking, variance of slope, and amount of patching, is applied, and projected into the future. *Sufficiency ratings* are also used for pavements and bridges.

As stated, today the needs studies are made by the states in a style largely mandated by the federal government. Manuals of procedure, computer information systems, and analysis programs are extensively used—embedded in the Highway Performance Monitoring System (HPMS), which includes data on the extent, condition, performance, use, and operating characteristics of roads. For instance, the pavement condition is measured on an index from 0 (extremely poor) to 5 (extremely good). That measurement produces its PSI (pavement serviceability index). Typically new roads have a PSI of 4.5 and roads are mended when the PSI drops to about 2.5.[7]

It is generally agreed that the needs studies do what they say they do (U.S. GAO, 1987). Even so, there is much to criticize. For example, a need may be recognized to increase the width of an arterial in a residential area and the cost of that action included in dollar needs. But as a practical matter, that monetary cost should not be included because the political-social cost of the improvement makes it highly unlikely (in other words, the political and social costs plus the monetary costs outweigh the benefits, indicating that it has negative net present value, and is thus not a need). Also, there are diverse pavement or traffic management strategies that might be less costly than the one incorporated in the analysis system. Moreover, the studies are not very demand sensitive; engineering standards drive needs.

The situation is in considerable disarray. Can we determine needs in a better way? Can we change the point of view of cost studies? Are additional styles of planning needed?

The needs study is straightforward in concept, but it is hard to know what goes on inside the "black box" used when calculations are made. Seemingly simple changes in standards and/or calculation methods can change results. Everybody says we need more demand-oriented methods to estimate needs, and the studies have responded by including calculations based on traffic. But is that the answer? Recently, for example, the studies have been performing triage on low-volume rural roads: the needs studies find no need because of light traffic use.

The incremental cost method was established to assign costs of construction. Should we go to cost methods more responsive to the marginal costs of using the system?

An alternative way to allocate costs is to charge based on benefits received rather than costs occasioned. Thus those who benefit most would pay the most. This is more difficult to determine, especially in an unpriced system (vehicles do not pay for each segment at each time, rather they currently pay for their share of the system).[8]

States and Counties

State planning, initiated as per the 1934 Act, was not completely coopted by needs and costs studies and by attention to construction of the interstate. Rather, it evolved into a fairly short-term routine leading to the placing of projects in the construction pipeline.

From time to time, and especially now that interstate construction is winding down, the states have undertaken broader, longer-term, and richer planning activities. Indeed, this may well be a case where planning is developing options for new policy thrusts and programs.

Our view is that there is much healthy searching by the states, and we think that the recent literature supports that view. We may well be seeing the birth of new and richer state planning activities.

Counties developed routines for road development in the 1920s. What are they doing now? That question is not easy to answer because the counties are so diverse and because state–county relations differ so much from state to state. In a few states, the county level road system is provided entirely by the state (Virginia, for example). In California, Contra Costa County (largely urban) is in a very different situation from Butte County (largely rural).

We have one remark to make that fits the case of counties that are road poor, in the sense that they have lots of mileage but little in the way of economic activity to support the road system. Those counties are engaged in minimum maintenance; they are allowing some paved roads to deteriorate to unpaved conditions. Though retroversion of pavement to gravel may be warranted, some planning that supported systematic reductions in the road net would be in order.

Interstate Era

The initiation of the interstate highway system followed a long period of gestation. Some interstate ideas can be traced to the 1920s: limited access designs, interchange designs, and the regional highway proposals of that time. In particular, in response to the logistics problems of World War I, the Pershing map of the 1920s proposed an extensive system of federal roads (Gifford, 1984).

Bureau road programs faced problems in the 1930s, the depression decade. There was the argument that Bureau work was not labor intensive, it did not respond to the need for jobs. (The argument that the purchase of things such as cement and road-building equipment created jobs was too complex for the political scene.) Road money began to flow to the Works Progress Administration (WPA), and that Administration began to supply funds for wages to urban public works departments. In response, rural road program interests began to press for Bureau-constructed toll roads. In turn, the Bureau issued its *Toll Roads and Free Roads* (BPR, 1939), a feasibility study of a 22,500 km (14,000 mile) national toll road system (three north–south and two east–west routes). The study said that tolls would pay only 40 percent of costs, and the toll proposal died. As an alternative, the Bureau proposed a 43,500 km (27,000 mile) "free" system to be built to toll road standards.

Bureau Chief Thomas MacDonald disliked the toll road concept, for it was contrary to the institutional ethic of the Bureau, *free roads for all*. He was also concerned about the likely dysfunctions of toll road institutions: self-perpetuating monopolies, nepotism, graft, and so on. There is every indication that the Bureau did not want the toll road study to find feasibility. Examining that study, one finds that traffic growth projections were modest and tolls were projected to dampen traffic growth greatly. Also, the proposals were expensive and overdesigned, certainly more than was needed at the time for much of the mileage. Interestingly, the proposed designs were one lasting impact of the toll road study. Aspects of those designs were eventually incorporated in the interstate highway system.

Returning to interstate proposals, the Bureau proposed that the system be built as a free road system, the White House asked for greater emphasis on rural roads (the proposal made for a rather thin net: two east–west routes and three north–south, as mentioned), and a revised proposal was prepared in 1936. In 1941 an Interregional Highway Committee was formed, and its 1941 report, *Interregional Highways*, recommending a 71,000 km (44,000 mile) system built to toll road standards, was enacted into law that same year. The 1956 Act, 15 years later, implemented the system. During that 15-year period a fair amount of work was done on route locations, designs, and so on. The urban extensions of the system were at issue, and they remained at issue well after 1956. Many thought that the urban extensions would prove too expensive and also that federal involvement in urban transportation was not appropriate. It is said that President Eisenhower was not aware of the urban extensions when he signed the 1956 Act, and he was not pleased when shortly afterwards he saw urban construction beginning on a drive to Camp David.

Also during that period some toll roads were constructed: the Pennsylvania Turnpike before World War II and other turnpikes in the late 1940s and early 1950s.

The Bureau's *General Location of the National System of Interstate Highways* (1955) was one result of the 15-year period of planning. There were three approaches to urban links (illustrated in figure 13.2):

1. small urban places were bypassed;
2. medium-sized urban places were served by a connecting link; and
3. larger places (where links often connected) were served by circumferential routes, as well as routes that entered the city.

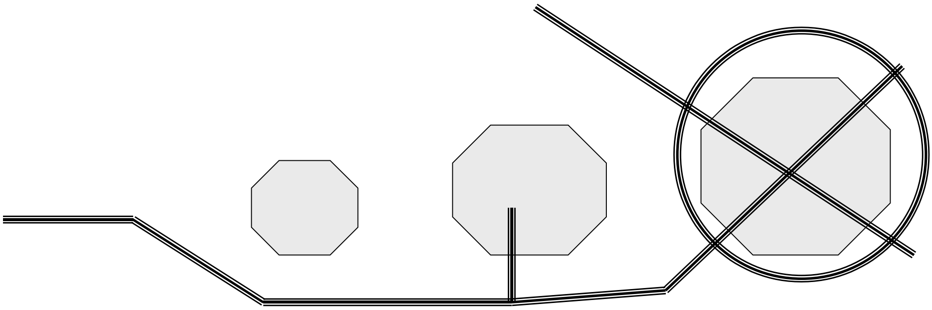


Figure 13.2. Three approaches to urban links.

The Bureau went to considerable effort to review local plans, and it had in mind the coordination of the urban links of the interstate with local plans (Horwood and Boyce, 1959).

Financing was much debated. The Bureau wanted a pay-as-you-drive system, others wanted bonds. An interesting proposal made from time to time involved taking excess property for right of way and selling it to finance the system as the system was developed and benefits emerged. The final financing decision was to use the federal fuel tax and to match state funds on a 90/10 percent basis. In 1956 the main financing question was appropriate allocation of costs to vehicles of varying size and weight, although discussion of benefit-based financing continued for several years.

There are many fathers of successful "inventions"; the interstate is no exception. Senator Albert Gore, Sr., from Tennessee, was the Senate proponent of the 1956 Federal Highway Aid Act and the Highway Revenue Act. These acts authorized $31.5 billion in federal and state aid to build the interstate highway system. There was much debate as to whether the roads should be "free" or "toll," dating from the 1930s. Gore fought against the plans to finance the highways with bonds to be repaid with tolls and was able to get enacted pay-as-you-go taxes on fuel, tires, and trucks. This "free" system clearly lowered transaction costs in collecting revenue, and increased use of the system compared with the "toll" alternative. However, it made management of the system more difficult as variable pricing (by time of day and by facility) is impossible with gas taxes, resulting in the overconsumption of urban and suburban roads and congestion that confronts commuters daily.

Many attribute the Interstate system to President Dwight Eisenhower. As an army colonel, Eisenhower made a famous cross-country journey in 1919 between Washington D.C. and San Francisco, which took two months. The road trip in that era was very much an adventure. And while roads improved in the following 36 years with the construction of the U.S. Highway system, the German Autobahn was another inspiration for the U.S. Interstate program. Eisenhower, among others, observed the relative efficiency with which Germany could move forces back and forth in a two-front war during World War II.

Federal Trucking Regulation

The extension of federal regulation to trucking appears to have posed no very difficult problems. By 1935, the industry was sizeable and growing in spite of the Great Depression. It was unregulated, and there was fierce competition among trucking firms—competition claimed to be threatening the stability of the industry. At least a few railroads were beginning to feel the threat of truck competition. An important matter was the availability of a model and an existing organization—railroads and the Interstate Commerce Commission (ICC). The depression grew and the truckers and the railroads sensed a crisis of competition. With little debate and the agreement of all concerned, regulation was enacted. Protocols previously developed for the railroads were applied. The ICC granted antitrust exemption, rate bureaus were created. The freight classes used by the railroads were adopted. Shippers paid about 110 percent of the rail carload rate for truckload shipments and about 115 percent in less-than-carload/less-than-truckload situations. The situation stabilized.

Unlike the railroads, which were no longer growing, the truckers wished to be protected from new entries. The Commission applied a good part of its resources to actions relative to operating rights. A firm could only expand through the purchase of valuable operating rights. The creation of such monopoly values hardly seems to have been in the national interest.

It is one thing to create a federal activity; it is another to change an activity. Deregulation of trucking appears to have been an extreme case on the simple side. It was difficult to develop a case for a national role for regulation of trucking, for the truck business is hardly a natural monopoly, nor do the fortunes of a few firms have national impacts. In addition, there was the recent model of rail deregulation, which occurred in 1980.

Efficiency gains from trucking deregulation are said to save shippers about $25 billion per year (about 10 percent of the truck freight bill). Several old line, unionized less-than-truckload lot (LTL) carriers had difficulty adjusting to the deregulated environment and went out of business. The adjustment period seems to have passed quickly (Glaskowsky, 1986).

Yet, the desire of the trucking industry for a trucking agency in the USDOT is an example of a desire to have an advocate with influence in power, even when regulation is slight. This modest change in structure, promoting an existing group, resulted when the Federal Motor Carrier Safety Administration was created in 1999 (taking responsibility out of the Federal Highway Administration). Here the dysfunction was that other modes were represented in the Department, but trucking wasn't. The American Trucking Association heralded the agency as "a major victory for highway safety" (ATA, 1999).

Discussion

Turnpike and other early road experiences were building blocks for twentieth-century road program governance, construction, and financing. In addition to the transfer of railroad regulatory experiences, which were applied to the trucking industry, the railroad experience affected construction because railroad engineering was the training experience for many civil engineers.

But while the railroads integrated rolling stock and track in the same organization (if in separate legs), the highway system differs. This has posed a great number of system difficulties, many of which will be discussed in the next chapter on urban highways. However, the disjoint control of trucks (owned by trucking firms) and pavements (owned by governmental road agencies) has created a number of extra costs that proper management of the system might avoid. Pavements are rated for different loads of trucks; roads are restricted to 5-ton, 7-ton, 9-ton, and 10-ton axle weight trucks. Shipments across this network are constrained by the lowest weight limit permitted on the roads to be used (or risk violation—though weight enforcement off the interstate highways is very sparse). Some roads should be upgraded, some trucks should have more axles, but the disjoint nature of the control makes this coordination difficult. A major solution to these problems lies in rethinking highway financing. The ability to charge truckers different amounts for different roads would put the proper incentives for behavior back in the system (Small et al., 1989). Economists have been arguing this for several decades, and the policy community, which has some working examples and the promise of modern revenue collection technologies, is finally absorbing it. A second solution, to improve materials to the point that they are "too cheap to meter," that is, so that they are sufficiently strong that the load using them doesn't matter (within reason), is the analog to building your way out of congestion. Laying pavements with near zero variable (per use) costs may be technically possibly, but their upfront fixed (one-time) costs are likely to be very high.

14

Urban Highways

People of Earth, your attention please. . . . This is Prostenic Vogon Jeltz of the Galactic Hyperspace Planning Council. As you will no doubt be aware, the plans for development of the outlying regions of the Galaxy require the building of a hyperspatial express route through your star system, and regrettably, your planet is one of those scheduled for demolition. The process will take slightly less than two of your Earth minutes. Thank you. . . . There's no point in acting all surprised about it. All the planning charts and demolition orders have been on display in your local planning department in Alpha Centauri for fifty of your Earth years, so you've had plenty of time to lodge any formal complaint and it's far too late to start making a fuss about it now.
—Douglas Adams, *Hitchhiker's Guide to the Galaxy*

Introduction

On January 23, 1959, the San Francisco Board of Supervisors voted to remove seven of the ten planned freeways from the City's master plan. The Embarcadero Freeway, which had already been constructed from Folsom Street to Broadway, was halted, mid-ramp so to speak, and left to sit there for another 30 years until the Loma Prieta earthquake prompted the city to pull down the remainder and reopen the waterfront.

On November 2, 1956, the *San Francisco Chronicle* published a map of the proposed freeways through San Francisco while its editorial page was noting about the emerging revolt:

> The remarkable aspect of these protests and claims of injury is their tardiness. They concern projects that have for years been set forth in master plans, surveys and expensive traffic studies. They have been ignored or overlooked by citizens and public officials alike—until the time was at hand for concrete pouring and when revision had become either impossible or extremely costly. The evidence indicates that the citizenry never did know or had forgotten what freeways the planners had in mind for them.

The newspaper was referring to protests including a petition signed by more than 30,000 residents of affected neighborhoods.

The "Freeway Revolt" which sparked the Board of Supervisors move was a bitter fight between citizen-activists and the professionals. It was a revolt that was to be replayed in many other U.S. cities over the next three decades, with different outcomes depending on the city.

The revolt in San Francisco was reported in many newspapers across the United States. It is often taken as an urban anti-interstate revolt, but as the western terminus of Interstate 80, the interstate mileage was minimal. The freeways were to be state and city planned and funded. The plan, first developed in 1947, was only partially completed.

The now mature urban vehicle-highway system is large and intertwined in most facets of American life. Yet, the vehicle-highway system is almost never treated as a system. People talk about highway policy, automobile policy, safety policy, congestion policy, truck weight policy, and so on. Historically, public policy has been directed to the provision of highways, although Interstate Commerce Commission regulation was extended to interstate truck operations during the 1930s, at the same time the states began to regulate intrastate trucking. Beginning in the 1960s, and in response to Ralph Nader's *Unsafe at Any Speed* (1972), U.S. federal safety policy has been significantly extended.

The auto-highway system (AHS) and the truck-highway system (THS) use common fixed facilities, which requires some common features of the equipment. The organization and technology of equipment production also have some common features. The systems differ in their functions, and this is reflected in the operations components of the systems.

A variety of firms operate in the truck-highway system: specialty carriers, less-than-truckload lot (LTL) common carriers, owner-operators, and so on, and smaller trucks are often used for both personal travel and hauling freight. Considerable variety also appears among the users of and the functions performed by the auto-highway system.

We should recall the sheer size of the systems. According to the U.S. Bureau of Transportation Statistics (year 2000 data), the average person in the United States travels a little over 16,000 km (10,000 miles) per year and the bulk of that is by automobile. The average vehicle (cars, motorcycles, trucks, and buses) is driven about 19,300 km (12,000 miles) per year. About 19,000 ton-km (13,000 ton-miles) of freight are moved per year per capita. Of average household expenditures of $38,045, transportation consumes 19 percent or $7,417. Of that, private vehicles consume $6,990 ($1,291 in gasoline, $3,418 in vehicle purchases), and public transport the remaining $427 (of which $274 is airline fares, and only $47 is mass transit).

Different growth processes seem to be running in systems. The auto-highway system has a buy-in character. When the family obtains an automobile, travel increases. So as we have automobilized, aggregate travel has increased as more and more households have bought into the system. Now, most have joined, and increases in aggregate travel result mainly from population increases. This is a simple point, yet one often sees projections of vehicle miles of travel (VMT) that assume that historic growth rates will hold in the future. In fact in the year ending in December 2000, VMT growth was negative for the first time since the data were tracked (though in the following year it rose again).

We address urban highways in this chapter. Though the formative experiences are similar, and result from the same laws, urban and intercity systems serve very different purposes and have very different problems. We profile Robert Moses and Jane Jacobs, two icons of the highway and antihighway movements, respectively. We discuss the formation of the urban interstate system, and examine the cases of I-94 in the Twin Cities and the Big Dig in Boston.

Profile: Robert Moses

Robert Moses was born in New Haven, Connecticut, in 1888, the son of a department store owner and grandson of a New York merchant. He studied at Yale and Oxford, and received a Ph.D. in Political Science from Columbia in 1914. His first job was with the Bureau of Municipal Research, a data-crunching organization in New York that let him work on city budget issues. After World War I, he led New York's Committee on Retrenchment and Reorganization, and thus aligned himself for Alfred E. Smith and the good government movement that emerged during the 1920s. He rose through the political ranks, and in 1927 was appointed New York's Secretary of State.

Though he had tangles with Smith's successor as Governor, Franklin Delano Roosevelt, Moses was able to leverage the power accumulated while under Smith to keep him in a dominant position in New York infrastructure for the next 35 years. In 1922, Moses drew up the New York State Park Plan—which included the ability to issue bonds to rehabilitate parks, and to build parkways, and more importantly, highways leading to the parks. In 1924 Moses became Chairman of the State Council of Parks, and also was president of the Long Island State Park Commission.

His parks, especially on Long Island, were very successful, and New Yorkers clamored to reach them. In 1930, Moses extended the parkways into the city. These parkways were 90 to 180 m (300 to 600 ft) wide, gracefully curving, with no traffic lights and low overpasses (thereby prohibiting both trucks and buses from using them). Roadside commerce was also prohibited aside from special rest stops.

His success with the parks and parkways led the new Governor, Herbert Lehman, to make him chair of the Emergency Public Works Commission in 1933. This commission promoted new river crossings over the Hudson and East Rivers in New York, which would be toll bridges, which would require toll authorities, which naturally would be run by Moses. These authorities were self-sustaining and self-liquidating organizations, supported by user fees, which could issue bonds repaid by future revenue. They were new publicly authorized monopolies without elected leadership. In 1933, Mayor LaGuardia asked Moses to serve in his city cabinet. Moses agreed provided he could retain his other positions. Unlike present-day politicians, Moses was able to hold state and city positions simultaneously, allowing his empire to grow.

Aside from an independent revenue stream and the control of multiple agencies at city and state level, Moses' tools included having his plans ready and fully designed before the money became available, thus allowing him to deliver projects quickly. Today, projects have to go through lengthy design and environmental approvals before they can be started. So even if cash is available, it will be years before the ribbon cutting. Somewhat more deviously, Moses tended to underestimate the cost of projects, so they would be started, and costs and quality desired would escalate: he offered the sponsoring politicians two choices, provide more money, or he would stop construction and the politician would have to explain why he wasted all that money building a half-finished useless project. Though this happened repeatedly, politicians were always willing to swallow the promise of the low cost because Moses had the reputation of delivering the ribbon cutting before the next election.

It would take far too long to list all of Moses' achievements here. Robert Caro (1975) wrote a 1344-page book, *The Power Broker*, describing and decrying what Moses did to the city. But whether he was loved or hated, he radically reshaped New York into a modern city using parks and road building as his tools.

Profile: Jane Jacobs

Jane Jacobs was born in 1916 in Scranton, Pennsylvania, the daughter of a doctor, and moved to New York at the age of 12. She too attended Columbia University and afterwards entered the publishing industry as an editor and writer for magazines such as *Architectural Forum* and *Fortune*.

A student of the city, she has published several books, including the *The Death and Life of Great American Cities* (1961). In that first book she celebrated the rich, textured chaos of urban streets, like her neighborhood in Greenwich Village, which had shopkeepers and other citizens monitoring the public spaces as "eyes on the street." She railed against urban renewal and freeway building (such as Moses' Cross-Bronx Expressway) that gutted organically arising places, vital centers of urban life, and replaced them with artificial inhumane spaces.

In 1962 she became Chair of the Joint Committee to Stop the Lower Manhattan Expressway. Sponsored by the Downtown Lower Manhattan Association, led by David Rockefeller, the Lower Manhattan Expressway was proposed by the highway builders (including Moses) and incorporated into the interstate highway plan to provide, as the name suggests, a new eight-lane limited access roadway from the west side of Manhattan (the Holland Tunnel) to the east (the Manhattan and Williamsburg Bridges). (It had sister projects, the Upper Manhattan Expressway and the Mid-Manhattan Elevated Expressway.) The road would have bisected neighborhoods such as Greenwich Village, Little Italy, Chinatown, and SoHo, displacing thousands of residents, merchants, artists, and artisans. In December 1962 the highway was canceled and Moses was defeated by a woman he had called a "busy housewife." In April 1968 she was arrested in another protest against the highway. (In transportation infrastructure, "no" rarely means "no.") The collective protests ultimately led to the highway being cancelled.

Budgeting Urban Highways

A review of the work of the Bragdon Committee (actually, General Bragdon and staff) will assist in summarizing the mood of the 1950s. The treatment of the work of that committee is based on discussions with Ellis Armstrong, Commissioner of the Bureau of Public Roads around the time of the events described, Lee Mertz, former head of planning at the FHWA, and Paul Sitton, in the Bureau of the Budget at the time. On this topic and the urban interstate generally, see the full review by Gary Schwartz (1976). Schwartz emphasizes financing, examples, and legislative history.

President Eisenhower depended on staff work very heavily, as many administrators must. He supported the Interstate Act of 1956 as a measure to counter unemployment, and his Assistant for Public Works Planning, General J. S. Bragdon, began to give the interstate his attention.

The 1956 Act had authorized the expenditure of $27.5 billion over 13 years for the construction of the interstate. Bragdon was shocked in 1958 when the interstate cost estimate (ICE, the cost to complete) came in at $39.9 billion and the end date slipped into the 1980s. Bragdon, working with the Bureau of the Budget, took it as his task to correct the situation, and worked for a couple of years to get the estimate under control and trimmed down.

Working with a staff of about 25, Bragdon made analyses and made suggestions to the BPR (through the Department of Commerce where it was then housed). A dozen or so memos record Bragdon's recommendations and the BPR's reactions. Bragdon was very concerned about the money required for the program. He suggested expenditure reductions, and the BPR typically countered these by reference to the Act and Congressional intent.

Bragdon suggested that the states that wanted to accelerate programs build toll roads. They could use the money from those tolls to accelerate the provision of untolled facilities. The net effect would be to speed up construction.

Though he was interested in toll roads, Bragdon's main thrust was reduction of expenditures in urban areas. His argument was that the Congress had not intended to manage urban problems. He made many proposals suggesting limiting the number of lanes in urban areas, no capacity for rush hour traffic, limited number of interchanges, building outer loops only, and limited number of spurs into the cities. All of this was to keep the cost down. He argued that the Secretary of Commerce had the power to take routes off the interstate and should take some urban routes off.

Bragdon did not understand the progressive, cooperative traditions of the Bureau, as discussed by Seely (1987). Many of his suggestions were unthinkable in that context.

A point of difficulty for Bragdon was the lack of information on where roads were needed in the urban areas. The BPR and AASHO had been working with the American Municipal Association and had plans for 149 of the 288 cities of over 25,000 in population, and 45 more were on the way. Bragdon did not think it was proper that the BPR was responding to what the cities wanted. He demanded that planning be required by the BPR. While it was to be comprehensive, it was to be in the frame of strict policy on state–local arrangements (i.e., Bragdon's ideas of how urban extensions should be allocated). Plans, as Bragdon imagined them, could be completed in two months.

As remarked, the Bureau was working with the AASHO and the American Municipal Association in a cooperative style. It had arranged the First National Conference on Highways and Urban Development at Sagamore, Syracuse University, New York, in 1958, which addressed design and planning issues.

Returning to Bragdon's demand that planning be mandated, the BPR countered that it did not have the power to require planning. That remark may seem strange from the perspective of today, for the federal government now requires significant planning efforts from local and state governments. The issue is a constitutional one. The constitution allows Congress to tax to "provide for the common defense and the *general welfare* of the United States." But there is another clause that the states have all the powers not specifically reserved for the federal government. The debate over the meaning of the welfare clause began with Hamilton and Madison, and there is a parallel long trail of court cases.

In the early days of the Bureau's programs, funding was allocated according to post road mileage, for providing for the mail was one of the powers of the federal government. Later, no questions were raised about matching money for the federal aid system.

An additional question to be settled was whether the federal government could withhold tax monies it has collected to get the states to do something. That was the leverage the Bureau would have to use to get planning started—either plan or no federal money will be available.

The power of the federal government to withhold funds was not settled by court cases until the 1970s, and it was that unsettled question that had made the Bureau go slow in requiring planning.

There was a "showdown" meeting between Bragdon, the BPR, and Eisenhower in 1960. It is recorded that Eisenhower said that running the interstate through congested cities was not his concept and wish. However, the BPR pointed out that the "Yellow Book" (showing urban extensions) was in the hands of Congress, and it was responsible for the 90/10 formula (90 percent federal funding, 10 percent state), rather than 60/40 as first proposed. Because Congress knew of the urban extensions, the program was committed to them.

Our interest in Bragdon's work is because it represents some of the thinking of the times. There was the fear that urban expenditures formed a monetary black hole. Was urban congestion a federal government problem? The interstate cost estimate kept going up and increases in taxes or program stretch-out were not popular. In the early 1950s, there had been considerable questioning of whether a federal program was needed.

Our view is that the thinking of the times resulted in the urban interstate being built on the cheap, or at least contributed to it. The centerline mileage of links was limited, capacity was increased by adding lanes. A lower level of service was accepted in urban areas compared with rural areas.

Cheapness producing congestion created by channeling traffic onto a limited mileage facility is our main point. There was little or no debate about improved arterial, parkway, limited truckways, or other alternative designs. In spite of the multiple lanes constructed to serve estimated traffic for 20 years, interstate links were soon congested.

How did we get into this mess? Schwartz (1976, p. 512) says, "If there was a moving-party heavy for the urban interstates, it was the cities themselves rather than the highway lobby. . . ." He points out that city planners were generally in favor, and that politicians looked to free money from the federal government. Alf Johnson of the AASHO and some of the BPR managers that Garrison knew cooled on involvement in urban areas as the many problems became apparent. The regard for the Bureau of Public Roads was quite high, as suggested by the event in box 14.1.

Building Urban Highways: The Case of I-94

Aside from the urban freeway revolts, the construction of the interstate proceeded about as well as can be expected in most cities. Although over budget and late, it was eventually built. One such case is I-94 between Minneapolis and St. Paul, Minnesota.

Between 1947 and 1950 vehicle registrations in the Twin Cities increased 58 percent (Altshuler, 1965, p. 21). St. Paul officials realized that they needed to solve congestion and other transportation problems. Previously, city officials dealt with increased congestion by widening existing links. This option was becoming increasingly expensive as the city grew. Freeway plans were developed connecting downtown Minneapolis and downtown St. Paul, but it was not until the Federal Aid Highway Act of 1956 was

BOX 14.1 Regard for the Bureau of Public Roads

Ellis Armstrong, Commissioner of the U.S. Bureau of Public Roads from 1958 to 1961, told a story to Garrison some years ago, one of many that Garrison has heard illustrating the independence and professionalism of Bureau leaders. After receiving letters and phone calls from (then) Senator John F. Kennedy, Armstrong agreed to meet with politicians and business leaders who argued for a shift in the location of the Interstate south of Boston.

Leaving the meeting and greeted by Boston reporters and TV cameras and asked for his comments, Armstrong remarked, roughly, "I've received lots of interesting information but I have to take it back to Washington for study. The Interstate is a carefully planned and balanced system. Moving a link 10 miles to the south here means we will have to consider moving the entire system 10 miles to the south."

Concerned that his attempt to be humorous might backfire, Armstrong was relieved that, when the story played on local television, no one questioned his remarks, nor did Senator Kennedy. That, it seems, is a comment on the confidence and authority that Bureau professionals had gained through years of service. Perhaps it also says that some citizens recognized that nonlocal concerns mattered.

implemented that it became certain a freeway would be constructed. The Federal Aid Highway Act ensured there would be funds available (90 percent federal to be matched by 10 percent state). With the construction of some freeway ensured, the next step was to determine which route it should follow.

St. Paul and state officials recommended that the route follow St. Anthony Avenue, a largely residential city street parallel to the busiest route between the two cities (University Avenue), which happened to run through a minority neighborhood (The Rondo).

George Herrold, St. Paul's Chief Planning Engineer until 1952, argued against the construction of a freeway along this route. He proposed a plan dubbed the "Northern Route" about a mile to the north of the St. Anthony Route. The Northern Route, because of its use of existing railroad right of way and industrial land, would not displace many residents or sever neighborhoods. In St. Paul, the St. Anthony Route divided the state capitol and government buildings from the central business district. Despite Herrold's advice, St. Paul and state officials would not deviate from the proposed St. Anthony Route.

With the St. Anthony Route all but built, concerned residents began to speak out. The St. Anthony Route would displace nearly one in seven of St. Paul's African-American residents. African-American community leaders quickly concluded that it would be nearly impossible to divert the freeway, so they devised a list of actions they requested government officials to comply with: help displaced residents find adequate housing, provide proper compensation, construct a depressed (below grade) freeway to enhance aesthetics. The displacement of the African-American community members was especially significant because there were few options available to them. At the time (the 1950s, before fair housing laws were enacted), most white communities would neither sell homes to them nor rent property to them. For this reason, officials feared that the African-American community would become overcrowded. In the end, only the second and third actions were followed through.

The Prospect Park neighborhood in Minneapolis was also severed by the St. Anthony alignment, and there were worries that the freeway would turn this diverse upper-middle-class neighborhood into a low-income one. Residents claimed that having a low-class neighborhood within close proximity to the University of Minnesota would make the University unappealing to students and faculty. The community had one request, that the freeway be placed over an existing railroad spur; however, limited funding prevented this idea. The freeway did, however, skirt the Malcolm E. Willey House designed by Frank Lloyd Wright. Despite the freeway separating the neighborhood from the Mississippi River, the neighborhood did not deteriorate. The freeway was completed in the late 1960s.

Aesthetically, the I-94 freeway is a scar across the surface of the city, which in addition to having displaced residents and disconnected local streets, has moved traffic from a relatively even distribution to a more hierarchical one, so that movement depends on fewer, now more critical links. While certainly more people are moving longer distances everyday on the urban freeway, congestion has far from disappeared. One can ask in retrospect whether building the road was the right thing, or whether building it *there* was the right thing, but there is no real "control" for this experiment. Asking what-ifs is easy, answering them is harder. But no one is seriously calling for the removal of this element of the interstate system, suggesting that the collective intuition of those who think about the road daily argues that "sunk costs are sunk," and while in retrospect not everything was done perfectly, leaving it in place is better than removing it.

Rebuilding Urban Highways: The Case of The Big Dig

Perhaps the last major construction project on the urban freeway system is the "Big Dig," Boston's relocation of its urban freeways from an elevated highway to underground.

The story of the Big Dig began with the preinterstate construction of the Central Artery, an elevated highway through downtown Boston that was funded by the state. Like other highways constructed in the United States in the 1950s, the highway reduced traffic congestion in Boston for a while, but by the mid-1960s Boston's highways and local roads were again heavily congested. Highway planners proposed a ring road around the downtown central business district as a solution to the congestion, and a third tunnel was proposed in 1968 for construction between downtown Boston to near Logan Airport.

The question of whether additional roads should be built raged in Boston during the late 1960s and early 1970s. Two projects survived: a restricted use tunnel from downtown Boston to Logan Airport, and reconstruction of the Central Artery that would relocate the highway underground, eliminating the division between downtown Boston and Boston's North End and Waterfront neighborhoods, which had been determined to be a detriment to the City by this time.

Over the next 20 years, the Central Artery/Tunnel project evolved through complex negotiations into what is being constructed today—the most expensive urban highway project ever undertaken in the United States. The project was only made possible because in the early 1980s the Speaker of the House of Representatives, Thomas P. "Tip" O'Neill, served the Boston area, and on retiring was able to get the highway as a "present" from the Congress and then President Ronald Reagan. Nearly every component of this project underwent numerous modifications to address concerns of special interest groups, modification that often resulted in raising the concerns of other special interest groups. Mitigation costs mounted. Ultimately it is expected that most of the project's more than $14 billion cost is due to mitigation. The engineering challenges of constructing a tunnel underneath a highway, while keeping that highway operating, should not be underestimated[1] (Hughes, 2000; Altshuler and Luberoff, 2003).

The Big Dig is an exception to highway planning in the last quarter of the twentieth century. The Clean Air Act Amendments of 1990 (CAAA-90) restricted highway development in air pollution nonattainment areas and promoted actions to restrict vehicle uses. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA-91) reformulated funding to allow for a "level playing field" between transit and highways, allowed for direct relations between the feds and councils of governments in large urban areas, authorized increased funding for transit, and also authorized a National Highway System (NHS). Legislation in 1995 implemented the NHS. The Transportation Equity Act for the 21st Century (TEA-21) basically followed the formula of ISTEA. Another attempt to build a new urban transportation facility was the Alameda Corridor, described in box 14.2.

Discussion

Let us review the overall situation and inquire about prospects.

The rapid growth of cities beginning in the late 1800s accelerated the provision of urban roads, and the cities built institutions and took actions appropriate to their needs. They created public works agencies, imposts on property owners paid for the construction and maintenance of local streets, and with experience, ways were found to fund and build parkways, viaducts, and arterial streets and to broaden funding bases using property taxes on vehicles and tolls on costly facilities. Design and planning concepts emerged; every Grand City needed a Robert Moses-like Grand Plan. Planning was strengthened as the states passed legislation enabling city planning and zoning for the control of land uses.

Although there was much progress there were nagging problems: street and railroad conflicts, state highways that dumped traffic on city streets, congestion, and graft and corruption in street programs. Suburbs enabled by streetcar services were quickly becoming automobile suburbs and there were hints of the suburbanization of employment. Running faster just to keep up with the increasing use of automobiles was the response of street construction and traffic control programs. But their progress stumbled when the Great Depression of the 1930s reduced funding from property taxes.

Urban growth resumed in the late 1940s and 1950s and by and large the cities had ambitions, institutions, and plans but little money. But there was hope because state and national political stages were changing as the balance of political power gradually shifted from rural to urban areas. (There was lag; the population of urban areas exceeded the rural population by the 1920s.) By 1950 political support for federal and state expenditures in cities was in sight and almost in hand for highways and many other programs.

The picture just painted was the context for snapshots presented in this chapter—the Bragdon Committee reports, the freeway revolt, the building of limited mileage

BOX 14.2 The Alameda Corridor

The Alameda Corridor is a system of rail routes that connect the California ports of Los Angeles and Long Beach to downtown Los Angeles 32 km (20 miles) north. In the 1990s, the ports of Los Angeles and Long Beach became the busiest ports in the United States due to the enormous expansion in Pacific Rim trade. Los Angeles and Long Beach ports are first and second in the United States for container shipments, with 5.18 and 4.46 million TEUs (twenty-foot equivalent units) respectively for the year 2001. They are third in the world for container shipments, behind Hong Kong (17.8 million TEU) and Singapore (15.5 million TEU) (Goodwin, 2002). Congestion on the rail routes spilled over onto highways because the railroads had track on the streets. Additional freeway congestion resulted from container traffic. The Alameda Corridor project aimed to increase efficiency in movement of cargo throughout the United States and to overseas markets.

The Southern California Association of Governments (SCAG) formed the Ports Advisory Committee (PAC) in October 1981 to improve highway and rail access. PAC members included local elected officials, representatives of the ports of Los Angeles and Long Beach, the U.S. Navy, the U.S. Army Corps of Engineers, the railroads, the trucking industry, and the Los Angeles County Transportation Commission (LACTC). First, PAC dealt with the problems of highway access to the ports. The committee recommended numerous small-scale highway improvements, which were completed in 1982. The trains were consolidated on an upgraded Southern Pacific San Pedro Branch right of way in 1984.

The Alameda Corridor Transportation Authority (ACTA) was created in August 1989 by the cities of Long Beach and Los Angeles. A seven-member board representing the cities and ports of Long Beach and Los Angeles and the Los Angeles County Metropolitan Transportation Authority (MTA) governs ACTA. ACTA believed that the project was not going to be accomplished without federal intervention and invited Congressmen and other elected officials to the ports to see the seriousness of the situation. Congress in 1995 identified the Alameda Corridor as a "Project of National Significance," which secured federal funding for the project. Congress appropriated a loan of $57 million for the project in 1997. The U.S. DOT authorized a $400 million 30-year loan for the project in 1998. The ports provided an additional $394 million. ACTA utilized the "design-build" construction process, wherein a single firm was responsible for both the engineering and construction of the project, and the engineering would not be finished before construction began. To finance the project, ACTA sold $1.2 billion of revenue bonds in January 1999, with additional funding from California state grants and sources administered by the Los Angeles Metropolitan Transportation Authority. The total financing package was approximately $2.43 billion (Hankla, 2001). The loans, grants, and bonds will be repaid by user fees from the railroads, ranging from $15 for a 20-foot and $30 for a 40-foot container.

The Alameda Corridor Project began operation on April 15, 2002, with 33 trains using the corridor. It is estimated that 100 trains will use the corridor by the year 2020. Plans are being made to extend improvements eastward from downtown Los Angeles.

high-capacity state/federal facilities in cities, the actions of Robert Moses and his imitators, and almost half a century later, the status of the urban road system. The heavy hand of the experience is there, but have we learned from it?

One might say that we have learned to balance local, state, and federal interests and to pay more attention to the social and environmental impacts of large programs. That is a matter of style and equity. It is important. But how well balance and compromise are achieved is debatable. One thing is certain: project and program approvals require resources of time and money. Obtaining action requires a trail of studies and plans, a posture of local, state, and federal cooperation and funding, and providing funding to compensate for negative impacts. Burdened by "What's mine is mine and what's yours is open to debate" negotiations, obtaining approvals is costly, and one wonders if high transaction costs constrain the search for innovation.

Imperatives for congestion relief, improved public health, the city beautiful, and large parks in rural settings affected city building in the late nineteenth and the early twentieth century, and imperatives continued to drive programs. Defense, congestion, and employment in public works construction and equipment manufacturing energized creation of the interstate and its urban extensions. Today there is emphasis on constraining urban sprawl and the automobile. The cynic might say that we have learned that programs require claiming imperatives for action.

Coupled with high transaction costs, imperatives have given us "megaprojects" such as Boston's Big Dig and the Alameda Corridor. To tame the automobile imperative constrains funding leading to an underinvestment in roads. Of smaller size are projects and investments in nonroad-based transportation projects (transit) in response to congestion and environmental imperatives. Congestion and funding imperatives drive interest in tolls, and congestion drives interest in advanced traffic control systems.

The paragraphs above strove to say where we are using the languages of programs and events. Speaking in a more general fashion, the authors see the spinning out of the maturing of the auto and truck highway system in urban settings. The system's institutional and technological aspects are rather fixed, and strident claims of imperatives are needed to nudge its evolutionary path. With maturity, productivity growth comes hard and there is market channeling as efforts are made to fit the system to market niches.

Will market channeling uncover new formats that renew urban transportation services? Might the building blocks of abandoned railroad routes and yards, congested highways, heavily subsidized transit services, preautomobile walking streets, and other relics from urban transportation history merge with modern sensing and communication technologies and create new futures?

15

Canals and Rivers

In the space of one hundred and seventy-six years the Lower Mississippi has shortened itself two hundred and forty-two miles. That is an average of a trifle over one mile and a third per year. Therefore, any calm person, who is not blind or idiotic, can see that in the Old Oolitic Silurian Period, just a million years ago next November, the Lower Mississippi River was upwards of one million three hundred thousand miles long, and stuck out over the Gulf of Mexico like a fishing-rod. And by the same token any person can see that seven hundred and forty-two years from now the Lower Mississippi will be only a mile and three-quarters long, and Cairo and New Orleans will have joined their streets together, and be plodding comfortably along under a single mayor and a mutual board of aldermen. There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact.
—Mark Twain, *Life on the Mississippi*

Let no one who wishes to receive agreeable impressions of American manners, commence their travels in a Mississippi steamboat.
—Frances Trollope, *Domestic Manners of the Americans*

Introduction

The Kentucky River joins the Ohio River about midway between Louisville and Cincinnati. It drains the Blue Grass country and extends to the coalfields of eastern Kentucky. River development was essential to settlement in the early days, and Kentucky made surveys and plans for improvement as early as 1798. The appearance of steamboats on the River in the 1810s pressed for funds for channel clearance. To deal with the problem of low water several months of the year, Kentucky asked the federal government for a survey. The survey was made, but at that time the federal government invested where rivers formed state boundaries and individual state interest was blurred. Augmenting the federal survey with a state survey, the state developed a plan for 15 dams and locks, maximum lift 4.6 m (15 ft), to manage the 69.5 m (228 ft) change in elevation of the river from the Ohio to the mountains. Considering the flow of the river and potential traffic, it was decided to construct 11.6 by 51.8 m (38 by 170 ft) locks and seek a channel depth of 1.8 m (6 ft). Work began in the 1830s, and by the 1850s the lower 193 km (120 miles) of the river had been improved. The locks were stonemasonry, but the dams were inexpensive stone-filled timber cribs.

The state issued bonds to fund the improvements; tolls were collected. However, the tolls just covered operating costs. No money was available to repair existing dams, much less extend service upriver. To cope, the state turned operations over to a private company, and it had no better success than the state. What is worse, the dams fell into disrepair and became mainly an obstruction to downstream navigation of floating logs. The state went to the courts and managed to regain control; it debated a new financing plan. At the same time, it asked Congress for help, and the Rivers and Harbors Act of 1878 was the first of a series of acts for improvements on the river.

Work began and continued for decades. To start, existing dams were rebuilt and new dams upstream were added. Interestingly, the first upstream dam was at the head of navigation, Beattyville, in the three forks area. Users there wanted a slack water pool for the storage of rafts and barges. Sudden release of water (through beartraps) in the spring was used to float tows to the improved part of the river.

But questions began to be asked about the improvements before the march upstream produced many new dams. The railroad was in the region by about 1850, and it had extended service to the Beattyville area by the turn of the century. The railroad captured packet boat and coal traffic, coal barges were no longer being used. The only traffic was log rafts, and dams and locks were in the way of that traffic.

Even if the improvements were completed, would the river recapture coal traffic? Recapture was in doubt. Coal from Pittsburgh could move to Carroltown at the mouth of the Kentucky River in about the same time as the Beattyville–Carroltown move, and the latter was more expensive because of the smaller-scale facilities.

The U.S. Army Corps of Engineers pointed out the problems. People in Kentucky wanted the improvements and the march upstream continued into the 1920s working directly with the Congress. Eventually, 14 locks and dams were constructed and about 400 km (250 miles) of the river were improved. Some occasional traffic occurred, but in small amounts. In 1970, the Corps abandoned its responsibility for locks 5 through 14, and the state took them over. Now only recreational traffic uses the locks. The Kentucky River story is one from a larger set of stories now to be explored.

Water is one of three media through which transportation takes place (the others are over land and in the air). Most chapters in this book focus on land transportation, roads and rails, and we shall devote a later chapter to air transportation. This chapter focuses on inland water transportation. That said, water is not a single mode; while in general water transport requires boats of some form (few of us walk on water), rivers and canals and lakes and coasts have very different requirements than open seas and oceans. This chapter explores the deployment of inland waterways. Inland waterways include river improvements and canals, as well as coastal waterways.

River Improvements

Prior to the canal era, England's coastal and river trade took place using flat bottom sailing barges that could move 40–80 tons. The trade mainly centered on London. Coal, cattle, grain, building materials, and other commodities were moved to serve the needs of London. Rivers served collector-distributor functions for trade routes across open seas. Though technological change was slow in both dock and barge technology, more docks and barges were constructed as the coastal trade grew.

The developments of interest were river sited. On account of tides, wet dock construction was needed. A good bit of organization, construction, and financing experience accumulated in response. The low value of many of the commodities moved and the high costs of land transportation urged movement of barges as far inland on rivers as practical.

River navigation posed some physical difficulties: large tides, low water levels during some seasons, dredging needs. Use conflicts developed. Mill operators had dams and resisted releasing water for navigation. Owners with riparian rights claimed tolls for improvements or for the use of the embankments for pulling boats or transshipment and/or could resist river improvements.

A pattern seems to have evolved. Prior to 1500, city corporations were given river development authority (for instance, the City of London started developing the River Thames in 1179). Later, the Crown gave development authority to local landowners who put forward specific development and toll schemes. The latter is of interest because it is part of the model carried over to the canal era.

Canals in the United Kingdom: Eighteenth Century

The river experience yielded the first institutional form for canals, while technological experience carried over. River development utilized dredging, flashboards (structures placed alongside the water to increase the amount of water that can be contained), and locks. Lock technology, in particular, could carry over directly as could some of the dredging technology. John Smeaton, later a famous canal engineer, obtained his first experience on river projects. The flashboard system required a good water supply, and canals could not be so wasteful of water.

The beginning of England's canal era was marked by the Duke of Bridgewater's 12 km (7.5 mile) canal from coalmines on his estate at Worsley to Manchester. Construction began in 1759, and the canal opened six years later. This was not a construction first, there had been long experience on the Continent, and some canals had been built previously in Ireland and England.

Bridgewater's canal had some interesting technological features. It tied into his mine drainage scheme, and the boats ran into the mine for loading. Although the canal could accommodate larger boats, the within-mine operations kept the beam of the boats to about 2.1 m (7 ft); they were 15 m (50 ft) long. In order to hold water, the canal was lined with puddled clay, and to avoid extensive lock construction an aqueduct was constructed over the River Irwell.

Bridgewater's canal caught the imagination of the public; it was a financial success, so it also caught the imagination of developers and investors. The result was a flurry of inland navigation acts between 1759 and 1794. Most of these were narrow canals, using boats of the same width as on Bridgewater's canal. Adoption of the standardized (2.1 m) boat width kept construction costs down and saved water, a problem for many canals. (Bridgewater quickly built a canal connecting Manchester to the coast; there had been starts before, and much later a ship canal was built.) Boats ran to 21 m (70 ft) in length, could carry about 30 tons, and were hauled by a horse walking along the side. Canal building yielded valuable experience with earth moving, lock structures, bridges, aqueducts, and tunnels as well as other civil engineering tasks. Construction activities were institutionalized, and navigators became "navvies."

Although navigation acts were private acts, the policy-institutional aspects of canal building began to fall into a pattern. Canal companies were organized and issued stock. Rights of use carried over from roads, and acts began to require that anyone could operate a boat if tolls were paid. This was not the case for Bridgewater's canal. Companies, such as Pickfords, emerged to offer canal plus pick-up and delivery service (Turnbull, 1979).

By the 1820s, the era of canal building in England was over. In part, the system was "built out" in that the feasible canals had been built and rail competition came along.

Developments were considerable on any scale, but England was not the leader in Western Europe. Building on Leonardo's invention of the miter gate with sluices, France, the Low Countries, and North Italy were well served by networks of canals by the late eighteenth century. The Canal du Midi dates from 1666. The decision to adopt standards suited for Flemish boats was taken in 1810, and a general plan for the canalization of France was adopted in 1820. (Another plan was developed and implemented in 1880, at a time when canals were pretty much obsolete.)

Building on the fringe of the feasible pressed for suitable technologies, and some small tub canals were constructed. Commodities were moved in trained, 6 ton "tubs." A horse could move each tub on a near-level tramway, and they could be handled easily on inclines.

Figure 15.1 provides an interesting classification of the sources of funds for canals and river improvements. Adding the tub canals, England had by about 1820 a four-level system of inland waterway improvements:

- The rivers and their improvements
- Broad canals, extending river navigation[1]
- Narrow, 2.1 m canals
- Tub canals

As mentioned, at this time the canal system was pretty much "built out"—canals had been built where feasible (figure 15.2).

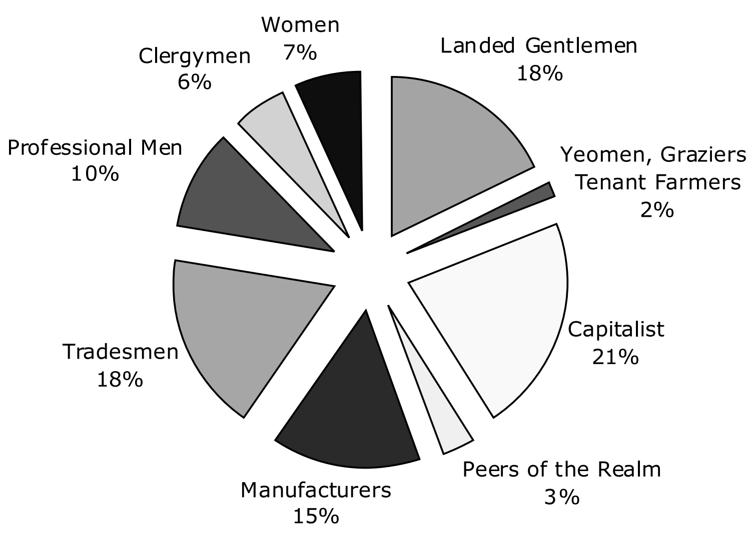


Figure 15.1. Sources of inland waterway capital in England, 1755–1815. (Source: Ward, 1974.)

Canals in the United States: Nineteenth Century

In a nutshell, by 1800 the coast from Philadelphia and southward was well served by small ships in local trade, and numerous ports offered trans-Atlantic services. The Connecticut and Hudson Rivers served limited roles in New York and New England, and needs there pressed for early canal and road developments. Also, the opportunities in the west (of Appalachia) and in the interior South pressed for major long-distance access improvements, to open up territory.

Although 1824 marked the beginning of continuing federal involvement in river improvements, using the services of the U.S. Army Corps of Engineers (see box 15.1), early appropriations were modest and were mainly restricted to rivers regarded as of national importance. Debates about the federal role continued. The states and private interests were busy with canal and river works and there was a rising tide of demands for federal appropriations. Avoiding conflict over specific projects, the federal government made land grants to the states for internal improvements, and the states and sometimes the federal government became stakeholders in projects by purchasing stock.

Many early small canals were built, especially in New England. These were in the English organizational, financing, and technology style, and they used some English capital.

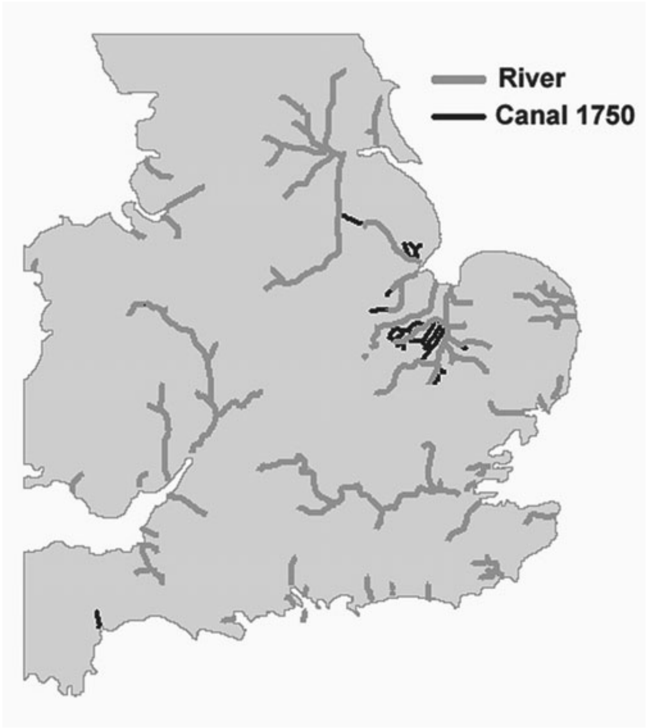
Where the terrain was difficult and/or water in short supply, inclined planes (such as in figure 15.3) were constructed. The plane shown in figure 15.3 was constructed on the Pennsylvania Canal as part of the portage tramway across central Pennsylvania. The canal boats could be handled in sections, an unusual feature of this canal (figure 15.4).

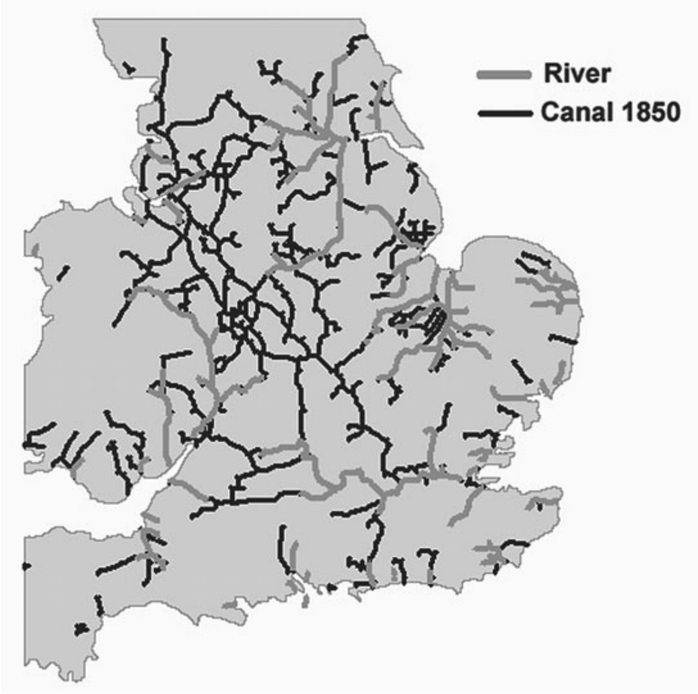
A benchmark, open-territory event was the opening of the 360-mile-long Erie Canal (built 1817–1825) from Albany on the Hudson to Lake Erie. Built with New York State support, the canal lowered costs and rates on shipments by an order of magnitude, and it set off a clamor for similar investments. With a lag of several years while large projects were organized, canal spending by the states expanded rapidly in the late 1830s, as did railroad construction. Reading the competitive situation and being displaced by government capital, spending by private canal companies decreased sharply. Committed to programs and projects, the public sector did not read the competitive situation. The state governments were slow to recognize the strong competition to be provided by railroads. Figure 15.5 shows the pace of development in the United States.

One reason for the quick demise of canals was the unusually cold winters of the middle 1840s—there were short shipping seasons just at the time new canals were opening and facing competition from railroads.

A so-called debt-repudiation depression began in about 1839 and continued to about 1847. The conventional reason given for that depression is the write-down of investments made in canals and some changes in currency and banking policy. While not dismissing those factors, Santini (1988) links the depression to the clash between the new and old technology and, in particular, to the displacements that the uses of the technology occasioned.

Early railroads were at first adjuncts to canals and then competition for them. Tramways had long been used to move products of forests and mines short distances,


River
Canal 1750


River
Canal 1850

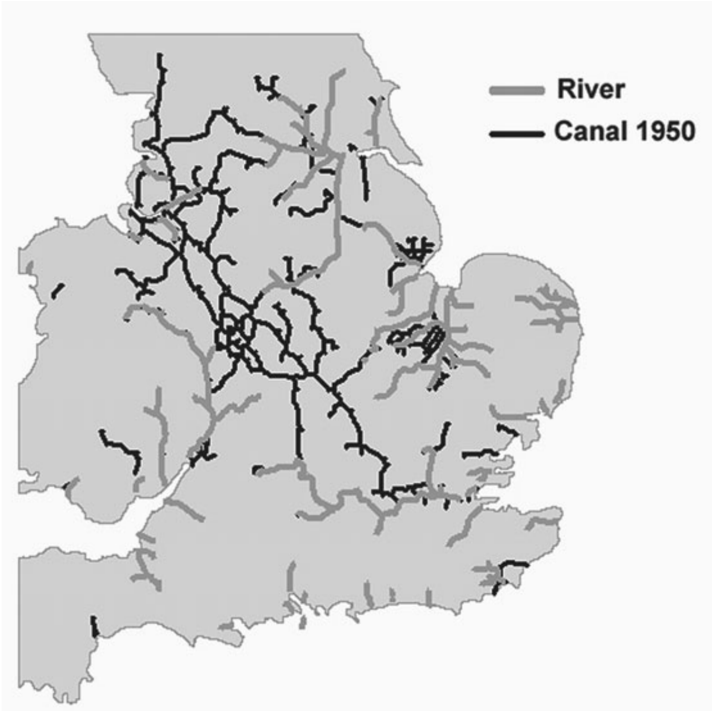


Figure 15.2. The birth, rise, and fall of canals in England (1750, 1850, 1950). (Source: Stevens, 2000.)

and they fed traffic to canals. Some years after the development of the steam engine, steam replaced animal power on tramways. The locomotive was evolved, and railroad deployment began competing—first for passengers previously carried in carriages or on canals. Railroads next competed for commodities and began to expand beyond territories already served by canals. Competition between canals and railroads is discussed in Goodrich (1962) and McCullough and Leuba (1973).

The above is a simple and well-known summary of canal development, but we should remember that it holds for only a small part of the world, particularly the eastern seaboard of the United States and portions of Western Europe. Most of the world did not share the history of road and canal building; rather, the railroad was the mode that spread the commercial revolution, consolidated the control of central governments, and so on. These *different beginnings* are an important point. It is one of the reasons why the land transportation situation in Japan is quite different from that in the United States, for example.

Canals withered given competition with rail, some rapidly, some not. Bartholomew (1989) discusses the Delaware and Lehigh canals, which survived for some time. There was a mixed story for coastal transportation and inland waterway transportation, depending upon topography and peculiarities of markets. The lack of bridges in the San Francisco Bay Area, for example, kept the scow (hauling hay, building materials, etc.) and ferry boat in business well into the twentieth century. Coastal transportation of

BOX 15.1 France in America: The U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers was founded in 1802, the same year that Congress founded the U.S. Military Academy at West Point. During the early years instruction at West Point was in French, and the Corps followed the French tradition of science-based engineering and a prominent role for engineers in public works agencies. France was a leader in science and engineering, and French recruits to Washington's Army and the new nation's appetite and need for projects pressed for action. There was plenty to be done—surveying for canals and roads, navigation improvements, and construction in the new capital city.

The Corps's beginning is easy to explain, as is the Corps's continuing role in military engineering. Its early experience in surveying proposed projects and its scientific-engineering beginning help explain its early development of what is now called benefit–cost analysis. But what explains the continuing roles of the Corps in nonmilitary waterway, flood control, and other internal improvements?

An internal improvement role was debated at the Constitutional Convention and the provision of internal improvements was mainly left to the states. Improvement advocates Benjamin Franklin and Elbridge Gerry managed to include in the Constitution reference to post roads and post offices in addition to mention of military structures and navigation aids. But the states lacked fiscal means, and with private investors they pressed Congress for aid; appropriations were first made in 1802. Small appropriations were made for a number of years and defense was sometimes cited for justification. Surveys were common and led to the General Survey Bill of 1824 authorizing surveys for improvements of commercial or military importance or for the transport of mail. Even though the political and Constitutional grounds for federal action were weak, two years later an Act was passed and funds were appropriated for improvements to the Ohio and Mississippi Rivers. The U.S. Army Corps of Engineers provided a variety of services on inland waterways and at ports (Sherow, 1990; Shallat, 1994).

After beginning work on important inland waterways, such as the Ohio River, the Army Corps of Engineers institutionalized its responsibilities and strengthened district offices. Actually, the district office system had been developed by the 1850s, but those offices had only occasional work.

Following common law and tradition, federal involvement had focused on ocean ports and the tidal parts of rivers in the early nineteenth century. But actions by Congress increasingly applied to inland waterways and ports. These actions were legitimized by the Supreme Court in 1870 (*Pennsylvania v. Wheeling Bridge Company*). The Court said, in essence, that navigable rivers (those possible to navigate) are highways of commerce over which unobstructed trade may be carried. It specified the right of regulation and the right to improve facilities followed.

The Army Corps of Engineers became involved in flood control work in part because of the need for water to augment low river flows during the summer. Dams built to augment low flows could also be used for flood control, although there is a conflict between those two tasks. The Corps began work at the headwaters of the Mississippi in 1880. However, as large dams and locks were built on the Upper Mississippi and as other developments occurred, the Corps found that it was in the recreational resources and flood control business. Not needing much water storage space to augment low flow once high dams with locks and slack pools were built, these functions could be accomplished without too much difficulty.

BOX 15.1 France in America: The U.S. Army Corps of Engineers—cont'd

Elsewhere, and at other times and in different circumstances, the Corps took on flood control responsibilities; it began to do levee work to improve channels and for flood control. The levee work was an extension of its work with wing dams and dredging and started early on in the New Orleans area. The high dams were built in 1950s, and later electricity began to be generated with the Corps using a private company franchise system.

Already involved in port and nearby waterway navigation improvements, the Corps became the agent for river development, and as the role of the federal government expanded, its role increased accordingly

The Corps also became involved in water quality work. The first problem was the blocking of channels by debris, mainly from saw mills in the early days, and related problems of sewage in harbors and in slack water ponds. In response, 1899 federal legislation gave the Corps authority to control dumping of sewage and debris. But that "clean water act" was restricted in meaning by the courts. In essence, the Corps could restrict dumping that interfered with navigation, and that applied to sewage in only limited situations, for instance, where solids were filling a harbor. Industrialization and urban development led to a situation where one gallon of every four passing Louisville during low water had been through an untreated sewage system. A similar situation must have held on the Upper Mississippi.

The Corps got into general environmental quality work by the turn of the century. The Upper Mississippi, in particular, was regarded as a scenic and bird flyway route and the Corps made much of its role in providing supportive river improvements.

Corps programs were influenced sharply by the upturn in environmental awareness during the 1970s, just as highway and airport programs were. They also shared with those programs increased problems with land taking—they took land at fair market value but paid no relocation costs. The conflicts that resulted were a very real shock to the Corps, for it had regarded itself as a resource development, environment enhancement agency.

The Corps did not charge tolls for the use of facilities. That is a tradition that goes back to river development in Europe and the notion that waterways ought to be free to all. But that is ambiguous. Canal operators charged tolls, and a river improved with dams and locks is much like a canal.

The operative argument against tolls went something like this. We start improvements with a single dam. It is not reasonable to charge tolls or expect tolls to cover costs because waterway-related developments and traffic will not emerge until all the dams are built. The shorthand expression of that idea is "infant industry," and that expression has been much used in political debates about waterway tolls. But not all dams ever get built. Those opposed to tolls say the system isn't complete because many dams on tributaries still need to be built.

Today, the Corps expends about $5 billion per year on civil programs ranging from river and port projects and radioactive site cleanup, to dam safety and recreation site improvements. Funds are authorized in a budget separate from the military budget. Expenditures include some matching funds, and the Corps is essentially a civil works agency managed by the Army. Armies divide geographic responsibility, so the Corps has district and local offices. It is in the news when there is an argument about wetlands, the site for a new bridge, flood control and drainage projects, or when a member of Congress announces funded projects.

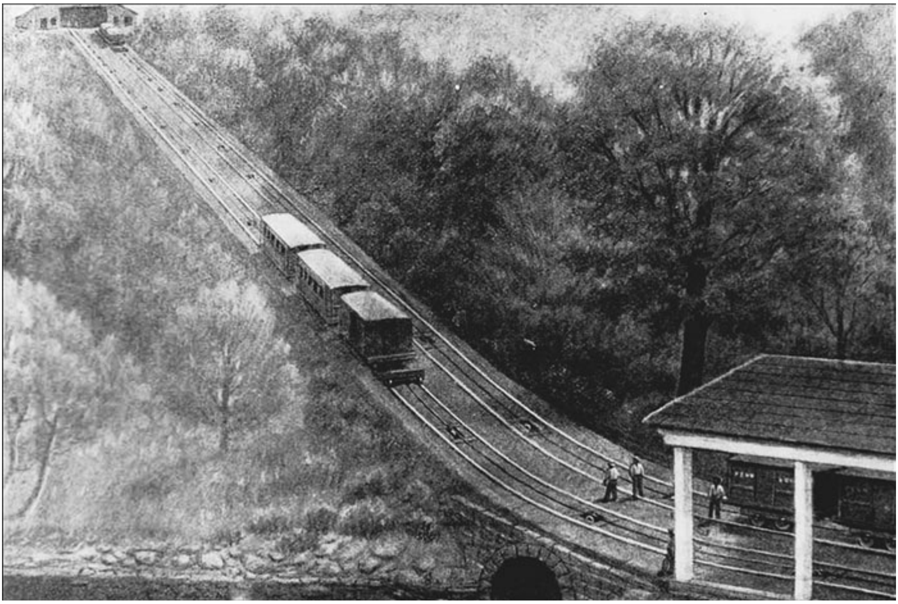


Figure 15.3. *Inclined Plane No.* 8, by George Storm, date unknown.

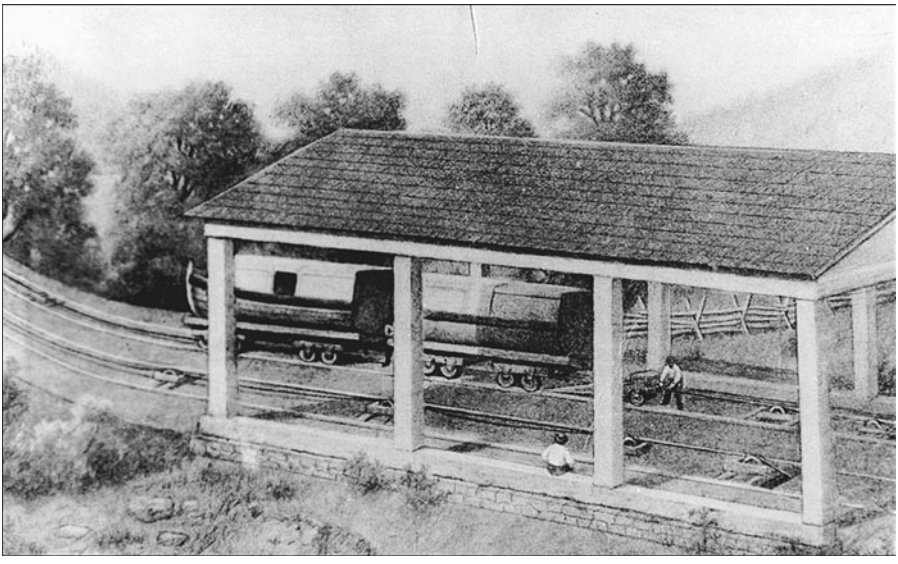


Figure 15.4. *A Sectional Canal Boat in the Hitching Shed,* by George Storm, date unknown.

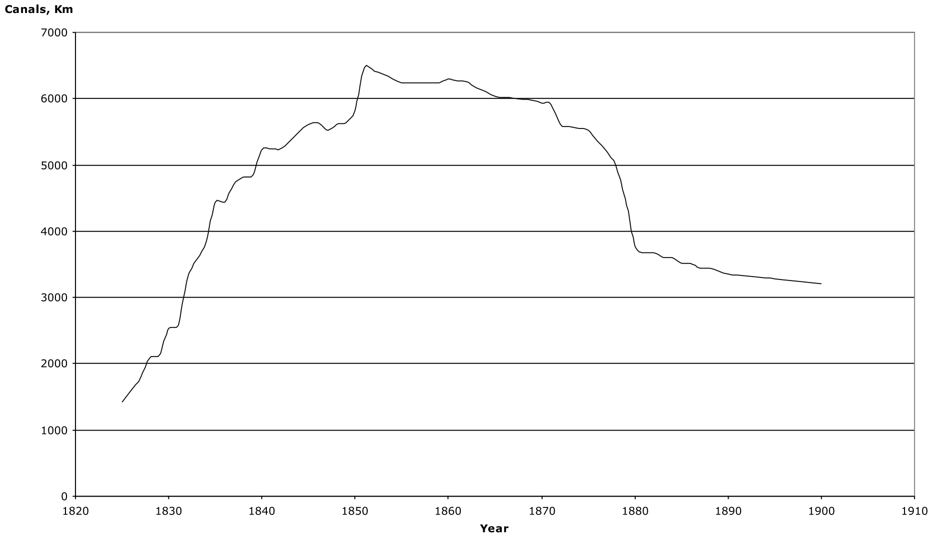


Figure 15.5. Canals in the United States (in kilometers).

bulk materials continued, and Great Lakes freight movements increased. River-based waterway transportation withered quite considerably (to be reinvented later through tug-barge technology).

Policy Today

The discussion above began to indicate how the structure and performance of inland waterway activities evolved. As would be expected, flow economies of scale on important routes on the network plus traffic patterns and variations in the natural conditions of routes result in vast differences here and there in the costs of operations and the provision of facilities (table 15.1). The Lower Mississippi and coastal facilities from the mouth of the Mississippi to the west are relatively inexpensive and those routes have lots of traffic. The tributaries of the Lower Mississippi and the Upper Mississippi and Ohio have more costly facilities and operating costs are also higher. Corps maintenance costs per ton-kilometer for the entire system run to about $0.10. That is vastly greater than the ton-kilometer cost of rail services. The evolution of the Ohio–Mississippi River system is discussed in box 15.2.

In light of these differences, one might suppose that there is much discussion of differential toll charges and network rationalization, especially abandonment of facilities. That is not the case. As a surrogate for tolls, operators pay a modest fuel tax regardless of where they operate. Congestion occurs at some locks and dams, and congestion tolls have been argued but not implemented. Taxes are collected to fund dredging, and the ports are now expected to share dredging costs. Everywhere, locals are expected to share the costs of improvements, for example, for flood control facilities.

Table 15.1 U.S. Army Corps of Engineers Costs to Operate and Maintain Selected Inland Waterways

River	Cost per ton-mile
Mississippi River	$0.03
Ohio River	$0.05
Appalachicola, Chattahoochee, and Flint Rivers	$5.26
Allegheny River	$9.04
Kentucky River	$11.23

Source: Budget of the United States Government, 2003.

Note: See webpage of Corps of Engineers—Civil Works, http://www.whitehouse.gov/omb/budget/fy2003/bud24.html. See also: http://www.amrivers.org/corpsreformtoolkit/riverbarges.htm for some similar, but different, estimates.

BOX 15.2 Ohio River–Mississippi River System

Before the Ohio River–Mississippi River system could become an effective nineteenth-century transportation system, it first had to be domesticated. This required cleaning out the snags and timber blockages (rafts) that had accumulated over the centuries. The next steps included channeling, using jetties to narrow the rivers to focus flows to cut deeper channels. Steamboat traffic increased, and St. Louis, Cincinnati, and Pittsburgh were among the many inland cities served by the steamboats of the times.

It was during this period that the lasting expression "pork barrel" came into use. Farmers in the Upper South and Lake States shipped pickled pork downriver in barrels and as states and private interests sought federal funding for river and harbor improvements, they were wishing for pork barrel funds.

The Civil War devastated much of the river fleet and, much more importantly, rapid railroad expansion captured passenger and much freight commerce. That could have been the end of the story—after about 1900 modest river commerce continued in niche markets where river and competitive conditions permitted.

But that did not happen because many recalled the valuable services performed by the river fleets before and during the war, and there was concern about the growing monopoly power of the railroads in the absence of competition. A Congressional Report in 1873 called waterways natural competitors and regulators of railway transportation. In 1888 Congress asked for and funded the construction of locks and dams along the Ohio that would provide a 1.9 m (6 ft) channel and 22 years later a 2.7 m (9 ft) channel was authorized and began to be funded.

Looking around today, 2.7 m (9 ft) channels are found on the Mississippi and its main tributaries, channel widths run 45 m (150 ft) or wider, and locks are 33 m (110 ft) in width and 180 to 360 m (600 to 1200 ft) in length. Locks tend to be smaller on the lesser used tributaries. There is seasonal congestion at some of the locks and need for continuing channel and lock maintenance. There are advocates for deeper channels and larger locks and dams. However, environmental groups and competitive transportation firms oppose such improvements.

The Kentucky River gave an early lesson about attempts to improve lightly used routes. But that lesson was pushed aside by political demands for improvements, and over its history the Corps improved many "Kentucky Rivers," such as the Cumberland and Missouri Rivers. There is not much debate about these facilities.

The Corps now has many tasks extending beyond inland waterway and coastal navigational facilities. Flood control work and related stream improvements give it a presence in every state, and the same district offices that do civil work also do military construction. Dredging work at ports is another important Corps responsibility. Recently, the Corps has taken on the job of dam inspection, and is a player in the development of maglev technologies. It is involved in wetland development. In part, the expanding scope of Corps work represents an institutional response to its having accomplished its major work. Expanding scope also reflects the Corps's credibility. It has access to engineering expertise and is a long-term user of benefit–cost techniques (since the 1930s) in the context of multipurpose development. Its project and system plans are state of the art. Whether the Corps deserves to be so well regarded is another matter, in part because its benefit–cost studies are often questioned.

By about 1970 the growth of traffic was yielding significant delay at locks on the Ohio and Upper Mississippi. Operators seeking scale economies were creating a demand for increasing the controlling depth to 3.7 m (12 ft). The Corps responded, and plans began to emerge for dredging and the modification of locks and dams. In addition to increasing lock depth, where not already doubled, locks were to be doubled. Larger locks were proposed to avoid the breaking of tows and reduce delays. Lock and Dam 26 on the Upper Mississippi moved a little and needed urgent repair. The Corps proposed rebuilding it to the higher standards, and the project became a *cause célèbre* in the environmental movement. The dam was rebuilt, but as a consequence of the debate the plans for enlarged, higher capacity facilities are on the shelf. But work for the Corps is available because there is a considerable backlog of repair and rebuilding required.

The Corps's activities have some transit policy features and some highway policy features. The district offices do plans and programs and manage construction; Washington rations money among districts. That is highway-like. At the same time, local groups work directly with Congress to push projects in a pork barrel style (Ferejohn, 1974). Like the Federal Transit Administration, the Corps has managed to build some "Miami subways": for example the Tenn-Tom, a project to link Mobile, Alabama, with the Tennessee River via the Tombigbee River (see box 15.3).

We see a somewhat larger, overriding question. The United States has to make up its mind about what it wants to do with its water resources. We told the Kentucky River story to lay background for this point. River transportation was the name of the game in the early days. But today inland water transport is economically reasonable in only a few places. Large subsidies are required elsewhere.

Yet, the imprint of river transportation remains in the location of cities; old, unused, or little used dams; and in other physical remnants. The important thing is that river transport remains in the minds of those in the regions that once had those services; it is part of the culture and history. This sense of history, roots, role, or nostalgia has value, and perhaps it should be the main consideration in policy development. If we recognize that the subsidy for water transportation is not really for transportation, but rather to preserve the history of water transportation, then we can decide if the history is worthwhile.[2]

BOX 15.3 The Tenn-Tom

The French explorer, the Marquis de Montcalm, first recommended that the Tennessee and Tombigbee Rivers be connected in 1760. At the time, that territory was in French hands, and such a canal would aid in French administration of that area. The canal idea reemerged several times: in 1810 a petition from Knox County, Tennessee, argued for the connection, and in 1819 the new state of Alabama studied it. In 1874 another study was undertaken by the administration of Ulysses S. Grant, which concluded that the Corps of Engineers could build it technically, but that it would be economically impractical. Again in 1913, it was found to be cost prohibitive. The Corps again studied the waterway in 1923, 1935, 1938, and 1945. Congress approved the waterway in 1946. Proponents asserted that this would be a natural extension of the works constructed by the Tennessee Valley Authority. However, most people outside the region saw the Tenn-Tom project as pork barrel, and railroads opposed it as government subsidy for competing modes. President Lyndon Johnson budgeted funds for engineering and design in 1968 despite the opposition, but in the 1970s environmental groups became opponents as well. Though construction started in 1972, it was in the courts for over seven years during the construction period. It finally opened in 1985 at a cost of at least $2 billion. The U.S. Army Corps of Engineers predicted that 27 million tons would be shipped in the first year; by 2000, however, only 6 million tons per year were actually being shipped. As with many large-scale engineering projects, they are ultimately technically successful but economic failures.

Discussion

The modern modes owe much to canals. They demonstrated the payoffs from capital-intensive transportation improvements. On the hard technology side, they provided for the development of construction know-how. They also provided experience to manage, finance, and operate related institutions. This was learning by those who provide transportation. Burton's (1992) discussion of railroad construction organizations illustrates many direct links to the canal experience. The public learned about investment opportunities and about the off-system developments induced by transportation improvements.

Canal learning provided experience toward generic policy for transportation and public works. Of course canals have been around for a long time. We have not addressed learning by the English from other Europeans, or learning by Europeans from the Chinese or the Egyptians (e.g., Pharaoh's Canal, 2000–610 B.C.E).

Canals developed following the experience with toll roads. Unlike toll roads, upfront capital for investment was required for canals. Also, canals usually required more engineering work. A style of engineering-fiscal planning emerged, and was engaged in by early civil engineers. Although a more complex matter, canals were organized and deployed in much the same way that precursor toll roads had been developed. Subject to constraints on the availability of water and suitable grades, canals tended to parallel thriving routes of commerce (as did the continuing development of coastal shipping). Although the engineers of the times also worked on road plans, bridges, and harbors, the planning and construction of canals was their major activity.

The discussion treated changes that took place during a period of population growth, economic development, and renewal and change in political institutions. On reflection, we are struck by how well the transportation development story unfolds with only minimal attention to these matters. Even more, we are struck by how the story unfolds with little reference to war and revolution and the great international political and economic changes taking place.[3]

The main conclusion from the discussion above is that experience was accumulated and embedded within the modes. Know-how (rules or policy) evolved bearing on organizations, pricing, and management and also on the use of hard technologies. With these exceptions, government actions were generally reactive. Even so, the notion emerged that government ought be more active. For instance, Adam Smith in his *An Inquiry into the Nature and Causes of the Wealth of Nations* (1776) urged:

> The third and last duty of the sovereign or commonwealth is that of erecting and maintaining those public institutions and those public works, which, though they may be in the highest degree advantageous to a great society, are, however, of such a nature that the profit could never repay the expense to any individual or small number of individuals, and which it therefore cannot be expected that any individual or small number of individuals should erect or maintain. The performance of this duty requires, too, very different degrees of expense in the different periods of society.

16

Maritime

Whosoever commands the sea commands trade; whosoever commands the trade of the world commands the riches of the world, and consequently the world itself.
—Sir Walter Raleigh

Introduction

On July 1, 2002, the contract between the Pacific Maritime Association (PMA), which is the industry association for the operators of 29 ports on the West Coast of the United States, and the International Longshore and Warehouse Union (ILWU) expired. This was of national importance because West Coast ports handle about $1 billion worth of freight daily; see table 16.1 for details. It was in many senses a classic dispute of capital versus labor. The PMA wanted to modernize technology, such as introducing optical scanners and global positioning systems (GPS) to automate information flow at the ports. The ILWU was concerned about the employment of members (and especially the use of nonunion employees to replace members). However, the situation was somewhat atypical because union salaries ranged from $80,000 to $158,000 for what are normally considered "blue collar" jobs. So the union had successfully captured many of the monopoly rents available from the ports during previous labor disputes.

The ILWU had been established in 1937, as a breakaway from the (East Coast based) International Longshoreman's Association (ILA). The union was forged in 1934 by a bloody West Coast waterfront strike and a general strike in San Francisco. After many years of control by communist figures such as the Australian-born Harry Bridges, the ILWU remained an aggressive and powerful union. To illustrate their control, in September 2002 the ILWU, which controlled day-to-day work assignments, required they be randomized, and required strict adherence to safety regulations (a work-to-contract strategy). This policy, rather than allowing workers to conduct tasks in which they were skilled, resulted in productivity at the ports being reduced by 20–90 percent. The rationale for this was not simply to gain leverage over the PMA, but also to protest

Table 16.1 Selected Pacific Gateways: Percent Imports from Asia in 20 ft Container Equivalents

	Value of all imports (billions)	% imports from Asia
Seattle	$23	6%
Tacoma	$14	5%
Portland	$8	<4%
Oakland	$16	4%
Los Angeles	$119	35%
Long Beach	$49	30%

Source: *Journal of Commerce's Port Import Export Reporting Service* (Census Bureau, 2002).

Note: Total imports from Asia were 7.9 million 20 ft container equivalents (TEUs) for the year ended July 2002.

work conditions that had resulted in five deaths on the docks in the Los Angeles region in the past five years.

In response to this work slowdown, on September 27 the West Coast port operators shut down cargo terminals for 38 hours, and then on September 30 the PMA closed ports until the ILWU agreed either to an extension of the existing contract or a new contract. This strategy locked out 10,500 workers from their jobs. The irony of this management–labor dispute, which cost the economy hundreds of millions of dollars, was that the monetary difference between the two sides was estimated at only $20 million.

Intentionally evoking images of the movie *On the Waterfront*, wherein former boxer and longshoreman Terry Malloy (played by Marlon Brando) has to choose whether to betray the criminal union leaders on the New York/New Jersey ports or keep solidarity with his fellow workers, the PMA brought armed guards to the negotiations on October 1—offending the union (or, at a minimum, giving reason for the claim of offense).

The U.S. Secretary of Labor, Elaine Chao, tried to intervene in the negotiations. However, she failed to negotiate a contract extension that would reopen the ports for 30 days. The ILWU supported an end to this lockout, but the PMA resisted believing the union would continue to work to rules.

A Board of Inquiry established by the federal government to investigate the issues reported, "We have no confidence that the parties will resolve the West Coast ports dispute within a reasonable time." This finding set the stage for the beginning of the invocation of the Taft–Hartley Act (see box 16.1). On October 9, President George W. Bush sought and received a federal district court order requiring the West Coast ports to reopen.

On November 1, a tentative agreement was reached. The management desire to cut clerk jobs (and introduce more computer technology) was agreed to, resulting in cuts of 400 marine clerk jobs. In exchange, however, it was agreed that the new jobs created would be union jobs. In addition, agreements had to be negotiated about pension security, health insurance benefits, higher wages, and safety provision. The details were worked out by November 24 for a six-year contract. Chief federal mediator Peter Hurtgen said that the negotiators "demonstrated statesmanlike leadership, which made this agreement possible." The ILWU membership voted after Thanksgiving in favor of the contract.

BOX 16.1 Taft–Hartley Act

The 2002 West Coast port strike was the first successful use of the Taft–Hartley Act in ports since President Richard Nixon employed it in 1971 to stop another longshoremen's strike, the last major work stoppage at the West Coast ports, which lasted for 134 days.

A Republican Congress, overriding President Harry Truman's veto, passed Taft–Hartley in 1947. The law had a number of provisions: it outlawed the *closed shop*, in which only union members would be hired, but it permitted a *union shop*, which required nonunion workers to join the union. More to the point of this discussion, Taft–Hartley provided for a 60-day *cooling-off period* after a contract expires before a strike may be called. Moreover, the President may extend that period by 80 days. After that period, the National Labor Relations Board has 15 days to poll employees to see whether they will accept management's final proposal and an additional five days to count votes. Then, if the workers reject the proposal, they can strike.

However, this procedure is rarely imposed; it serves more as a threat. Prior to 2002, it was last used to calm a 1978 coal strike. Not surprisingly, unions oppose these provisions, referring to the Act as "Plain ole slavery."

How come ports are so important that a strike can result one of the most significant labor disputes in the last three decades in the United States? How can unions demand wages in this industry three or four times higher than those of other comparably skilled workers? This chapter explores that question, by giving both a world overview and a focus of the U.S. case.

Measured on imports and exports, the United States is the world's largest trading nation. Worldwide, about 40 percent of the maritime tonnage is engaged in petroleum movements (and products), about 21 percent is dry bulk, and the remainder is general (19 percent) and specialized cargo (20 percent). The liner trades move about one-half of the general cargo. Tons moved in the marine trades are roughly similar to the tonnage divisions of the fleet. The United States has ports to match cargos, yet its provision of seaside services is nil. It has about 1.7 percent of the world's liner fleet, and less than 0.5 percent of the dry bulk fleet. The United States has about 5 percent of the tanker fleet, and most of these tankers are of special sizes that fit some of the conditions of U.S. trade.

This chapter begins by addressing the emergence of trans-Atlantic trade. Ports and ships are considered, since the waterways were given free.

Beginnings

In the early days, the European colonial powers sought to profit from sailing to and from their colonies. England, for example, established a set of navigation laws in the 1660s restricting trade with the colonies to English ships. This same urge, to "carry our trade in our ships," continues today. Actually, the colonies fared well from this policy on one dimension. A key resource for the building of ships was hardwood (especially oak), and masts required tall pines. The United States had those resources and labor skilled in ship construction. So the American shipbuilding industry developed early, and by the time of the Revolutionary War nearly one-third of all the ships in Britain registered as English were colonial built (Dickerson, 1951). That was quite an industry, for the wooden ships of the times lasted ten years at best. The replacement market was coupled with market expansion.

Just after the revolution, the United States initiated the mercantilist policy to "carry our trade in our ships." In 1789, the Congress gave a 10 percent tariff advantage to goods hauled in American bottoms. It also discriminated in port dues—they were lower for American ships, and such ships were only charged once a year. The latter ensured that the coastal trade would move in American ships. Later, the 1817 Act invented cabotage restrictions to ensure control of coastal trade. In 1828, the United States passed a reciprocity act to deal one-on-one with other nations' trade restrictions. We shall see that today's situation is somewhat of a modern-day version of these early matters.

Profile: Isambard Kingdom Brunel

Along with his father Marc, Isambard Kingdom Brunel comes near the top of any list of great engineers of the nineteenth century. He is recognized for his great works: the Great Western Railway, tunnels, bridges, and large steamships. He was the chief engineer and a major promoter of the Great Western when it was organized in 1835. The route from Paddington Station in London to Bristol was opened in 1841. Afterwards, Brunel constructed or purchased links and built a system to serve the west.

Brunel was sensitive to the economies of scale achieved by building larger equipment and suitable facilities. The Great Western was built with mainly double track at a wide 2.1 m (7 ft) gauge. Inverted U-shaped rails were used. Where there was overlap with standard gauge railroads, as on the Oxford–Birmingham route, three rails were used (Hay, 1985).

Passenger cars ran 24.4 m (80 ft) in length, and drawings of freight and passenger cars suggest that they were two to three times the size of cars on standard gauge railroads. At first, Brunel placed the body of the car within the gauge, that is, the wheels, for reasons of safety and ride quality. Later, the bodies were raised above the wheels and made wider, enabling passengers to sit four on each side of the aisle.

A debate over gauge developed, perhaps because other railroads feared the expansion of the Great Western. In 1845 a Royal Commission on Railway Gauges was established. It looked into the gauge problem and concluded that the wide gauge was superior to Stephenson's standard 1.435 m gauge (4 ft 8½ in).[1] But it established Stephenson's gauge as the standard because it already dominated the mileage.[2] The Great Western got along fine for a while using its gauge, but gradually shifted over to standard gauge, primarily by adding a third rail to accommodate both gauges, and completed the conversion in a final push over one weekend in 1892.

At the time of the start of the railroad, Brunel went into the steamship business. Brunel designed the SS *Great Western*, which entered service in 1837, steaming to New York in 19 days. The *Great Western*, a wooden, paddle wheel steamer with sails, was not the first of its type in service. But at 1,340 gross tons[3] it was two or more times larger than the few previous paddle steamers. Unlike previous steamers, its size permitted it to carry sufficient coal for full-time steaming and thus keep a schedule.[4]

The SS *Great Britain* followed in 1843. Although continuing the convention of sails, this was an iron ship with a screw propeller, sized up to 3,270 gross tons. (A somewhat similar ship, the *Rainbow* at 500 gross tons, was constructed in 1836 and had been successful in the European trades.) The SS *Great Britain* ran aground in 1846. Refloated and reengined, it was used in the Australian trade until 1886.

The SS *Great Western* and the SS *Great Britain* were not new, strictly speaking, yet they triggered the development of the Atlantic liner trades (and some other liner trades). They were the right designs at the right time and place and brought together other parts of the design. The SS *Great Eastern*, a later ship, is profiled in box 16.2.

BOX 16.2 The SS *Great Eastern*

The SS *Great Eastern* (figure 16.1) was the largest ship of its era. Its tonnage anticipated the tonnages appearing about 40 years later, around 1900, although its speed was consistent with the ships of its time. For a size comparison, the *Great Eastern* was 207 m (680 ft) in length; the SS *Kaiser Wilhelm II*, constructed in 1903 and the largest ship at that time, was 206 m (676 ft) in length.

Brunel took advantage of several things. The *Great Eastern* was of iron construction, and the limitations of wood could be set aside. The main disadvantage of wood was that connections were difficult, and, for the loads to be carried, structural pieces were large relative to iron.

The form of the wooden ship was also limiting. To obtain thrust from sails, forces had to be carried through the masts, rigging, and ship structure to overcome the resistance of water to ship movement. Ships had to be broad if they were to be stiff under heavy press of sail. Brunel's use of propellers and/or paddle wheels overcame that problem.

Brunel also took advantage of knowledge. Newton had studied the resistance of bodies moving in a fluid and had proposed the "principle of similitude." William Froude, working for Brunel, used the principle (for the first time in ship studies) to apply the results of physical model studies to predict the roll behavior of the *Great Eastern*. Froude (best known for the *Froude number*, a dimensionless parameter defining turbulence that relates the speed of open channel flow to the square root of gravity times depth) had some ideas on resistance/propulsion relations, yet the *Great Eastern* was underpowered.

This knowledge was the base from which Brunel acted. Relative to earlier ships the SS *Great Eastern* was long and narrow—its profile was followed by subsequent liners. It had a double hull, and high bulkheads with no doors between them: 15 traverse and two longitudinal through the boiler and engine rooms. The *Great Eastern* was a nearly unsinkable ship.

The *Titanic* was the largest ship in the world in 1912, at about 40,000 tons. She too had 15 traverse bulkheads, but they were carried only 3 m (10 ft) above the waterline (in contrast the *Great Eastern*'s were over 9 m [30 ft]). The 30 to 40 doors in the bulkheads had to be closed by hand. The iceberg that the *Titanic* encountered opened the first five bulkheads. As compartments filled, water overtopped the remaining bulkheads.

Brunel took advantage of the technology in the search for scale, yet the *Great Eastern* was not a commercial success. He should have achieved lower unit cost (cost to serve a passenger) than smaller vessels, though he did not achieve quality (speed) advantages. Perhaps the size of the market prevented realization of lower unit cost.

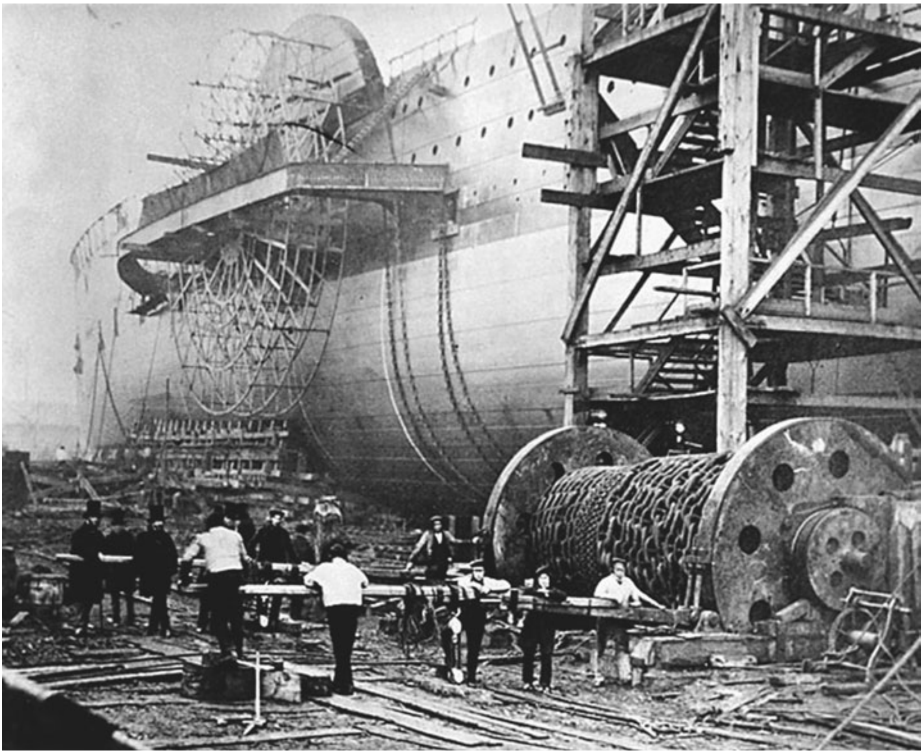


Figure 16.1. The SS *Great Eastern*. (Source: Hulton Archive.)

Ocean Liners

Several precursor service developments were ready to be incorporated into the liner system. Freedom of the seas had been established as a principle; except for coastal trade, anyone could sail in any service and anywhere. Beginning about 1812 and, in part, as a consequence of the War of 1812, a system of independent ship operators had emerged. Previously, large shippers, like the East India Company, had tended to carry their goods on their own ships. Packet (scheduled) passenger and high-priority goods and mail services had emerged in the New York–Europe trade.

The sealanes required no development. Except for the bar which had to be dredged and where dredging had already started, New York was a deep-water port. Deep-water ports were already available on the south and west coasts of England. A large shipyard with special tools had been constructed in Bristol.

After the first crossing of the *Great Western*, the British offered mail contracts to support the service. This led to the development of the Cunard Line, which soon dominated the trade. In 1840 the Peninsular and Oriental (P&O) Line was given a contract to carry mail to Egypt and India. Many operational aids were in place or coming into place. Insurance systems improved and the British (soon followed by others) developed ship register and safety ratings systems.

The growth cycle of passenger and high-priority freight ran from the 1820s and 1830s through the end of World War II. At that time, container ships and aircraft displaced the service.

The takeover of liner services by steam-powered vessels was very quick. We do not have data on that; however, we do have data on steam versus sail for all services. Figure 16.2 displays a typical predator (steam)/prey (sail) relationship. Sail tonnage grew by a factor of 3.5 between 1800 and 1880, and the tonnage in 1920 was about the same as it was in 1800. Actually, a better sense of the displacement of sail would be given if the tonnage of steam was inflated by a factor of about 4—the working capacity of a steamer was about four times that of a sailing ship. Figure 16.3 shows the improvement in trans-Atlantic crossing times, which was rapid during the early days of steam, but began to level off by the middle of the twentieth century, when air travel took off.

American Shipping, 1830–1950

The American shipbuilding advantage was strained in the 1830s when the British began to use their advantages in propulsion power know-how and iron and then steel production to build large, fast steamships. The British also started a mail contract program in 1839, a program emulated by the United States in 1845. Recall Brunel's construction of the *Great Western*. With the advantage pioneered by Brunel, the British began to dominate the trades.

The clipper ship was the U.S. response to the British steam and iron hull advantage, a response that kept important market niches for the United States for some years. However, the U.S. Civil War destroyed the U.S. fleet, and by the 1870s the United States had little presence in maritime trade. Steps were taken to reverse this in the late nineteenth century. To build up the inputs needed for the shipbuilding industry, the Morrill Act of 1884 placed tariffs on iron and steel plates and on marine engines. To build up the market, it restricted the U.S. registry to ships built in the United States.

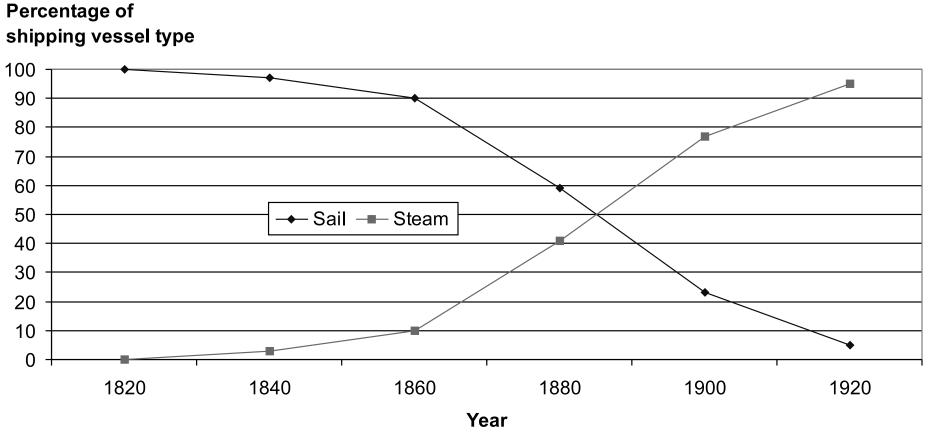


Figure 16.2. British fleets of steamships and sailing ships. (Source: Fletcher, 1958; Ville, 1990.)

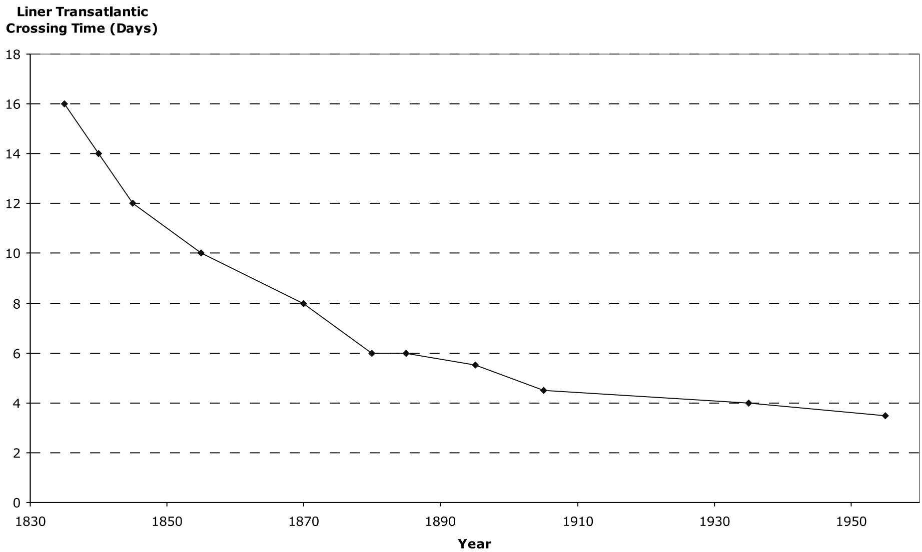


Figure 16.3. Liner trans-Atlantic crossing times (in days), 1838–1955. (Source: Hugill, 1993.)

Many say that the United States was preoccupied with internal development during this period, and this was the reason for the decline in the shipping industry. To us, that sounds more like an excuse than a reason. The United States was not competitive. The Morrill Act did not make the United States competitive; by 1900 U.S. tonnage was at the 1807 level, and ships of U.S. registry moved only 9 percent of U.S. foreign trade.

By the turn of the twentieth century, the United States had acquired some colonial interests and a taste for world power. A symbol was the around the world trip of the Great White Fleet of 1908, which brought the U.S. maritime situation in focus. For logistics, the fleet had to be followed by a ragtag collection of foreign-flag trampers. The Navy had long been concerned about logistics dependence on foreign-flag vessels.

The Cargo Preference Act of 1904 had already begun to respond to that concern; it required that military goods shipped overseas be carried on U.S. ships. To help enlarge the fleet, the Panama Canal Act of 1912 allowed the registry of foreign-built vessels, and it enlarged the market by extending cabotage (the exclusive right to navigate in coastal waters—see box 17.2 in the next chapter) to Hawaii and the Philippines. The Seaman's Act of 1915 required U.S. crews on ships of U.S. registry. These were efforts to enlarge and control a fleet of vessels, but their impact was not great.

World War I created a crisis, and the Shipping Act of 1916 established a Shipping Board with the power to construct and operate ships. When the United States entered the war, the Board acted with vigor. The main result was a large U.S. fleet at the end of the war. The Act also endorsed the participation of U.S. carriers in open conferences to set rates (i.e., participate in the maritime rate setting in the style of rail tariff bureaus). This was a murky area previously. The European carriers had established conferences in the Atlantic in about 1875. Because antitrust laws were established and enforced in the United States, participation by U.S. carriers was at question. An open conference is one that publishes rates and permits anyone to join. The Act also allowed transfer of Shipping Board ships to foreign registry—Panama at first, and then Honduras. The reason was to encourage neutral flag carriers during wartime.

The 1920 Jones Act required U.S.-flag (U.S.-built, owned, crewed and documented) carriage between U.S. ports, and disposed of the Shipping Board and its ships. The ships were sold at near scrap prices. This law thus endorsed the principle of cabotage. With the disposal of the fleet, U.S. maritime activities slumped. The slump set off half-hearted debates, and it yielded the 1928 Act, which reestablished the mail subsidy and made available construction loans for shipbuilding.

Things drifted along until the 1936 Act established the U.S. Maritime Commission and charged it with determining the type of fleet needed, determining essential trade routes, assigning services, and establishing wage and manning requirements for ships. The Act canceled mail subsidies and established construction-differential subsidies (CDS) and operation-differential subsidies (ODS). The CDS ranged from 35 to 50 percent and made low-cost loans available. The subsidy was only available if approved by the U.S. Navy, and the ships constructed were in the essential naval reserve. The ODS had no limit placed on them, except that ships had to be less than 20 years of age and operate in the foreign trades. These subsidies began to rebuild the U.S. fleet modestly, and by 1941 the U.S. fleet had about 16 percent of world tonnage.

The United States emerged from World War II with 60 percent of the world's tonnage. The 1948 Merchant Ship Sales Act was passed to dispose of the tonnage, and by 1950 the U.S. fleet was reduced to 36 percent of world tonnage.

Policy at the beginning of World War II was to build easily assembled, inexpensive, and rather slow-sailing ships, for example, the Liberty Ships. But some analysis soon showed payoffs from improved technology tankers (also termed tankships) and other new models that were placed in production and began accumulating in the fleet. Many older ships were scrapped, and these newer ships, purchased especially by U.S. and European operators, formed the basis of the post-World War II fleets.

But although not generally recognized at first, there was still room for technological change. In part this was scale-up in form, especially for tankers. Tankers ranged from 16,000 dwt T-2 to upwards of 600,000 dwts.[5] Tankers larger than 160,000 dwts are termed very large crude carriers (VLCCs). Most are in the size range of 250,000–450,000 dwts. Modern designs have the bridge aft, and use a single screw and rudder.

A problem for the United States is that East Coast ports are limited to 77,000 ton tankships. Moreover, many important refinery facilities are located in ports that can only take 50,000 dwt ships. Japan and Western Europe have established VLCC facilities. San Francisco Bay can handle tankships of about 100,000 dwts. The Panama Canal is 32 m (106 ft) wide, and that yields about a 70,000 dwt tanker.

Passenger ships also scaled up to large sizes (today the *Queen Mary 2* is about 150,000 tons), but with the advent of air competition they are now largely deployed in the resort trades.

Neobulk ships have emerged. These are bulk carriers specialized to new trades, and they range from scrap and lumber carriers to auto carriers. Such items were once carried as general cargo, and specialized chemical, wine, and other ships have been developed for other former general cargo commodities. Dry-bulk ships have been scaled up to 270,000 dwts.

Logistics Revolution

Up to this point in history (just after World War II), longshoremen climbed onto cargo ships and using brute force, with the aid of nets and grappling hooks, moved small packages on and off ships. The process of loading and unloading might keep a ship in port for weeks. This "break-bulk" shipping was a major bottleneck in world commerce. It enabled the longshoremen to become a powerful union (as noted at the opening of the chapter), and operations were prone to theft.

At this point, a major innovator emerged. Malcolm McLean, a trucker from North Carolina, conceived of loading trucks directly onto ships, without packing and unpacking. In a sense, ships would be used as transoceanic ferries. The trailers could be stacked if the wheels were removed and the sides reinforced. McLean bought a tanker company (named Pan-Atlantic, and renamed Sea-Land Service), and modified its ship to carry detachable trailers. At first, the ship could handle only 58 trailers, but soon this process was scaled up. In April 1956 the first container ship sailed from New York to Houston.

McLean's *Ideal-X*, which sailed in 1956, mounted containers on the deck of a T-2 tanker. Similarly, the first Matson ships placed containers on the deck of a Victory class ship (see box 16.3). The first specially built container liners carried 200 TEUs,[6] and those recently constructed are running 4,000 TEUs. Presently, about 90 percent of general cargo moves by containers stacked on ships. Over 200 million containers per year are now moved worldwide. Rosenstein (2000) notes the rapidity of containerization. From a footnote in the book *Marine Cargo Operations* (Sauerbier, 1956), containerization was essentially complete in 1971, when all containerizable cargo on the trans-Atlantic route was containerized (see, e.g., figure 16.4).

Containerization takes an old idea (putting things in containers), which has been around since the first pots and barrels, and scaled it up using advanced technology. The scaling made many older, smaller ports obsolete and created a generation of new superports that acted as hubs in a packet-based freight transportation system.

In addition to scale-up and specialization, there have been increases in speeds, for example, cargo ships from 20 to 66 km/hr (11 to 36 knots) and tankships from 20 to 26 km/hr (11 to 14 knots). However, fuel is a healthy part of operating costs, and to improve fuel efficiency, speeds have been reduced in some trades. The bulbous underwater bow section has been widely adopted, as have finer stern sections, and welding has largely replaced riveting. Low-speed diesels offer fuel efficiency advantages over turbines.

The State of the Fleet

> *You don't understand! I could've had class. I could have been a contender. I could have been somebody, instead of a bum, which is what I am.*
> —Terry Malloy in *On The Waterfront*

The adoption of sensors, communications, and computers, along with containerization, has yielded sharp reductions in the labor required as well as advances in ship routing and scheduling. Armed with technical know-how, one would think that the U.S. fleet gained

BOX 16.3 Matson's Innovations

The Matson Navigation Company's *Hawaiian Merchant* sailed on August 31, 1958, with 43 aluminum containers on deck inaugurating Matson's early entry into container shipping. The Matson Research Corporation had recommended converting ships for up to 75 on-deck container movements and the follow-on step of having ships specially constructed for container service. Almost two years after the *Hawaiian Merchant* sailed, the *Hawaiian Clipper* sailed in April 1960 as the first specially designed Matson container ship.

How could we have innovation and risk taking by an old liner company? Matson's experience was operating partly in domestic markets sheltered from foreign competition and in other markets where ship construction and operating subsidies applied. Tightly regulated by government and traditions, system-changing innovation was out of the question. But does regulation always stifle innovation?

Now owned by Alexander & Baldwin, Inc., a Hawaii-based company, Matson serves the California–Hawaii and U.S. Pacific Possessions trades with specialized container and automobile ships. Starting over 100 years ago with sailing ships in the Hawaii sugar trade, Matson is perhaps best remembered for Hawaii, Australia–New Zealand, and Pacific islands passenger liners. Its rich and complex corporate history includes taking risks, betting on technology, and the spawning of associated companies for new ventures. For instance, betting on the future of air services, in 1936 it joined with Pan American Airways to offer air services in Hawaii and it established an airline subsidiary in 1943 only to have those endeavors thwarted by regulation.

Inflation in the 1940s and 1950s along with labor strife at ports forced Matson to seek repeatedly for increased tariffs, but these were strongly resisted. Increased liner size or velocity was not a route to increased productivity and cost control because of the time required in port for gangs of 16–20 laborers to load and unload ships—in the Hawaiian trade, a ship spent as much time in port as it did sailing.

Like any good story, there was tension, conflict, gambling, and mystery. Matson's Hawaii market could be and was challenged by competitors, so failure could wreck the company, which was already shaken by losses in other markets. Should Matson take the bold step of being the first to offer container services throughout the Pacific? It took steps by arranging port terminals in Japan and the Philippines. Tensions were high as its Board of Directors' support vacillated and bowed to the realities of current economic conditions, and there are Matson docks in places where Matson ships have never called.

Mysteries included how to manage opposition by labor, the pace of market development, and the development of landside intermodal relations.

Small containers were already in use, serving mainly as lock boxes to thwart pilferage of valuable commodities. What size should general cargo containers be? Because many states had truck length limits, Matson chose 7.3 m length × 2.4 m width × 2.6 m height (24 × 8 × 8.5 ft) so that the containers could be moved as doubles—one on the truck and another on the trailer. Larger "high cube" containers came later.

In ports, Matson saw the opportunity for land-based gantry cranes replacing shipborne cranes. Container movement equipment and sorting and storage demanded large docks. Innovative managers at Matson Docks, Inc., and the port of Oakland, California, took risks and made investments.

Those who stood aside, such as managers at the port of San Francisco, were left behind as the predominant technology emerged in the format developed by Matson and others.

Figure 16.4. A container ship being loaded in Vancouver, Canada.

from these developments. One would think that the U.S. fleet could have been a contender for world trade. Instead, the United States has, on world comparison, a small fleet.

We do not have a good answer to the question of the lack of U.S. comparative advantage. Discussions we hear stress the low cost of buying and using World War II ships—that was a bargain with the devil for Western European and American operators. Other nations without those ships adopted new technology forms to produce competitive ships, and that eventually gave them a lead. The tankships were the first ships to scale up, and shipyards building those gained technology experience. We also hear that the U.S. shipbuilding industry is too navy-oriented, both in technology and contracting style.

The debate continues about the fiscal aids that government gives sea trade (not Jones Act) shipbuilders and operators, and it is argued that these aids are counterproductive. Construction-differential subsidies, through their tie to naval interests, overemphasized the break-of-bulk cargo liner, and the operation-differential subsidies blunted operators' searches for efficient ships and ship operations. To avoid the special U.S. conditions on registry, some large operators have extensively used flags of convenience. Today, the Liberian flag is widely used.

To try to turn this situation around, 1970 legislation extended the construction and operating subsidies to nonliner ships, and the CDS was increased to 50 percent. 1984 legislation allowed liner service to inland points using contracts with other modes. That advantage is available to all liner operators, of course. But one cannot blame the situation entirely on subsidies.

Table 16.2 The U.S. Domestic Fleet

	Coastal and Oceangoing	Inland	Great Lakes
Container ships (full container/roll-on-roll-off)	55		
Tankers	104		3
Dry cargo barges	982	22,279	101
Tank barges	456	2,791	41
Cement carrier			8
Dry bulk carrier			56
Tugs and towing vessels		5,424	

Note: (Jan. 1999) This table does not count passenger vessels serving as ferries, excursion vessels (one of which is part of the Jones Act Fleet), and gaming vessels. The Jones Act Fleet vessels are generally part of the Coastal and Oceangoing category.

While table 16.2 shows the domestic fleet, some say that the real fleet is the effective U.S. control (EUSC) fleet. Ships registered with Liberia, Panama, Honduras, the Bahamas, and the Marshall Islands are often considered part of the EUSC fleet, and simply registered with these "flags of convenience." These ships are generally owned by U.S. citizens or corporations, and are subject to requisition.[7] The EUSC concept originated prior to World War II to avoid the Neutrality Act as a way to provide material to Great Britain. Most of the ships are crewed by non-U.S. citizens, and thus seizing the ships will not result in gaining the crews (the principle that sailors were not to be pressed into service established by the War of 1812).

The EUSC fleet defined as above (7,927 ships) is about 18 times the size of the flag fleet (443 ships), and constitutes about 28 percent of the world's fleet (28,296 ships) (table 16.3). The Maritime Administration encouraged development of the EUSC in the late 1940s by allowing World War II ships to be transferred to foreign flags in order to encourage new work for American shipyards. These ships were transferred with the agreement of the Defense Department; they could be recalled, if needed. Some effective control was maintained then, but effective control of today's EUSC fleet is a fiction. Many of the ships are tankships, and are too large to call at U.S. ports. Yet, during the Gulf War of 1990–1991, many tankers switched to a U.S. flag to ensure the protection of the U.S. military.

Ports

The story of port growth parallels that of the ships that sail to them. As the ships grew, so did the ports. Sea and land transportation surged with the beginnings of modern commerce and industry, and the need for port facilities followed. Two styles emerged for development. On the European continent and overseas where Continental nations exerted power, central governments planned and developed ports. Forts protected space for housing, government functions, and material handling. Canals provided ship access to docks. The central government funded the ports using customs and rent receipts (Konvitz, 1978). There were variations in physical layouts, of course, depending on local physical situations.

Table 16.3 World's Fleet by Flag of Registry

Flag of registry	Total ships	Deadweight tons
Panama	4,727	180,170
Liberia	1,509	78,490
Greece	707	47,168
Bahamas	990	44,928
Malta	1,319	44,198
Cyprus	1,222	35,687
Singapore	852	32,365
Norway (NIS)	651	28,480
China	1,453	22,480
Hong Kong	419	22,387
Marshall Islands	258	18,787
United States	443	14,968
Japan	603	14,095
India	298	10,271
St. Vincent and The Grenadines	740	9,815
Italy	420	9,733
Isle of Man	205	9,288
Korea (South)	485	8,907
Turkey	541	8,856
Bermuda	97	8,405
All other flags	10,357	144,359
Total all flags	28,296	793,836

Source: U.S. Maritime Administration (2002).

In contrast, in the early days the central government in England did not exert power in the Continental style, and port development in England and in places that it influenced was laissez-faire, local initiative in style (Jackson, 1983). Although institutional and funding arrangements required central government permission, plans were developed and executed locally, often by a company established for development purposes. Defense facilities often were not constructed; port development varied greatly depending on local commercial and physical situations.

Ports increased in size to accommodate demands, and investments were made where increased throughput permitted the effective use of capital. If traffic were limited, cargo handling was managed by lightering. A 100-ton ship would anchor in a river, and lighters of rowboat size or small barges would move cargo to and from shore. Landing stages accommodated lighters or small barges at the riverside.

Cargo handling was "by hand," with simple mechanical aids. Small ships had to stuff and unstuff, and quantities of throughput were small. In the eighteenth century a dock might have a manual capstan (a cylindrical machine for raising heavy weights by coiling a cable) used for warping (moving) ships, but that was all. Steam engines were available in the eighteenth century but were not used on the docks. They were stationary and could not be well employed in loading or unloading small quantities.

Some ports used manual cranes. A few specialized docks had walking cranes (1750–1850). Laborers walking around a 5 m (16 ft) drum geared to an external boom and hoist powered the crane. Powered hoists were not used until the mid-nineteenth century. A central steam engine pumped water to a large storage tower, and the pressure head drove hydraulic crane motors (or water was pumped to an accumulator under pressure).

Increased movement of goods warranted investment in quays. One reference refers to 460 m (1,500 ft) of quays in London by the year 1700 and remarks on their crowding and need for additional facilities.

Investment in Liverpool commenced in 1709 when an enclosed dock was constructed. The enclosed dock was built to deal with relatively high tides; the alternative would have been very deep quays. The facility was built using a small estuarial pool (Liver Pool), and it provided 5.5 m (18 ft) of water. Occupying 1.6 hectares (4 acres), it could accommodate 100 ships. Pools or basins began to be constructed in London some years later. The West India Docks opened in London in 1802 and enclosed some 12 hectares (30 acres).

Where the topography was favorable, gravity flow of bulk commodities emerged. On the River Tees, for instance, Port Darlington was constructed downriver from Stockton so that rail cars could be dumped directly into coastal vessels.

Other cases differed depending on trade growth and local circumstance. In Hamburg, for instance, there was very early use of warehouses on small shallow canals. But as ship sizes increased, river anchoring and the use of lighters became common. Eventually, ships anchored to large barges for cargo handling and storage, and lighters worked the barges. That system continued until the 1880s.

Following these early beginnings, ports increased in size over the years. Facilities were improved to accommodate larger, deeper draft ships, and extended well beyond the early fort-like ports. Mechanical devices were developed and deployed for material handling. There was a burst of development in about 1850 as steam liners were placed in service. In spite of these great changes, we judge them as more growth than development in character, with development (change of form to accommodate new functions) awaiting the emergence of container liners and large cargo ships.

Ports grew, enabling economies of scale. One factor limiting the exploitation of economies of scale was ship size, which was not increasing very rapidly.

For centuries, general cargo ships were measured on register tonnage, with one register ton representing 2.8 m^3 (100 ft^3) of space. Net register tonnage space is tonnage so measured minus space used for machinery and crew quarters. Columbus's *Santa Maria*, the largest of his fleet, was a 300 register ton ship. Large sailing ships at the end of the sailing era were running at 600–700 tons[8] (though steel-hulled, steel-masted "grain racers" would carry more than ten times as much around the beginning of the twentieth century: Odlyzko, 1997). The economy of scale for ships just wasn't there. As ships scaled up, the number of sails and requirements for crew increased in an almost linear way, as did the expense and difficulty of construction. (Rule of thumb called for three crew members per sail, though grain racers had crews on the order of 30.) Because of slow cargo handling, the dead time in port was long, disadvantaging large, expensive ships, the kind constructed by Brunel.

Water transportation has evolved considerably from the time of our story. Containerization radically changed the scale and scope of maritime transportation. The growth of Asia as a manufacturing center has led to the top four ports being Asian (table 16.4). London, which is too far inland and served by too shallow a waterway, is no longer among the top ports, nor is New York.

Table 16.4 Top International Ports and Containerized Cargo Throughput, 2000

Country	TEUs (millions)
1. Hong Kong, China	18.10
2. Singapore, Singapore	17.09
3. Kaohsiung, Taiwan	8.64
4. Pusan, Korea	7.54
5. Rotterdam, Netherlands	6.27
6. Shanghai, China	5.61
7. Los Angeles, United States	4.88
8. Long Beach, United States	4.60
9. Hamburg, Germany	4.25
10. Antwerp, Belgium	4.08
11. Tanjung Priok, Indonesia	3.37
12. Port Kelang, Malaysia	3.19

Source: *Journal of Commerce Week*, vol. 2, issue 8, Feb. 26–Mar. 4, 2001, p. 24.

Note: TEU (20-ft equivalent unit, standard container size). TEU statistics for 2000 are provisional. Empties are included in TEU count. Ship to ship transshipments are double-counted.

The story for each port is greatly conditioned by local circumstances. Growing ports increased capacity. Companies or local governments provided financing and exerted control, subject to enabling actions by central governments and to customs control and other operational matters of interest to central governments. Navigational aids were generally provided by local organizations. The City of London, for example, provided dredging and channel markings.

The theme in England was local government, quasi-government, or private institutions financing, constructing, and operating facilities. That theme continues for air and water ports in many parts of the world. On the Continent, central governments generally took the lead in port development. The position was that trade was essential to national development (the Crown could make money). Defense was also to be considered.

As far as policy goes, the American Association of Port Authorities (AAPA, 2004) calls for:

- Expanding sources for port development financing and revenues.
- Balancing environmental regulation and economic development.
- Providing waterside port access through dredging and dredged material disposal.
- Securing resources for intermodal landside access to ports.
- Using transportation trust funds for infrastructure development, not deficit reduction.
- Enhancing free and fair trade worldwide.

Thus, for ports to grow the industry association wants more sources for financing (they say that the markets are insufficient, and the ports would like subsidy), they want environmental regulations relaxed (but make no suggestion that they should pay for the externalities they generate), they want resources to expand landside access, and they want a free trade policy. Only the last is fully consistent with free market competition.

Outside the United States, many ports, like airports, have been privatized. That may be a direction in which the United States heads in years to come.

Discussion

A key issue remaining within the ocean freight industry (as in international air travel) is that of regulation and protectionism. While it is one thing for a government to let domestic firms compete for domestic trade unfettered (at least all of the gains stay national), it is another to allow unregulated international flows. Ships from most countries can carry U.S. trade to other countries. In that sense, trade is already deregulated. But there are periodic pressures (to support the domestic shipping or shipbuilding industries) to impose some sort of protectionist measures (e.g., cargo reservation), to reserve a certain fraction of cargo for U.S.-flag ships. Other countries do similar things to a greater or lesser extent.

With respect to the vitality of the U.S. fleet and construction industry, one impression we have is that we ought to let things run their course. It has been said that U.S. bottoms are more expensive because of mandated safety features, and they are more expensive to operate because of high labor costs. But as other nations develop, labor costs and requirements for safety rise. One can make similar comments about shipbuilding. The problem with that view is that cost differences are bound to be around for a long time, and the U.S. fleet and shipbuilding would disappear if there were no construction and operating costs subsidies. At best, we would end up with a U.S.-owned foreign-flag fleet, as we have in the bulk trades. But that is a risk. The defense sector would not accept that risk, because they would not have an effective U.S.-controlled (EUSC) resource. They would not have the shipyards either. An option would be to continue policies now in force, make them stronger, and put more money behind them.

Recent (and we expect continuing) trends in shipping include:

- More use of computers and communications, not so much to reduce manning, but to track cargo, including identity-preserved cargo, and for security checks.
- Better fuel efficiency through continued improvements in engine, ship, propeller, and rudder designs.
- Continued rise in ship sizes. This is limited by physical constraints (e.g., the Panama Canal or harbor depths).
- Further development of hubbing ports (such as Singapore and Rotterdam), in part to gain economies of scale in shipping.
- Specialization and increasing sizes of containers, though again constraints (easy transfer to trucks or trains) play a role.
- Simultaneous loading of multiple containers (stacks) to speed up port turnaround.
- On-ship devices for stowing containers.
- Continued specialization of ships of all types.

Since the logistics revolution, shipping has been reborn, grown, and matured again, and though it is still evolving, change is again coming slowly. There may be a new logistics revolution like containerization around the corner—speedy, giant ships from trans-Atlantic and trans-Pacific trade. If trends continue, the number of important ports will decline with the size of ships, but those few ports will continue to expand in size. The remaining constraints will continue to be the canals and the harbors.

17

Aviation

Airplanes will eventually be fast, they will be used in sport, but they are not to be thought of as commercial carriers. To say nothing of the danger, the sizes must remain small and the passengers few, because the weight will, for the same design, increase as the cube of the dimensions, while the supporting surfaces will only increase as the square.
—Octave Chanute, American aviation pioneer (1904)

You define a good flight by the negatives: you didn't get hijacked, you didn't crash, you didn't throw up, you weren't late, you weren't nauseated by the food. So you're grateful.
—Paul Theroux, *The Old Patagonian Express* (1979)

Introduction

Providing supersonic flight at Mach 2, and travel at 18,000 m (11 miles) above the weather, high enough to appreciate the curvature of the earth, the Concorde just oozed the future. Yet in June 2003 Air France, and in October 2003 British Airways, retired their Concorde fleets (seven aircraft), a mere 27 years after they started regular service, after serving over 2.5 million passengers. The trend in transportation has been toward steadily higher and higher speeds. So is the retirement of the Concorde without a comparable replacement indicative of the general retrenchment in the aviation industry, or does it suggest cost and technological limits on speed increases?

The history of transportation is full of fits and starts; many U.S. passenger rail routes achieved their highest routine speeds in the 1920s and have yet to match those records. Is the history of supersonic transport different?

The Concorde was perhaps the first major technology to be developed jointly by two governments, the British and French, who in 1956 signed a treaty on the design, development, and manufacture of a supersonic aircraft within six years. A little ambitious, the first prototype was rolled out in 1967 in Toulouse, France, and took flight in 1969. In 1973 the Concorde made its first flight to the United States, landing at the new Dallas–Fort Worth Airport. In 1976 British Airways began supersonic service between London and Bahrain, and in 1977 from London to New York. The first crash of an

Air France Concorde occurred on July 25, 2000, and resulted in the grounding of the fleet until July 17, 2001.

The Concorde was the only supersonic passenger craft to get off the drawing board and into continuing service, although there had been plans for a U.S. supersonic aircraft at around the same time. In 1963 President Kennedy announced that the United States would develop a supersonic transport, or SST. Boeing won the contract over Lockheed and North American, though it turned out to be a Pyrrhic victory. Despite President Nixon's assertion on September 23, 1969, that "The SST is going to be built," the SST was cancelled in 1971 for both market and environmental reasons; there were and are concerns about the effects of sonic booms. Later, in the 1990s, NASA, along with Boeing, spent $1 billion designing a "High Speed Civil Transport," which was cancelled due to high costs (expected to be $18 billion in development alone) and insufficient expected revenues.

The Soviets built the Tu-144, dubbed the "Konkordski" due to its striking similarities that many assert are the result of industrial espionage. The Tu-144 was the first commercial supersonic aircraft, flown in 1968. During the 1973 Paris Air Show the plane crashed, probably because of an unusual maneuver to avoid hitting a French Mirage fighter that was secretly filming it (Nova, 1998). The French and Soviets colluded to cover up the story, which was only revealed after the end of the Cold War. The Tu-144 did make semiregular service in the Soviet Union between Moscow and Alma-Ata, Kazakhstan, between 1977 and 1978, but was retired soon after another crash. NASA later cooperated with the Russians to study the Tu-144, reactivating the plane in 1995. Other schemes have been proposed, but none has been successful.

The final decision to retire the Concorde is of course premised in market economics, which the Concorde, as a state-sponsored enterprise operated by state-sponsored airlines, had been fighting its entire life. The cost of operating the aircraft could not be recovered by fares; very few people had such a high value of time. The year of retirement, 2003, during a period of fears about war (Iraq), terrorism (9/11), and plague (the SARS virus), along with price volatility in oil, was an era of major troubles for the airlines. U.S. Airways, United Airlines, and Air Canada all went through bankruptcy and American was tottering on the brink.[1] Rod Eddington, British Airways' chief executive, said: "This is the end of a fantastic era in world aviation but bringing forward Concorde's retirement is a prudent business decision at a time when we are having to make difficult decisions right across the airline."

In 1998, in the United States, personal expenditure for transportation amounted to $866 billion, $97 billion of which, about 11 percent, was for air transportation (BTS, 2000c). The activity is relatively small (but growing to about twice the share and four times the dollar amount as ten years previously), but on expenditure grounds it receives more than its share of attention. Perhaps that is because it is thought that its policy problems are more acute than elsewhere. However, we have difficulty seeing air transportation problems as much different and deeper than problems elsewhere. We think the reasons for relatively high problem visibility and debate include the status of users (the "jet set" are still image-makers, movers and shakers) and the feeling that air service is somehow more vital than other services. And recently the terrorism issue has made air transportation even more prominent.

This chapter treats air transportation using the structure–performance–conduct format used previously. Comparisons are made to the auto-highway, truck-highway, and transit systems.

System Evolution

Lifting vehicles (kites, balloons) have been available for centuries, and as propulsion systems came along there were efforts to apply them. An early assumption was that vehicles would emulate birds, and that assumption continued with respect to control of flight into the 1920s, even after the propeller was adopted (and after the Wright brothers flew with a fixed wing in 1903). In hindsight, we know that the developers of the times took an overly simplistic view of the way bird flight is controlled.

The system began to evolve in the 1920s in over-water market niches. Important actors were Pan American Airlines and producers of "flying boats." Commercially viable planes were produced, firm organizations and passenger interrelations were worked out, and there was important development of en-route control systems. Although, where national borders were crossed, firms had to make arrangements for rights to provide service and there was airmail subsidy, governments were not much involved in the 1920s and early 1930s.

Overland commercial systems began to evolve in the 1920s, but their birth is best marked at about 1935 by the development of the DC-3, a suitable aircraft for such services (Heppenheimer, 1995). While Boeing's Model-247 was the innovative aircraft, combining the best of existing know-how, Douglas's DC-2 and DC-3 were larger and faster, and flew farther. In particular, the DC-3 "got it right" for the conditions of the time (size, velocity, cost); it was the Model T of aircraft, so to speak.

At about the same time, suitable aircraft for other markets began to evolve, for example, the Gypsy Moth and the Piper Cub for recreational flying, the Norseman for Arctic flying, fighter and bomber aircraft, and so on.

Evolution of the system includes more than equipment. Aids to en-route navigation evolved; during the 1930s there was the development of the AM radio range, suitable voice communication radio, tower and en-route traffic control, weather forecasting, and so on. Airmail played a major role (see box 17.1). Heavy government involvement in the 1930s included the development of the precursor to the Federal Aviation Administration (FAA) and government regulation following the railroad model. The airmail subsidy was very important.

The situation was quite similar in other nations. However, during this period they were more affected by the winds of war.

The first uses of the system were for airmail communications and the substitution of air travel for ship and rail. Recreational flying and some business uses evolved early. We think that service today provides much more than substitution, for many aspects of activities have been organized or reorganized and enabled by today's service.

The increased internationalization of air travel after World War II drove an international policy agenda beginning in the late 1940s. As part of that, a debate in the United States continued from the 1930s, as to whether there should be a recognized U.S. flag carrier. The United Nations, established at the end of World War II, became involved in air transportation rather early on through its International Civil Aviation Organization.

In the early days, services had mainly been from small, privately owned fields, many not much improved over pastures. All that was needed was a level grass field and a shack or so. As DC-3 service came along, longer runways and pavements were needed. Airports began to be developed by cities (Barrett, 1987). Airports provided a gateway to a city, and they enabled the city to participate in the air system. On the heels of

BOX 17.1 Airmail

Airmail contracts were the savior for young airlines. Melville Kelly authored the Contract Air Mail Act of 1925 and the Foreign Air Mail Act of 1928 (the Kelly Acts), which used the post office to subsidize (and ensure monopolies) for given origin–destination pairs. The mail contracts covered the costs of the flights, enabling airlines to sell seats for a profit.

In 1930 the Watres–McNary Act enabled the Postmaster General to award competitive airmail contracts to the "lowest responsible bidder" rather than simply the lowest bidder. This made the Postmaster General, Walter Folger Brown (who helped draft the Act), a virtual czar over the airlines, determining their fate. The main three east–west routes were given to United Airlines (controlled by Boeing at the time) (the northern route, New York–Chicago–San Francisco), Transcontinental and Western (TWA) (the middle route, New York–St. Louis–Los Angeles), and American Airways (the southern route, Washington–Dallas–Los Angeles). Eastern Airlines was awarded the main north–south route on the east coast (Boston–New York–Miami). Braniff was later awarded a north–south route connecting Chicago and Dallas, and Delta was given a route connecting Charleston with Dallas. These big six continued to dominate U.S. domestic air travel until the era of deregulation, and their hubs (or hubs of successor airlines) are still located in cities for which they received contracts in 1930, showing the effects of lock-in.

World War II, many military fields adjoining cities were acquired for commercial use. Although a few airports have been constructed from scratch, in the main the former military fields have been expanded to accommodate traffic growth.

Air traffic control improvements introduced after World War II, included changing to FM beacons and the use of radar.

Successful jet engine, jet frame commercial aircraft came on the market in about 1960. The B-707 was the first commercially successful jet aircraft, though the Comet and other aircraft had appeared in Europe earlier. Considerable improvement in service quality, faster, longer stage length, and a smoother ride, resulted.

The longer runways required for jet aircraft created a problem for airports, as did the need for larger terminals as traffic swelled. To meet these needs, the federal government introduced a tax on tickets and developed an airports and airways trust fund, modeled on the highway trust fund.

The 1930s regulation had been modeled on the railroads. Management of labor disputes was handled by the Railroad Labor Relations Board. Costs were set for passenger travel using tapered per mile rates. Established during the 1930s, regulation shared the aim of trucking regulation, to protect existing operators from new entries. Policy was also concerned with service to small communities; there was the requirement that small community service be included in the route structures of firms and a minimum level of service provided.

Regulation kept new firms out of the business. Even so, old firms were able to increase service areas, and service was gradually increased in the larger markets. Prior to deregulation, complex classes of fares had been introduced along with hubbing.

Indeed, O'Hare Airport in Chicago was a hub for DC-6 service as early as the 1950s. Deregulation of routes and fares, but not safety or air traffic control, came along during the Carter administration.

Pan American Airlines

> *To provide mass air transportation for the average man at rates he can afford to pay.*
> —Juan Trippe's stated goal for Pan Am

The Trippe family were bankers descended from English seafarers who had settled in Maryland in the seventeenth century. Born in Sea Bright, New Jersey, in 1899, Juan Trippe attended Yale, where he played football and served as a Navy flier during World War I. Trippe formed his first airline, Long Island Airways, to provide taxi service in the New York area to other wealthy gadabouts. When that company failed, he and his classmates from Yale joined Colonial Air Transport in 1922, which was a beneficiary of the federal airmail contracts, serving the Boston to New York market. While not Hispanic, he used his name as a way to enter the Latin American markets (the source of his name "Juan" is disputed). After clashing with Colonial over expansion, which Trippe favored but the stockholders opposed, Trippe formed a new company (Aviation Corporation of America) in 1927, and using his name as an aid, obtained Cuban landing rights from Cuban President Garardo Machado. However, when the airline won the landing rights, it had no airplanes, no money, and no contract. One competitor had the airmail contract, but no landing rights. A third company, Atlantic, Gulf, and Caribbean Airways, had access to Wall Street financing. A new company was formed from Trippe's new company and the two competitors (none of which was operating planes at the time) and adopted its name from one of those newly merged companies (run by Henry "Hap" Arnold, who went on to run the Army Air Force during World War II). In 1927 the new company under Trippe's leadership was able to provide airmail, and by 1928 passenger service, between Havana, Cuba, and Key West, Florida (Young, 2001).

Trippe successfully used the levers of government (both U.S. and non-U.S.) to further private ends, making Pan Am effectively the United States flag carrier. With airmail contracts lined up in Latin American markets, the State Department would work on his behalf to ensure it a monopoly position where possible. Trippe then used Pan Am's dominant position in the air carrier business to play airframe manufacturers such as Boeing and Douglas against each other. The Clipper services, establishing long-distance over-water services (first Carribean, then Atlantic and Pacific routes), were essential for Pan Am to ensure dominance.

While Trippe started out providing luxury services with his Long Island Airways, he was the first to expand the market to the middle classes by establishing "tourist class" fares between New York and London ($275 in 1945) (Branson, 1999). This drew the ire of competing flag carriers and the IATA cartel, and Britain closed its airports to Pan Am, forcing the airline to fly to Shannon Airport in Ireland.

Trippe introduced jet aircraft, the Boeing 707, in 1958, which were faster, higher, and carried twice the load. Trippe created the "jet set" with the trans-Atlantic jet services, but then brought the "jet set" within reason by continuously lowering costs and prices. While the 707 had a cost of $0.041 per seat km ($0.066 per seat mile), he wanted to lower that further, which could only be achieved with greater economies of scale. A new class of still larger jets was needed. To that end, he told Boeing, "If you build it, I'll buy it," to which Boeing's CEO William Allen replied, "If you buy it, I'll build it." The supplier–customer relationship was not simply a market transaction, but involved significant negotiation. Aircraft were far from a perfectly competitive market, and at the time the same was true of airlines. Pan Am was intimately involved in the design of the 747, including ensuring that part of the upper deck would be for passengers.

While the 747 was ultimately a very successful aircraft, still in widespread use, it had such high fixed costs that it almost bankrupted both Pan Am and Boeing. Pan Am was hit hard by rising oil prices in the 1970s, which forced it to raise fares and reduced demand. Trippe died in 1981 and Pan Am merged with National Airlines, a Miami-based domestic carrier. The airline failed in 1991.

Policy

The formats for current policy problems (within components, component to component, system, and system versus its environment) hold for the air transportation system. Not much is to be gained by listing problems. Instead, brief remarks will be made on several policy matters. After highlighting the discussion, some comparisons will be made of air, transit, and highway systems.

The airport problem has historic path-dependence aspects. Once airports got going, a variety of forces "locked in" their behaviors, not the least of which was their association with particular cities (big, politically powerful), making location adjustments almost impossible.

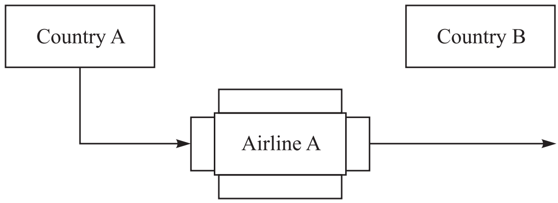
The longstanding maritime cabotage policy needs to be considered. Cabotage refers, in the maritime case, to coastal transport within a nation, and nations have long reserved that trade for ships flying their flags. Others may bring their ships to my ports, but they may not carry freight between my ports. That principle was extended to air transport in the early days. For instance, a foreign carrier may not offer airport-to-airport service within the United States. A carrier can, of course, fly from San Francisco to New York to Paris. But the carriage of passengers who just want the San Francisco–New York service is prohibited, resulting in a waste of resources. The policy issue is that of how the principle of cabotage will be resolved as the European Union evolves. Will the EU impose cabotage restrictions on non-EU airlines? If it does, that will hurt the U.S. carriers. It might result in pressure to eliminate cabotage restrictions within the United States. The first six airline freedoms, described in box 17.2, were established by the 1944 Chicago Convention of the Provisional International Civil Aviation Organization, which later became a UN unit.

Interest in supersonic (or hypersonic) transport reappeared. Even if not supersonic, the development of a new aircraft requires a multi-billion-dollar front-end investment, a sum that may be out of the reach of a single large company such as Boeing, though not necessarily out of reach of a joint-venture or a public–private partnership such as Airbus. A variety of institutional, financial, and technological issues appear.

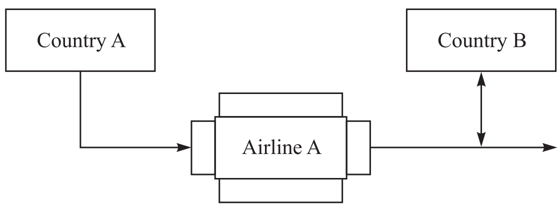
What about private aviation issues? The Piper Cub and some other aircraft developed in the 1930s suggested an opening path for a "plane for anyone" society, planes that cost about as much as an automobile and are as easy to operate. That dream held into the

BOX 17.2 Air Freedoms

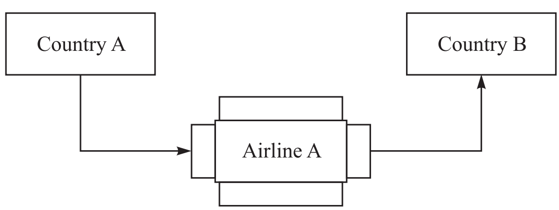
First Freedom (Transit Freedom): The right to fly and carry traffic over another country without landing.



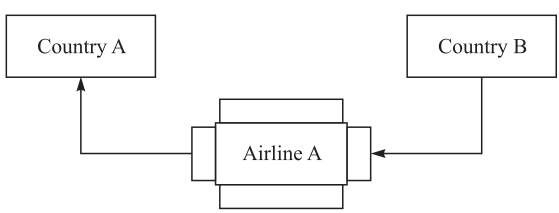
Second Freedom: The right to land in another country without boarding or deplaning passengers (e.g., refueling).



Third Freedom: The right of an airline from one country to land in a different country and unload passengers from the airline's country.



Fourth Freedom: The right of an airline from one country to land in a different country and load passengers to the airline's country.

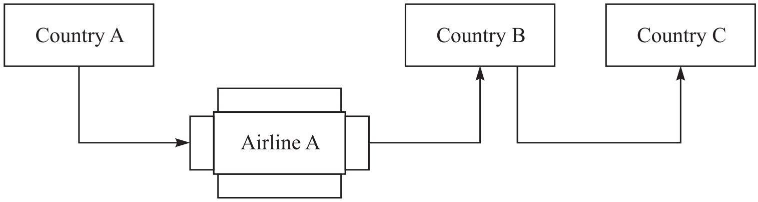


Fifth Freedom (or Beyond Rights): The right of an airline from one country to land in a second country, to then pick up passengers and fly on to a third country where the passengers alight.

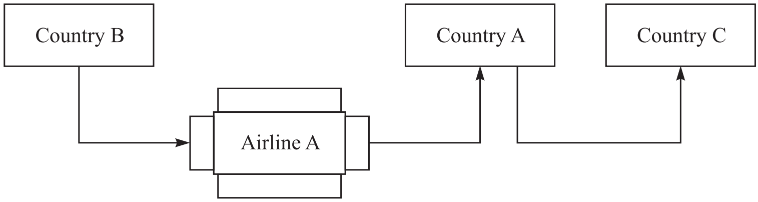
(continued)

BOX 17.2 Air Freedoms—cont'd

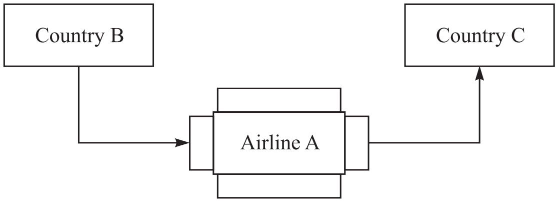
- Intermediate Fifth Freedom: The right to carry passengers from the home country to the second country (implied by the Third Freedom).
- Beyond Fifth Freedom: The right to carry passengers from the second country to the third country.



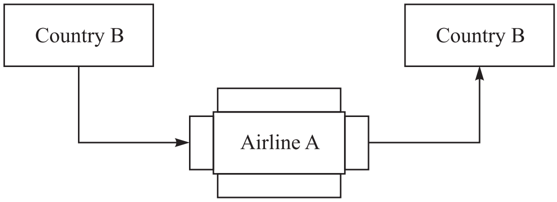
Sixth Freedom: The right to carry traffic from one state through the home country to a third country.



Seventh Freedom: The right to carry traffic from one state to another state without going through the home country.



Eighth Freedom (*Cabotage*): The carriage of air traffic that originates and terminates within the boundaries of a given country by an air carrier of another country.



1950s, but the path never opened. If it ever did, what kinds of policy would be needed? Other private issues include safety and the availability of airspace.

Deregulation has had positive and negative affects, and there is discussion of reregulation. As is the case in all systems, there is the issue of the amount of deregulation achieved.

Growth Pulses

Figure 17.1 suggests two growth trajectories or pulses for the air transportation system—one with DC-3 piston type aircraft (the solid line), another with jet service (the line with triangle markers). We can think of other pulses—as the freight system shifted to diesel locomotives and as the nature of the automobile changed in the 1930s, for example. Figure 17.2 focuses on air travel in the jet era.

Following Nakicenovic (1988), we explore a logistic model for commercial aviation. Our predicted jet era model (fitted through 2001 data) has a very good fit ($r^2 = 0.98$) if we assume a final market saturation at 10^9 total domestic enplanements, and we reach within 10 percent of that value in 2024. This of course assumes no change in technology.

There were pulses in the equipment component of systems and pulses in regulation, which inspired a major reorganization to a hub-dominated system, but we can think of examples of pulses in other system components. A pulse in a component strains the incremental ways that components grow and develop in relation to each other. For instance, the diesel locomotive, the jet plane, and the interstate strained other components. Reactive public policy was undertaken—policy to ease strains.

Another policy question has to do with proactive efforts to achieve a pulse in air transportation. Recalling the strains set off by pulses, should public policy be addressed

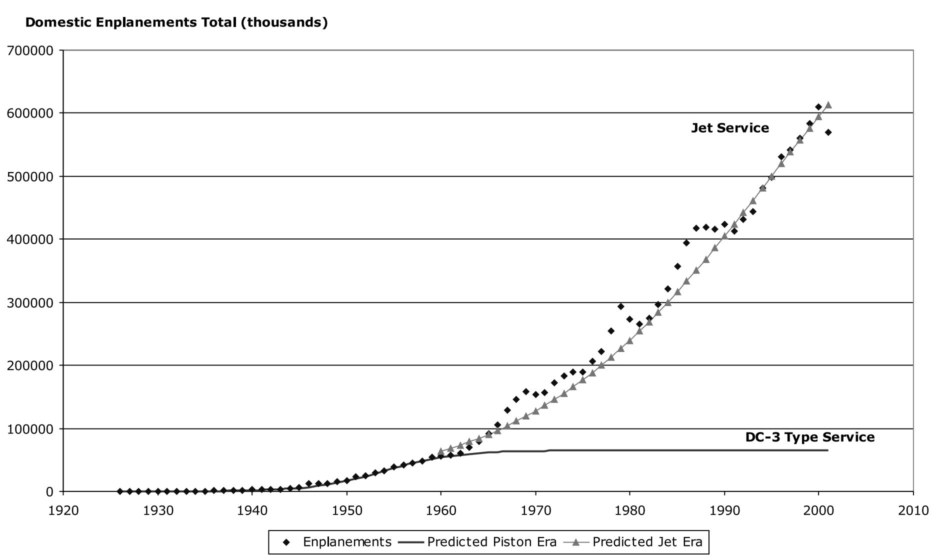


Figure 17.1. Domestic enplanements, 1927–2001.

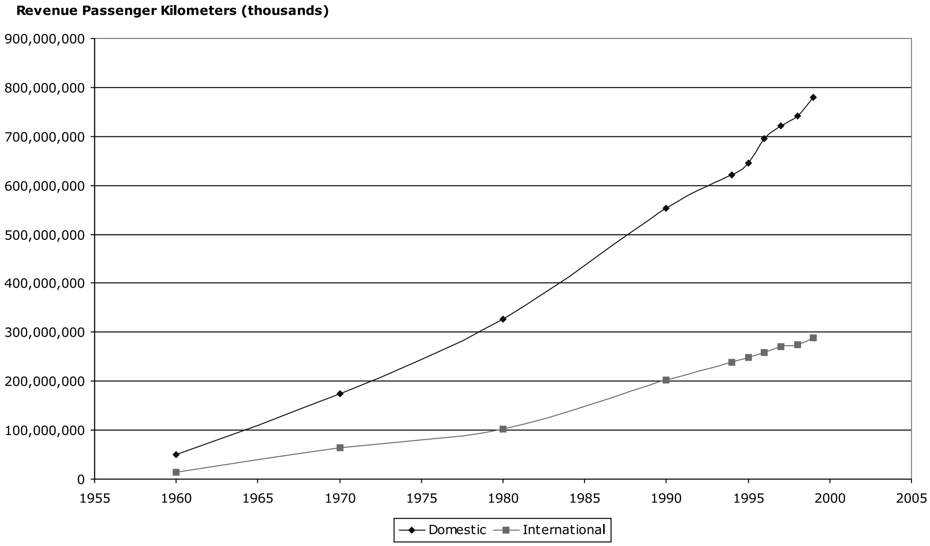


Figure 17.2. U.S. air travel revenue passenger miles, domestic and international.

to more than one component of systems? Is seeking a pulse worthwhile when a system has almost run its growth trajectory?

System Comparisons

Air, transit, and highway systems compare across a number of attributes (see also Gifford and Garrison, 1993). The word “system” (or “mode”) does not fit any of the systems very well. We noted the truck-highway and auto-highway systems. For air, there are commercial and private aviation systems and freight versus passenger systems. Transit has at least the varieties of suburban rail, bus, and elevated/subway. Often, *diversity* is ignored in policy debates. Diversity is suggestive of ways systems might change. It is also the reason for the distortions created by one-size-fits-all policies.

One way to recognize the problems of the air system is to see them as a result of *force-fitting*. That occurred partly when the system in the United States grasped the opportunity to use post-World War II former military airports. The commercial part of the system has been forced to work out of those airports (coerced might be a better word than forced). The few major new airports that have been built have duplicated the World War II airports in important ways. The big force-fitting was the introduction of the jet into the DC-3 system. The jet forced scale changes in nonequipment components of the system. In some ways, the horse-powered highway systems have a parallel to the DC-3, and the motorized systems were force-fitted as the jet was. Trucks and autos operate on streets built before motorization and on facilities built later, but which carry over premotorization protocols. Bus transit is in that situation also. The birth of rail had more of a “put together a new form to fit a function” character, and rail mass transit grew from such beginnings.

We have stressed how once the structure of a system becomes established, the behavior of the system is conditioned by its structure. Indeed, *behavior reinforces structure*. We have stressed how the exploration of new functional forms is thwarted, remarking mainly on limitations on the explorations of technology options and markets.

One way to state the urban transportation problem is to say that the systems available do not fit their environment very well. That is because the environment has changed and, importantly, perceptions of how environments ought to be have changed. Although there are several aspects to this, a simple statement to illustrate the point is to say that the urban market is not dense enough for transit but is too dense for autos.

A desirable property of systems is the capability to *adapt* to changes in their environments. In some ways, transit systems have adapted better to changes in the urban environment than the auto system. The adoption of the bus in the 1920s through the 1950s and the recent development of paratransit services are examples of changes responsive to the environment. On a closer view, there have been interesting changes in the ways rail transit works.

We have stressed the locked-in character of systems and their consequential inability to continue to improve what they do. The present point is that locking in thwarts systems' abilities to adapt as their environments change.

Rules conditioned by structure and behavior are permissive of two classes of system-improving actions. These are actions seeking the economies of *networking* and actions seeking route *economies of scale*. The two classes interact. The articulation of services over a network permits achieving economies of scale on routes on that network; the efficiencies to be achieved via route economies of scale may motivate networking.

Considered alone, the improvements from networking seem to be mainly service improvements. Trucking organizations that operate nationally have costs similar to those of regional operators, but they offer better service for long-distance movements. It is nice to have a networked international air system. One can travel the world with a single booking and ticket, airplanes can be repaired almost anywhere, and traffic rules are universal.

The cost of networking results from the use of unitary technologies and the standards required by such technologies. Standards thwart change and the fitting of systems to local conditions.

Route economies of scale are often captured by upscaling equipment. If demand exists for a route, larger airplanes, longer passenger trains, or larger buses may be used. Commodities may be moved in unit trains, large tows, or large ships, such as very large crude carriers (VLCCs). In addition to capturing equipment-related cost reductions, the transportation-providing organization may also achieve cost reductions in passenger processing, managing, and so on. Movement cost may be lowered, but the queues may be longer. One waits longer, say, for a larger, lower-cost aircraft.

Just as the freeway system has enabled sharp provision-of-facility route economies for highway departments, hub-and-spoke traffic patterns concentrate traffic so that route economies of scale may be achieved.

The point we wish to make is that the search for these scale and network economies achieves service improvements or cost reductions, but also has costs associated with them. Federal Express, profiled in box 17.3, illustrates the cost reductions and reorganizational possibilities associated with network economies on the freight side of air transportation.

BOX 17.3 Federal Express

> *The concept is interesting and well-formed, but in order to earn better than a "C," the idea must be feasible.*
>
> —A Yale University management professor in response to student Fred Smith's (1965) paper proposing reliable overnight delivery service.

This chapter has mostly explored the passenger side of aviation; freight has tended to stay on the surface. Aside from airmail, the aviation contribution to civilian freight transport until the 1970s was quite small. That was the environment faced when, as noted in the quote above, Fred Smith, the founder of Federal Express, had trouble convincing his business school professor of the viability of his enterprise. After all, it was both technically difficult to coordinate overnight delivery at an affordable price (if it were not, would it not have already existed?), and there was uncertain demand, since we had had instantaneous communications for over a century. What needs to arrive overnight that can't be communicated by telephone?

The company began operations in Memphis, Tennessee, on April 17, 1973, delivering 186 packages to 25 U.S. cities using 14 Dessault Falcon aircraft. The company grew quickly, especially after the 1977 deregulation of the airfreight market.

The innovations of Federal Express were several. First was the use of a single national sorting facility (in Memphis) to assure economies of scale, guaranteeing that there would be at least one connection from every important local distribution center to every other. They used this hub and spoke architecture to minimize total flights (e.g., the overnight guaranteed shipments can be satisfied with one round trip from every city to Memphis per day, aside from a few of the larger markets; smaller markets wouldn't necessarily require nonstop service). As a proposition, Federal Express would not succeed unless it began nationally. By its very nature as a last-minute shipping company, the shippers do not have too much time to figure out which company can serve which city overnight. Dropboxes, which were deployed in 1975, eliminated the need for carriers to pick up shipments from each individual (or requiring individuals to travel far to find a pickup site), thus lowering costs. The use of a Memphis hub led to apocryphal, though likely true, stories that to ship something between offices in the same building in New York was faster through Memphis than via the company mailroom.

The company further took advantage of time zones to reuse planes. A plane going east at 4 or 5 A.M. could return to Memphis, reload, and go west in time to do another delivery. This leads to the possibility of same-day delivery in these markets, as there is no reason to have a completely empty plane.

An innovation that came soon afterwards was the use of barcoding and scanning technology enabling the tracking of individual packages, minimizing losses because someone was responsible for a particular shipment. With the Internet, this reassured customers that their shipments were making safe progress.

While as a company Federal Express has had some stumbles, for instance, the Zapmail product mentioned in chapter 4, it has in 30 years become an important element in the global transportation/communications system, to the point that *to fedex* is a verb in common speech. The company has expanded internationally (though not with necessarily the same overnight guarantee), and into ground transportation. Meanwhile competitor United Parcel Service, a ground-based package company, has moved into its overnight market. Both have seen markets greatly expand with catalogs, and then Internet commerce, as individuals substitute shopping with shipping.

Discussion

In the main, the air system shares properties of systems previously examined. Its market is not as fully saturated as the others, but the predominant institutional and technological structure seems well established. It is less tightly tied to land routes than other systems, and rationalization has somewhat different terms than is the case in other systems; it involves sometimes sweeping changes in the geographic structure of services along with changes in the firms. (Gate availability and international negotiation requirements do limit the range of geographic actions available.)

At this time in the growth dynamic, we would expect most of the productivity gains from process and product technology to have been captured; emphasis would be on market channeling. That seems to be the case. Airports, equipment makers, and firms are competing in market channeling arenas. The figures on average fares (presented in chapter 2) and labor productivity (chapter 5) suggest the running out of productivity gains, though they are still being obtained. The impact of deregulation on efficiency is no doubt real, but the figures say that it is small.

Many airport managers are implementing versions of deregulation, especially by seeking markets and efficiency through adjustments in landing fees, and airline firms are seeking equipment and operations protocols tailored to niche markets. Access to services through fractional ownership/rental of aircraft is enlarging business aircraft services.

Might technological change in the form of the healthy interest in experimental aircraft combine with aircraft control technologies and new materials to yield the long dreamed-of airplane in every garage? Like other technological inevitabilities (picture phones, domestic robots) we shall surely obtain this vision, but it may take longer than expected.

This page intentionally left blank

Part IV

Complementary Experiences: Perspectives on Inputs and Outputs

Everybody uses transportation, and newspapers and magazines bombard readers with news of events, accidents, and grand plans with expenditures to match. Individuals fret about congestion and costs, and business managers worry about customer access and timely, inexpensive, and reliable deliveries of goods. A sizable public thinks that unnecessary transportation is gulping resources, fouling the air, and bringing an unwanted sameness to landscapes and cultures.

Although, over the long haul, services have become cheaper, faster, and better, service costs and congestion rank high among everyday complaints. There are perceptions that things are getting worse.

How can we place perspectives on this situation? Previous chapters have striven for perspectives one mode at a time. The chapters to follow move from retail to wholesale, so to speak. They will examine cross-cutting topics ranging from the ways systems interact with space and time frames to comparisons with other networked systems; they will weigh some of the inputs to the provision of services.

This page intentionally left blank

18

Communication

You could put in this room [the office], de Forest, all the radio apparatus the country will ever need.
—W. W. Dean, President, Dean Telephone Company

Introduction

In the two decades after the telegraph was developed it had become the most important communications technology since the printing press, obviating distance as a barrier to the exchange of information, so long as wires connected the two ends. Where previously it may have taken days or weeks for messages to be received, with the telegraph it was reduced to seconds. Yet not all ends were connected with wires, and though information could travel instantaneously within Europe, or within North America, it could not travel the same distance between the continents except aboard a ship. Bringing the Old World and the New World together required laying a telegraph cable across the Atlantic Ocean.

That cable would complete the missing link in the global communications system, melding the separate networks into one. But not only would the communications networks now operate faster, the implications for commerce would be enormous, the world could operate as a single financial market. A live wire between Europe and its overseas colonies meant that military crises could be defused, or managed, or exacerbated without the delay imposed by requiring communications to ride upon the fastest means of transportation.

This "Thread Across the Ocean," as one book on the subject (Gordon, 2002) calls it, was the premier engineering accomplishment of its day, employing the labors of Isambard Kingdom Brunel and the future Lord Kelvin, a work that failed four times before achieving success. The effort was led by Cyrus Field, an American entrepreneur and visionary, who, despite failing, kept raising funds and kept hope alive that the trans-Atlantic telegraph cable was not a fool's errand but a wise investment that would return profits to investors. Each failure, resulting from cables snapping or going dead, led to design improvements, stronger, more ductile cables that would be more robust in the difficult design conditions of the cold Atlantic seafloor. But stronger heavier cables could not be handled by the conventional ships of the age; it required the world's largest ship, Isambard Kingdom Brunel's *Great Eastern* (see box 16.2), which was used on the fourth and the ultimately successful fifth voyages to lay cables. Constructing the greatest communications network of the time, an endeavor that would substitute for traditional transportation-reliant material communications (mail), required the greatest transportation vehicle of the time to lay it.

The learning involved was not simply building stronger cable, but how to lay cable so it would not break, how to fetch dead and broken cable from the ocean floor, how to send electric signals thousands of kilometers without fading despite the cable being submerged inside an electrical conductor (seawater), and how to manage a trans-Atlantic enterprise. Soon after the ultimate success in 1866, the fourth failed cable was resurrected and reconnected, giving a second, redundant link. Its owners enjoyed a brief monopoly, but soon brought prices down to increase demand, and shortly thereafter faced competition (the competing cables were also laid by the *Great Eastern*). By 1903 there were more than 15 distinct trans-Atlantic cables, which meant that communications would not be severed even during two world wars.

The term "battle of the networks" applied to the competition of alternating and direct electrical current. It could just as easily apply to the many trans-Atlantic telegraph cables, the railroad wars, and events such as Gould's largely legal threat to break the Union Pacific's spatial monopoly on traffic in the middle part of the country to extort a payoff. Consolidating monopolies is important to control costs and ensure profits in network industries, and the railroads, with over 150 years of consolidation behind them, have done that. AT&T did that for 70 years. It tried to do that again in the cable television industry. Other firms are fighting a losing battle in trying to gain monopoly status. Airlines are attempting to establish networks with other airlines to provide better services, and further entrench customers within their system through "frequent flyer miles" type systems, thereby making them slightly less price-sensitive.

It appears that the structure, performance, and conduct of transportation systems are replicated in other systems. Transportation shares characteristics with other systems that:

- are networked and highly standardized;
- serve as universal input industries and are everywhere available;
- have strong economies of scale; and
- affect the public interest so much that they have been publicly supplied or closely controlled.

While water supply and electricity come to mind, there are also systems where the predominant technology is soft, for example, the public school system.

In addition to structural similarities, we see functional similarities between transportation and communications. Each is an organizing system; they organize the structure of production and consumption. The "What does it do that is worth doing?" question is similar for each, and answers tend to be rather hidden.

We think we have much to say that goes beyond the usual "How (or whether) communications substitutes for transportation?" question—though of course that is an important question. This chapter deals with structural and behavioral similarities of transportation and communication, including the telegraph, telephone, and the Internet. Comments will be made on similarities to and linkages with transportation as the story unfolds.

Telegraph

The electric telegraph grew up with the railroad, and it made long-distance railroading possible. But the first "telegraph" (writing from afar) was built in 1791 by Claude and René Chappe in France. It used sound along with times on a clock face, rather than electrical impulses, to send messages, and the revolutionary government soon adopted it. This telegraph simply enabled messages to be communicated over a distance without physically moving a person or a document. Abraham Niclas Edelcrantz developed an optical telegraph in Sweden soon after hearing of the Chappe invention in 1794. By 1795 the British had also devised a telegraph system using shutters (that passed or did not pass light) to transmit messages visually. Different combinations of open and closed shutters indicated different letters or words. By the 1830s such systems were common throughout Europe. Typically relay stations (or nodes) were located on hills for maximum visibility, hence the term "telegraph hill."

We do not have networks of optical telegraphs dotting the landscape today, as the technology was made obsolete by the electric telegraph. Some difficulties in the technology had to be overcome, including transmission of electric signals over long distances and efficient coding. Samuel F. B. Morse, a famous American artist, apparently unaware of the difficulties others had (few advertise their failures widely), proceeded to develop some of the core technologies that made up the telegraph system. He is most famous for the signaling code of dots and dashes named for him. He also developed a mechanism for recording the signals on paper, creating a transcript of the messages. Joseph Henry, an American scientist (and first head of the Smithsonian Institution), developed the means for transmitting electric signals over long distances by using small batteries in series rather than a single large battery.

In parallel with American efforts, Cooke and Wheatstone were developing a different electric telegraph in England. The first telegraph line was 2.1 km (1.25 miles) between the Euston and Camden Town stations on the London and Birmingham Railway in 1837. The first line had five wires (because of the complicated code they used). A later deployment on the Blackwell railway did as well, but as some of the wires broke, so operators improvised with a two-wire system, developing a more parsimonious code. After it was realized that fewer wires were needed, future deployments were simplified.

In 1844, using a federal appropriation of $30,000 (a not inconsiderable sum), Samuel Morse built a line between Baltimore and Washington along the right of way of a skeptical Baltimore and Ohio Railroad that had concerns that a telegraph might substitute and eliminate much passenger travel (Stover, 1987). A demonstration transmitting the passenger list on a train ahead of the passengers gave proof of the utility of the telegraph. Morse also took in a financing partner, Alfred Vail. Other applications of the Baltimore–Washington line include apprehending criminals and verifying checks. By 1845 the Magnetic Telegraph Company was formed to exploit the invention, building lines between major East Coast cities (the first opened in 1846). The first year the line was still running a loss, despite charging one cent for four characters. The federal government allowed Vail and his partners to acquire the federally funded Baltimore–Washington line. But soon telegraphy turned profitable and development exploded (see table 18.1) (Standage, 1998).

By the 1850s, consideration was given to laying a trans-Atlantic cable, despite huge technical obstacles. As discussed in the introduction, by 1858 Cyrus Field's Atlantic Telegraph Company had laid the first trans-Atlantic cable, and messages were transmitted. However, the cable soon broke. It was not until 1866 that the *Great Eastern* laid a trans-Atlantic cable that operated essentially continuously.

By 1861 a North American transcontinental line had been opened by Western Union, forcing the Pony Express out of business. While the Pony Express was fast (10 days to travel 2,900 km [1,800 miles]), the telegraph was almost instantaneous. Western Union, which eventually acquired a monopoly in telegraph services, was founded in 1851 in Rochester, New York, as the New York and Mississippi Valley Printing Telegraph Company, and took its current name in 1856 before opening up the transcontinental line. By 1866 the Western Union had acquired another 340 telegraph companies. It established relationships with most U.S. railroads, and carried some 80 percent of telegraph messages by the 1880s.

The telegraph proved very important to the operation of long-distance train services. Imagine you have one rail line between two points, but you want to operate trains in two directions. In the absence of instantaneous communications, you can set up a very precise schedule, but trains sometimes get delayed; or you can set up a very coarse schedule (eastbound in the A.M., westbound in the P.M.), but then trains will needlessly sit idle for hours. Or you could have a rule whereby inferior trains would wait until superior trains passed. With the telegraph, you can set up a dispatch and signaling system, and know when trains are coming from one direction to put a red light in the other, delaying trains for the minimum amount of time. This system also reduces the amount of track you need to build, lowering costs (wire is much less expensive than track). Train dispatching by telegraph took place in Great Britain by 1839, and was deployed along the New York and Erie Railroad in 1849. In the 1850s telegraphic control of trains was commonplace. Typically clerks and stationmasters at train stations were telegraph operators, suggesting another synergy to more effectively use available labor.

The telegraph was also responsible for establishing standard railway time, which became standard time shaping everyone's life. The railways adopted time zones so that

Table 18.1 Deployment of Telegraph

Year	U.S. telegraph km
1846	64
1848	3,200
1850	19,200
Country	**Telegraph km in 1852**
France	1,200
Britain	3,544 (in 1850)
Prussia	2,389
Austria	1,685
Canada	1,573

a train leaving New York at 11 A.M. was also recorded as leaving at 11 A.M. by observers in Philadelphia or Washington (both of which are west of New York, and had been offset by a few minutes). The Western Union time ball would drop daily from their headquarters (the tallest building in the United States at the time) at noon in New York, triggered by an operator at the National Observatory in Washington, D.C., from 1883 to 1913. Western Union came under the control of financier (and railroad magnate) Jay Gould.

Telegraphy peaked between 1930, when there was a total of about 16,000 U.S. telegraph messengers, and 1945, when the number of telegrams sent in the U.S. peaked. The number has declined significantly since then, being insignificant after 1950.[1]

Telephone

The story of the telephone's discovery is famous: a patent was granted to Bell on March 7, 1876. Elisha Gray, another inventor, had filed a caveat (an intent to file a patent) on a telephone on March 7, 1876, as well, a few hours later. The first application of voice over wire, "Mr. Watson, come here. I want you," was spoken just three days after Bell had filed the patent. It is worth noting that this first spoken telephone conversation was a request for transportation, Bell asking Watson to travel to his location.

Bell and Watson had been working on a harmonic telegraph, and voice was not the first priority. The Bell Telephone Company was chartered in 1877. While Gray did not get the patent or the fame, there is no need to feel sorry for him, as he went on to work for Western Union, cofounded their subsidiary Western Electric, and invented an early fax machine. Patent suits raged between the Bell interests and the Western Union/Edison interests. In 1879 the parties settled, with Western Union selling to the Bell interests telephone exchanges in 55 cities and a network serving 56,000 subscribers. In 1881 Western Electric (which acquired Western Union's telephone manufacturing arm) was sold to American Bell Telephone Company.

In 1881 the telephone was only five years old, and there were hundreds of thousands of customers (see figure 18.1). In 1885 the American Telephone and Telegraph Company (AT&T) was founded to build and operate long-distance services connecting local telephone companies. Theodore Vail, a first cousin once removed of telegraph financier Alfred Vail, was the first president of this company, serving for four years. In 1899 AT&T assumed control of and became the parent company of the Bell System.

In 1907 AT&T was in trouble and recalled an elderly Theodore Vail from South America (where he was running a transit company) to again head the company. Reviving their fortunes, in 1909 Western Union (and American District Telegraph [ADT], as well as some other telegraph companies) came under the control of AT&T, giving truth to the Telegraph in the AT&T name. However, by 1913 the Department of Justice required AT&T to divest its telegraph interests. The Kingsbury Commitment by AT&T agreed to the divestiture, and agreed to provide long-distance service to non-affiliated local telephone companies. It could only purchase other companies if the Interstate Commerce Commission approved (which it did in 271 out of 274 cases). In return its monopoly status was ensured. Corporate stasis for some 70 years set in, as AT&T was able to maintain its telephone monopoly through government protection.

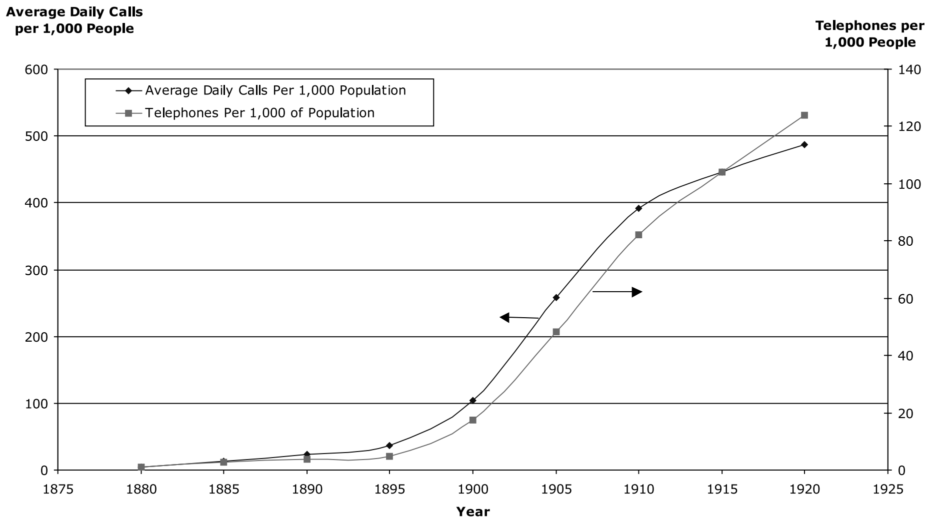


Figure 18.1. Telephone deployment. (Source: Hyman et al., 1987.)

The predominant technology of the telephone system hardened in the late nineteenth century and the government began to intervene. It is interesting that policy incorporated transportation learning; the roles of state public utility commissions and the Federal Communications Commission (FCC) mirror transportation roles. It is also interesting that the market for the telephone was difficult to imagine in the early days, and that has been true for transportation systems.

The product of the system was highly valued, and there was demand for deployment, locally and then on a larger scale. While in the telephone industry, government assisted and enabled, almost no government financing was required in the early days (which contrasts with many transportation technologies and the telegraph). A few local governments developed facilities.[2] With local use dominant, and long distance expensive, the state Public Utility Commissions (PUCs) looked after policy problems.

As time went along, the long-line (long-distance) system developed, and conflicts between firms emerged as a policy issue. American Telephone and Telegraph (AT&T), or the Bell System, used its long-line monopoly power in attempts to acquire those local companies it had not already acquired. The Kingsbury Commitment logic has become known as the *essential facilities doctrine* in antitrust law. If one company's facilities are essential to the operations of another, use of the facilities must be allowed. AT&T was forced to allow non-Bell locals to connect to the long lines under the same terms as the Bell locals.

The story so far is quite like transportation in character. A new service becomes available, and there is clamor for service. Perhaps we should remark that the essential facilities doctrine was a problem for the railroads too. It was managed in a different fashion (creation of interchange rules by the American Association of Railroads [AAR] and Interstate Commerce Commission [ICC] refereeing of joint rates) but with little difference in substance.

At about this time the corporate ownership character of the AT&T system had evolved to the form that held until the 1982 Consent Decree. AT&T owned the long lines, the Western Electric Company (equipment supplier), and Bell Labs; it controlled most of the local companies.

Is that ownership situation exceptional? We see it as a “how the die fell” outcome. It is a matter of the point in time when concentration in the industry was stopped. Who knows what the ownership situation in rail would have been if the ICC had not put a stop to change? The highway component of the auto-highway system did not see a stop put on it, and a layered system emerged somewhat like AT&T’s. The national system and local systems developed.

An agency modeled on the ICC, the Federal Communications Commission (FCC), was created in 1934 to play referee over prices and services. It operated in the “iron triangle” ICC style. (The FCC succeeded the Federal Radio Commission, but was given authority over both wireless and wired communications.)

Concentrated ownership got AT&T in trouble with the Department of Justice in the late 1940s, and the DOJ filed a suit to break up the company. The suit dragged on until Eisenhower became President when the suit was dropped. To save face, the Consent Decree of 1956 forced AT&T to agree not to go into the computer business. At the time, that was taken to be a near-zero cost decree because of the limited and near-saturated market for computers.

Was the situation in transportation different? AT&T was the most ownership-concentrated of the facilities we are discussing, and there was an attempt to deal with it first. The railroads and truckers were concerned about the antitrust powers of the Department of Justice, and they headed Justice off at the pass through special legislation limiting Justice control over them. Justice had from time to time attempted to limit the roles of railroad (and truck) rate bureaus. This was stopped in 1948 when Congress amended Title 49 of the U.S. Code by incorporating the Reed–Bulwinkle Act, which permitted collective rate making under certain circumstances.

AT&T next got in trouble over its tight rules on equipment. Implemented to an extreme, only equipment manufactured by Western Electric was allowed to be connected to the system. The non-Bell locals (the largest of which was General Telephone and Electronics [GTE]) had their own company, a matter tolerated by AT&T. Those who wanted to be system suppliers complained to the FCC and to the courts. They got partial relief in the courts in the Carterfone decision of 1968, which allowed use of terminal equipment other than that supplied by AT&T.

The market was not opened up quickly. AT&T insisted that it supply interconnect devices to protect its system from foreign equipment, and charges were such that foreign equipment was not so attractive. The new suppliers, now part of the system, asked the FCC to play referee. That put the FCC in a messy situation, but it gradually tended to support the foreign equipment interests. AT&T simply could not make the case that interconnect equipment was needed.

The story here is that of rules for system reliability, and such rules are common throughout transportation. The special Western Electric relationship was in part a matter of concentrated ownership, already discussed. AT&T truly perceived that it was in danger, and similarly, those in any transportation system would think they were in danger if there were the potential for rule violations.

The next problem was competition in long-line service. Some organizations have had long lines for many years. Railroads, in particular, had in-house long-line service, and as microwave technology advanced, more and more organizations were internalizing their service.

Microwave Communications Inc. (MCI) entered the private line business in 1968, and developed a plan to provide service, using microwave towers, between St. Louis and Chicago. Its format would be that of an outsider providing private line service as an alternative to an organization building an in-house system. It went to the FCC for permission to provide service, and a 1971 decision enabled operations such as MCI's. Organizations providing service were termed specialized common carriers.

MCI soon found that it needed more. It needed many users to attain economies of scale. To manage many users, it needed to connect its between-city system to users in St. Louis and Chicago via the local Bell systems. Otherwise, it would have to construct local microwave (or hard line) collection and distribution systems. To solve that problem, it got a ruling from the FCC for FX services in 1973. The idea was that one office in, say, Chicago would use MCI facilities to reach St. Louis, and then connect to the local Bell system to reach multiple offices in St. Louis.

The AT&T system had for many years subsidized local service from its long-line service for numerous reasons. Economies of route density on the long lines resulted in long distance becoming a "money machine" as traffic grew. Likely more important, though, was the Bell corporate culture and the value it placed on inexpensive, reliable, and nearly universal service. Cross-subsidy was the "right" thing to do. But if Bell charged MCI its local rates, then MCI would be skimming. It would be taking money from AT&T's grossly profitable long lines via a subsidy from AT&T to the collector-distribution part of the Bell service. AT&T and MCI began discussions to see if they could work out a solution on rates before going to the FCC to get it approved. In the meantime, MCI and other firms began to offer FX service. An example is a local number anyone could call from any phone in St. Louis and be connected with an airline reservations desk in Chicago. (AT&T offered this service too, through its message toll service [MTS].)

MCI was one of several companies developing similar businesses; there was, for example, SPRINT (which originally shared ownership with, and ran fiber optic lines along the right of way of, the Southern Pacific Railroad [the SPR in SPRINT]). We use MCI as an example because it was the most aggressive company and the first.

Nothing was exceptional here. Skimming is an old game in transportation—it is what the common carriers claim private truckers do. The Post Office says that UPS and Federal Express skim.

Cross-subsidy in the telephone system was and remains large. The charge for a long-distance call may be only a few pennies per minute, but charges to the long-distance carrier to pay for local access (in 1996) is 3 cents per minute on each end of the call (or 6 cents per minute per call) (Crandall and Waverman, 2000). This is in addition to a charge of $6.50 per subscriber line per year in access charges. In contrast, local calls, particularly rural services, are underpriced. The fact of cross-subsidy is not exceptional. Is the magnitude?

Transportation cross-subsidies have varied. Long-stage air travel once cross-subsidized short stage, and still does in some cases. Short rides on transit systems subsidize long rides. The largest magnitude of cross-subsidy is in the highway system. It costs a few tenths of a cent to provide for a vehicle km (mile) of travel on an urban freeway and, say, 20 cents on a lightly used rural road. Yet via the gas tax, users pay the same charge for facilities.

The 1973 decision by the FCC was soon given an interpretation by MCI (and, later, other specialized carriers) that shocked AT&T.[3] FX first was taken to permit one-to-many or many-to-one services. But suppliers decided they could put those together and provide many-to-many service. MCI called it Execunet. A subscriber could phone from any number in West Cupcake to any number in East Cupcake. He dialed a local number and accessed a private specialized carrier; the number given to that specialized carrier then accesses a city and a local phone. Costs were less than long-line costs because there were no AT&T's long-line tariffs, swollen by cross-subsidy to local phones.

AT&T was then shocked by a sweeping suit started in 1974, *United States v. AT&T*. Long embarrassed by the 1956 Consent Decree and with its hand strengthened by the flap over interconnect devices, the tension between specialized carriers and AT&T, and complaints about service, the Department of Justice sought to break up AT&T. The suit was started by the Ford administration, and it is said that the White House had no advanced knowledge of it. Court actions were started, and it appeared that an unusually aggressive judge would be able to settle it in about four years, a remarkably short time for suits of this class.

With concentrated ownership, AT&T was somewhat riper for a suit than actors in transportation systems—a matter of degree. AT&T was not as well shielded from the Department of Justice as are transportation operators—again, a matter of degree. (The Department of Transportation reviews most transportation mergers.) To manage, AT&T brought on star lawyers and planned to make the case that its ownership accounted for the nation's wonderful service; breaking up AT&T would ruin the best of worlds.

To deal with this suit and the many-to-many competitive services that were expanding, AT&T sponsored the Consumer Communications Reform Act (CCRA) of 1976. That is a wonderful title, but the purpose of the bill was to legalize the AT&T monopoly—it was dubbed the "Bell bill." AT&T thought passage was certain. It brought managers and labor from every congressional district to lobby. It thought that the public held the in-house AT&T view that its activities were "right." Bell did not read very well the shift of public and Congressional views about monopolies. At the same time the Bell bill was being debated, there was well-supported legislation moving along that would increase government power over monopoly. The Bell bill did not pass.

The AT&T corporate culture held one worldview, the rest of the world held another. AT&T pointed to the excellence of the Bell Labs (see box 18.1), the availability and low cost of domestic service, and leadership in the installation of advanced equipment. It compared its system favorably with those in other nations. Such internalization of information and values is a feature of transportation systems. For instance, the Federal Highway Administration (FHWA) sees its world exactly as AT&T saw theirs.

AT&T was in a difficult situation in the late 1970s. Failure of the CCRA hurt deeply, and Justice's aim was massive dismemberment. Justice had presented its case. Bell had begun its defense, a defense building from the image Bell had counted on for support of CCRA: what Bell does is right, and the proof is in the product. It would be unthinkable to ruin that product.

Two changes pulled the fat from the fire. First, there was a modest management turnover in Bell when Charlie Brown became chairman. We say modest, because Brown

BOX 18.1 Bell Labs

Bell Labs grew along with recognition of the importance of science and technology, and they were by no means unique. IBM (Watson), RCA (Sarnoff), DuPont, GE, and many other strong labs grew at the same time. Later, the automobile and drug companies developed strong labs. In these labs there has always been the tension between doing general, more basic research work versus product-oriented work for the corporation. Although well known for its scientific work (counting 13 Nobel Prizes among its scientists), the Bell Labs did most of its work for the company, a fact not generally known.

The Labs were divided after divestiture. First was a Lab owned by the local companies (now Telcordia, a unit of SAIC, originally the Central Services Organization, and then Bell Communications Research or Bellcore). Second was the Bell Labs owned by AT&T spin-off Lucent Technologies (the former Western Electric). A third lab, AT&T Laboratory, was created in 1996 after the Lucent spin-off. The cable TV industry has emulated the practice since 1988 with CableLabs.

The world of science and technology is so large that private labs cannot get the resources for broad command of relevant fields. Costs are too high for a private company, no matter how large and rich it is. The Ford Motor Company, for instance, has backed away from its commitment to a broad-based research program. In short, the Bell Labs would have had problems regardless of the break-up of the company.

was an inside manager who had a similar background to his predecessor. Although committed to Bell ideals, Brown saw that the Bell strategy was not working, and he began inside discussions about giving up some local companies as the cost of a settlement. The other change was the return of the Republicans to office in Washington. During the campaign, the Justice case against Bell had been cited as a destructive antibusiness extreme. New management at the Department of Defense said that destruction of AT&T would be damaging. Although the new administration judged it could not bear the political cost of dropping the Justice suit, there was a possibility of a settlement short of complete dismemberment.

Charlie Brown developed the inter-intra scheme—the spinning off of the local Bells—and sold it within AT&T. Next that solution was sold to Justice and the White House. It was much more painful than the Kingsbury Commitment of 1919 and the Consent Decree of 1956, but was far short of complete dismemberment.

The 1982 Consent Decree created (as of January 1, 1984) an AT&T that included Western Electric, Bell Labs, and long lines, and seven independent regional Bell operating companies (RBOCs): NYNEX, Bell Atlantic, BellSouth, Southwestern Bell, Ameritech, U.S. West, and Pacific Telesis. The RBOCs were prohibited from providing long-distance service, and AT&T could not enter local markets. The RBOCs over time have done some merging and recombining among themselves: NYNEX, Bell Atlantic, AirTouch Cellular, and GTE form what is now called Verizon. Pacific Telesis, Ameritech, and Southwestern Bell form what is now SBC Communications. U.S. West was acquired by a new long-distance company, Qwest (founded by SP Rail, the same people who founded SPRINT).

While there are lots of firms and maybe too many names to remember, the story can be recalled due to its similarity to the merger behavior of railroads. The Communications

Act of 1996 permitted the RBOCs to get into the long-distance business (and thus sell integrated services again) if they could demonstrate competition in local telephone markets to the satisfaction of the FCC. Some have been able to do so, though they clearly still, as of this writing, have an effective monopoly on local telephone. AT&T has tried to reenter the local market from two angles: acquiring a large cellular telephone company (McCaw Cellular) and acquiring large cable television companies (Tele-Communications, Inc., and Media One being the most important). Both have been spun off.

From its point of view, what mistakes did AT&T make? First, it did not protect itself from the Department of Justice. We suppose that is because it felt that what it was doing was right, and no one would question it. When it made an effort via the Bell bill, it was too late. If AT&T had made that effort earlier when telephone service was being deployed and services were rapidly improving, it might have been able to have favorable legislation passed. This strong feeling of right also lead AT&T to play hardball with foreign suppliers and MCI. Cooperation and cooptation might have been better tactics.

In the Consent Decree of 1956, AT&T agreed that it would not enter the computer business. Hindsight says this may have been a bad decision. But at that time, no one foresaw the subsequent growth of the computer business. At any rate, it is not clear that AT&T would have been successful in the computer business during this period (a later acquisition and divestiture of computer maker National Cash Register [NCR] demonstrated the point). Computers were not a part of their corporate culture and mission.

We are struck by parallels between FHWA and AT&T. The FHWA has been in trouble from time to time. As the Bureau of Public Roads, it was in danger in 1920 after the break-up of roads during World War I. When Eisenhower was President, he brought in Commissioner DuPont to ease out Chief McDonald and close down the Bureau. The nation was in a "get the Feds out of the way" mood. The interstate program saved the Bureau. FHWA is in trouble now, and there is nothing like the interstate waiting in the wings.

Recall MCI's specialized service. It invaded the money-making long-line business and took advantage of the subsidy to local service. Isn't that exactly what a toll road does? It is no wonder that FHWA has, despite supporting a few experiments, an antitoll road stance. FHWA has the feeling of self-evident rightness that so characterized AT&T. It plays hardball with those who disagree, and it has the Bell Labs "the truth is from our work" problem (see box 18.1).

Internet

Several significant telecommunications networks have been deployed since the telephone, including cable television (which remains largely one-way, though this may change with the advent of broadband cable modem service and video on demand), cellular telephone (including several distinct technology waves), and the Internet. All three have been very important in shaping activity patterns; the latter two have some important parallels with transportation as well. The Internet may be most interesting because of its potential.

What most distinguishes the Internet from the plain old telephone service (POTS) provided by AT&T and the regional Bell operating companies is the use of packets for communication rather than keeping an entire circuit open for two-way communications. The analogy that the Internet is the car/highway system to the POTS train has been made before and has some merit. Like the car, Internet packets are small and discrete, have a variety of origins and destinations, and share space on the network. Like a train (especially when we only have a single track), telephone requires a circuit between the origin and destination to be kept open—no other traffic can use that circuit (no other trains are allowed on that track). The analogy of course can be stretched too far, and there important differences. In cars, the intelligence (one hopes) lies with the driver, while with the Internet, packets are given direction by routers (as if the traffic signal told you which direction to go, not simply whether to go or not). Another analogy between the Internet and containerization might be more appropriate, as packets are more like freight than people. If a packet (or freight container) between Minneapolis and Tokyo must go by way of London, so be it—no one will complain if it is the low-cost route. A passenger making that trip would find it terribly inefficient.

Another key facet of the Internet architecture is that it is distributed; disable a link and the system can route around it. This is similar to a robust highway network, and distinct from a hub-and-spoke network with a few critical points.

The Internet was developed in the 1960s with funding from the Department of Defense's Advanced Research Projects Administration, and was originally called ARPAnet, which was deployed in 1969 (Hafner and Lyon, 1996; Berners-Lee, 2000). Figure 18.2 shows the growth of the Internet from 1969 to 2002, using the number of computer hosts connected to the Internet as the measure of size. Other measures are number of users, amount of traffic, and so on, but those are less reliable than this infrastructure-based measure. They show the same basic trends. Figure 18.3 shows the same data, but blows up the first dozen years (1969–1981). While the first graph suggests no activity before the advent of the World Wide Web in the early 1990s, even in the 1970s

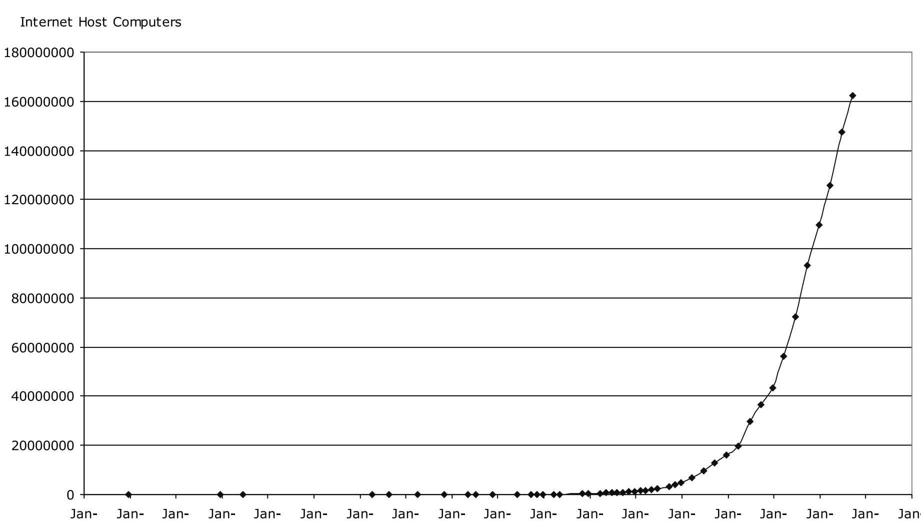


Figure 18.2. Internet host computers, 1969–2001. (Source: Kristula, 1996–2002; Internet Systems Consortium, Inc., 2004.)

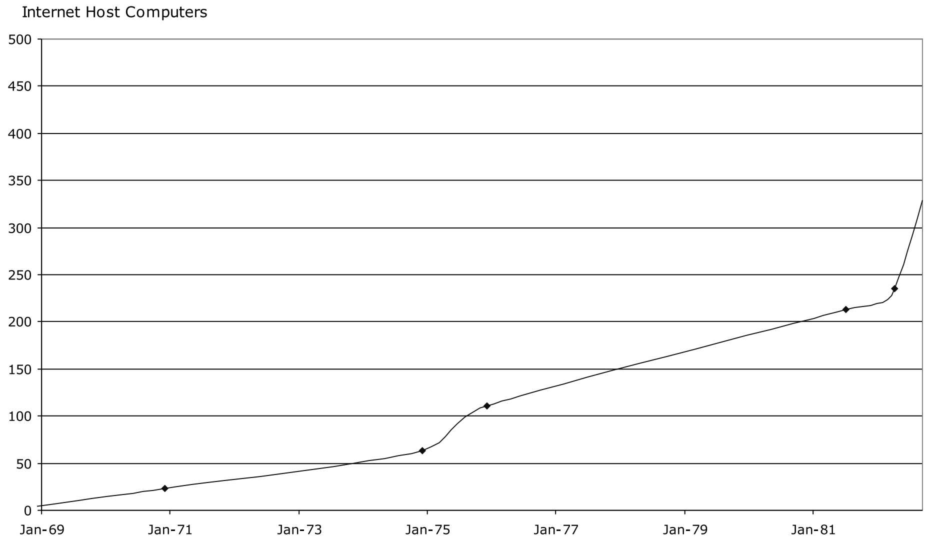


Figure 18.3. Internet host computers, 1969–1981.

there was significant (even exponential) growth, just at a much smaller scale. The S-curve phenomenon is (we expect) at play here as well, we just have yet to see the slowdown in new hosts. The maximum number of hosts is unknown. One can imagine, of course, one host for every personal computer (which would presumably peak at one per person), but then one for every cell phone, every car, and every appliance as well are not unreasonable speculations. Whether every electric outlet gets one may seem far-fetched, but the idea of a world where every electronic device has an address is plausible. That would give a very large number of potential host computers.

The Internet has, despite significant government involvement in its creation, remained largely unregulated. Some attempts at content regulation (the Communications Decency Act in the United States) have fortunately been unimplementable. Other attempts at using the legal system against copyright violations have had more success, the shutdown of the music trading service Napster for instance. But for every Napster brought down, a more robust network (in this case a peer-to-peer network with distributed indexes) such as Gnutella takes its place. Censorship remains in some countries—Saudi Arabia and China come to mind—but the ability to acquire data on the Internet may outstrip the government's ability to censor.

The content regulation on the Internet has an analogy in transportation in terms of the transportation of prohibited goods (e.g., drug trafficking), which have been very hard to restrict. While the penalties are severe if caught, getting caught is a low probability event, especially given the low staffing levels of inspection services. Guardians do not have the time (or, in general, the legal authority) to open every suitcase, every car trunk, and so on, except in commercial aviation, where scanners are used, at considerable delay to passengers.

The protocols for connection on the Internet and on other communications technologies are clear analogs to protocols and standards in transportation. Trains must be on the same gauge as the track, and one railroad's tracks must be like others if transportation is to occur. Truck widths and weights are another example, and must be compatible with the road. Trailers must have an interface with the truck. More recently, with containerization and the logistics revolution, as well as Intelligent Transportation Systems, information technology is bringing a new layer to transportation.

Discussion

Internet businesses also remind us of the airline and railroad sectors, in several respects: the boom and bust cycle, the large fixed and relatively low marginal costs, and the winner-take-all aspect.

Network industries are subject to large swings in profitability. Why? We can call it the *empty seat phenomenon*. When an airplane takes off with an empty seat, the airline is leaving money on the table (or the ground). The marginal cost of operating the plane with an additional passenger is almost nil, given that the plane is taking off anyway. It would cost but a few dollars in fuel and meals to have had one extra passenger. When load factors (percent of seats occupied) are high, so are profits. But when load factors drop just a little, it implies that demand is softening. Airlines are faced with an unappealing dilemma to try to retain or restore profits. They could try to raise fares to get additional revenue from the remaining passengers, but this risks chasing away more passengers. They could try to cut fares to encourage additional passengers, but this lowers revenue from the passengers they would have anyway, as some who would have paid the higher fare now pay the lower fare. They can try to cut costs and service, but this potentially costs revenue as well. Airlines of course do all three, and hope that by intelligently price discriminating (giving discounts only to marginal travelers, not to inelastic business passengers) they can recover. And of course, they can wait until demand picks up due to external circumstances. Trains and other time-sensitive transportation industries have the same pressures. Internet backbone companies, those that carry long-distance Internet communications, are in a similar situation. Unless their wires are brimming with traffic, like the airlines taking off with an empty seat, they are leaving money on the table. The wires are there, costing money (in terms of paying back the lenders or paying off shareholder), whether or not they carry traffic. Unlike manufactured goods, this capacity cannot be stored.

A second phenomenon is the *lumpiness* of network industries. The capacity in networks comes in discrete lumps: an airplane (which carries 150 or 300 passengers per hour), a wire that carries million of bits per second. Acquiring an airplane or a wire takes time; while there may be a few extra planes lying about, reconditioning them for service is not instantaneous, and orders for new planes take years. Similarly fiber optic cables take time to lay down.

Third, profits during the good years attract new entrants. When times are good and demand is growing, network industries are profitable. These profits provide a signal to others that there are *excess profits* in this industry, and it is a good field to enter. By excess profits, we are not implying a moral judgment, simply that profits are above market averages for an investment of apparently the same risk. So new companies enter the market. In the airline industry, buy and recondition a few planes and you can enter the industry, rent a gate at another airport and you can enter a new market. So every so often, a host of new carriers try to make it in the airline industry. A few survive, a few are acquired, and others go bankrupt when the market turns bad as the economy moves through cycles.

Similarly, since telecommunications deregulation in the 1980s, the United States has seen many new entrants first in the long-distance telephone and then the Internet markets. Firms saw potential excess profits and high growth rates. Each assumed that it would capture the lion's share of the new market and built new capacity accordingly. When they found they were not the only company with this idea, but had a score of competitors, prices had to be lowered to a point where they no longer covered the high capital costs (though they generally remained above the operating or marginal costs). Thus there is a situation with excess capacity. Over time, as information exchange explodes, this capacity may become fully utilized, especially if technologies like video (or better yet, 3-D projections) over the Internet take off. But in the meantime, debts have to be paid and companies lack the resources to do so. Hence, we see numerous bankruptcies in this sector (WorldCom [the parent of MCI] and Global Crossing are but two of many). Failing companies try to play with demand as noted above, but most eventually cut costs, reducing purchases from suppliers. They may even play with the books, leading to accounting scandals. This reverberates to equipment manufacturers.

The reason for overshoot can be understood by returning to the S-curve. Assumed forecasts are made by extrapolating previous results, which is how many businesses and investors operate, as shown in figure 18.4. In early years (birth and early growth) the rate of growth each year is greater than in the previous year. But in late growth and maturity, growth is slower than in the previous year.

As connecting or linking technologies, communications and transportation have much similarity, as well as competitive and complementary relations. Work now is mainly concerned with substitution of communications for transportation. An obvious

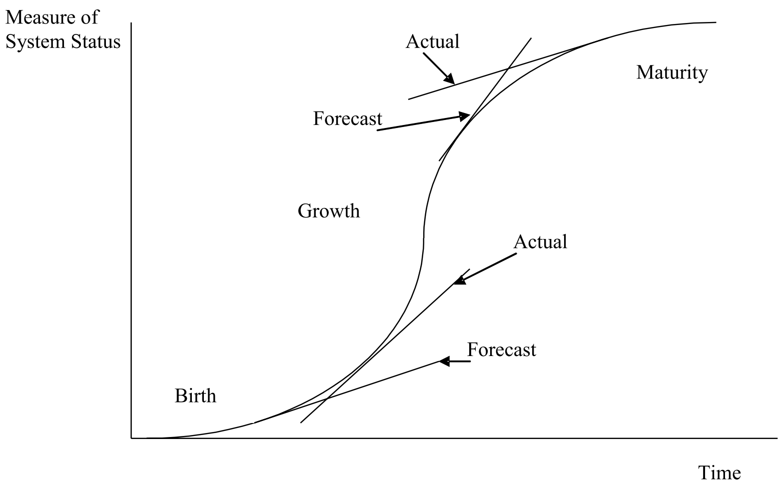


Figure 18.4. The S-curve and the danger of extrapolation.

extension is to complementary relations. Communications improvements are already pulling freight transportation services in new ways. A quick analysis says that improved communications and control are enabling such things as "just in time" inventory policies and real-time traffic control. Deeper analysis is needed, for much more than inventory and traffic policy may be involved. We need to know about changed ways of doing business, productivity gains, and the development and use of new production technologies.

19

Energy and Environment

Development by which societies today meet their needs, without compromising the ability of future generations to meet their own needs.
—Definition of "sustainability" by Gro Harlem Brundtland, *Report of the World Commission on Environment and Development* (1987)

Introduction

In 1984 the Reagan Administration shredded 4.8 billion ration coupons being stored at a warehouse in Pueblo, Colorado (Tugwell, 1988). These coupons had been prepared in the event of federal gasoline rationing being required, and were a response to the apparent fuel shortages of the 1970s. However, since deregulation (beginning in 1980 despite the efforts of President Jimmy Carter and continuing in the early 1980s under President Ronald Reagan), gasoline prices were falling and concerns about shortages disappeared.

Fuel shortages had been known before; World War II was an example. However, during the war, gasoline was being diverted from domestic to military use, and the shortages were little questioned. The oil shortages of 1973–1974 were associated with the Organization of Petroleum Exporting Countries (OPEC) oil embargo of October 17, 1973, which was a response to the Yom Kippur War when Israel's Arab neighbors attacked. The oil embargo shocked the system.

Oil is fungible, and OPEC members were not the only producers, so if OPEC stopped selling oil to certain parties, they might still sell to other countries, which could then substitute OPEC oil for their other sources, freeing those other sources to sell to the western countries. But still, all the disruption and production cutbacks should at a minimum have driven prices up, thereby decreasing consumption.

In a well-functioning market, the other effect of such a price rise is to encourage new producers to enter the market. Oil that was previously too expensive might now be feasible. Well-functioning markets have a way of equilibrating shocks so that supply still equals demand, even if the price changes.

So why were there shortages? Why were there lines at gas stations? The conventional explanation is that the embargo caused the shortage, but the evidence shows that domestic oil production dropped in 1974 (figure 19.1), and oil imports increased. That is a very strange response to a price hike due to an international embargo. The better explanation for why domestic oil production dropped has to do with the federal policy response to the shortage. Just after the embargo, Congress passed, and President Richard Nixon signed, the Emergency Petroleum Allocation Act (EPAA) (which had been in the legislative pipeline for some time). This Act instituted a two-tier price system, one tier for existing domestic oil reserves (whose prices were to be kept at preembargo levels), and a second tier for all other sources (whose prices were to be uncontrolled). The result was that domestic producers would sell little “old” oil at below market rates, and there was a contraction in domestic production until new oil fields (which would be priced at market rates) were brought on line, a process that takes several years. This law was in character with the era, which had seen other wage–price freezes. The Energy Policy and Conservation Act of 1975 extended EPAA and created a fixed maximum price for new oil. The Act also established the Corporate Average Fuel Efficiency (CAFE) standards, which are generally seen as successful.

The Iranian Revolution, followed by the hostage crisis of 1979, instituted a second period of shortage. Iranian oil was removed from the market, marking a 5 percent reduction in supplies to the United States. Again, this would be expected to increase prices (which it did, but clearly regulated prices cannot respond as quickly as market prices). Normally, individuals would respond to price hikes by reducing consumption in the manner most efficacious to them. However, to encourage the process, President Jimmy Carter proposed several conservation measures. These included a prohibition on the sale of gasoline during certain weekend hours, limiting thermostats in buildings to 18° C (65° F) for heating and 27° C (80° F) for cooling, and restricting nonessential lighting for advertising. Congress only approved the second measure. Nevertheless, because of a large change in the wholesale price of oil, and caps on the retail price, shortages ensued.

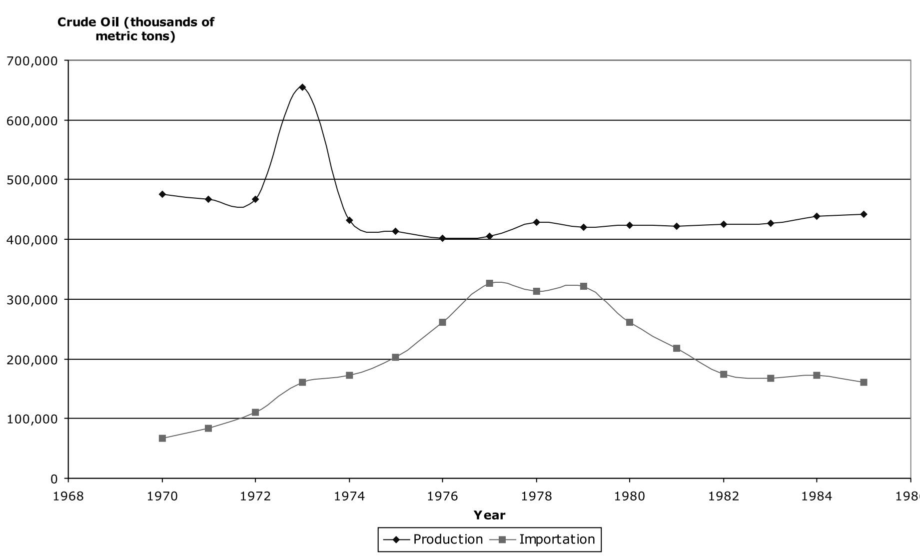


Figure 19.1. U.S. domestic production and imports of crude oil, 1970–1985.

The results of these policies follow the law of unintended consequences. New oil production boomed (while "old" oil was pulled from the market), which led to a boom in the Texas economy. Houston real estate especially took off. This boom lasted a few years into the 1980s, as people expected high oil prices to remain (markets had not equilibrated properly in the past, why should they now?). Ultimately it did crash, bringing their financiers, the newly deregulated (but still federally insured) savings and loan industry, down with it.

With deregulation in the 1980s (especially the Petroleum Price and Allocation Decontrol Act of 1981), along with more fuel-efficient autos in the fleet and changes in consumption patterns, domestic oil production increased and imports of oil dropped. OPEC responded with production cuts to keep the price of oil high, but the effectiveness of this cartel was broken when Saudi Arabia increased production in late 1985. By 1986 oil prices had dropped significantly. In the 1990s, the fuel efficiency of the U.S. fleet decreased with the large increase in the use of trucks, especially minivans and sport utility vehicles, as passenger transportation. However, oil disruptions associated with the 1990 Iraqi invasion of Kuwait and the 2003 U.S. invasion of Iraq did not result in shortages, though prices did rise in both periods.

Energy and environmental concerns are not new. In the first edition, George Perkins Marsh's *Man and Nature* (1850) pointed out how uses of the land affected microclimates and watersheds (Marsh, 1898). Already, Marsh was stressing "the dangers of imprudence and the necessity of caution" (p. vii). His concerns extended to damage to biological communities, and he mentioned the ways the Suez Canal would mix waters from alien seas. Jevons's late-nineteenth-century concerns about the exhaustion of coal resources illustrate another aspect of environmental questions, as does Thomas Malthus's earlier concerns about the inevitability of overpopulation. These references provide examples of what seem to be three major views of the environmental sustainability problem: (1) overpopulation, (2) natural resource exhaustion, and (3) damage to the environment.

In the opening quote, Gro Harlem Brundtland defined "sustainability." While we dislike the term because it implies a static world, we think we understand the sentiment. We take it to mean a condition where the use of resources can support a healthy ecological complex into the far distant future. In our view, that should not bar shifts from one resource to another as technologies and factor prices change. Actually, such shifts can aid in attaining a sustainable condition. For instance, fuel shifts have decreased the carbon intensity of energy consumption (decreasing CO_2 per unit of consumption) and acid precipitation.

Is Transportation Sustainable?

Uneasiness exists that the present transportation development path is not "sustainable." The word is used in many contexts, we hear:

- Transportation is gulping finite resources, petroleum in particular, and that cannot continue forever.
- Transportation-induced air and water pollution, soil degradation, and ecological insults are or will soon be causing irreversible harm.
- Transportation services result in the conversion of farmland to urban uses and damage to parks to a degree that cannot continue.

Even more broadly, the modern transportation-based society is consuming resources of all types at rates that cannot continue. The September–October 1994 *TR News* placed sustainable transportation first in its list of issues and stated that transportation policy is incompatible with a healthy world environment. Whatever their shape, these questions are important and deserve concern and action.

Thoughtful debates about these issues range from analytic discussions about the truth of claims through adjustment mechanisms of an economic or technological substitution sort to calls for drastic policy constraints on consumption. While the discussion to follow will involve technological options, it will not attempt to illuminate these debates.

Nor will we argue a reactive stance—the "something will come along when things get bad enough" school of thought. Lessons from history do give this school of thought some credibility. For instance, Thomas Malthus's message on the inevitability of over-population has been countered by the tapering of population growth in the industrialized nations, as well as by the development of more productive crops. The acute wintertime coal smoke pollution problems of London were largely countered by shifts in fuels. Soil erosion on the Carolina Piedmont has decreased following shifts in the location of cotton production. Even though history may blunt pessimism, we think the "something will come along" game is very chancy and costly. Moreover, that "something" is not dropped like manna from heaven; it requires explicit design, policy decisions, market shifts, or behavioral changes.

We do not find "sin now and regret later" discussions of interest. As mentioned, Jevons (1866) pointed out that at the then current rates of increases in English coal production, coal resources would soon be exhausted. He said, "we have to make the choice between brief greatness and longer continued mediocrity" (p. 376). It did not work out quite that way, of course. At any rate, there seem to be those who think that mediocrity is inevitable, and that "hunker down/get used to lowered expectations" is appropriate policy.

Instead of commenting on today's debates and actions, this chapter takes the view that energy consumption is both the problem and the opportunity. It is the problem because it wastes many types of resources, and emissions are tied to energy conversion. It is an opportunity because achieving reductions in energy use could well improve transportation services.

There is more. Recognizing that energy use is one of an array of air, soil, water, nutrition, and other problems, Jack Hollander (2003) makes the point that poverty is the real environmental problem, while affluence permits adjustments to problems and dealing with them. Transportation enters because it enables economic and social affluence and adjusting to changing circumstances. Transportation, by creating wealth, enables solutions to the problems it creates. Also, population increases, resource use changes, and adjustments in economic and social activities will demand improvements in transportation's flexibility and efficiency.

Postponing further treatment at this level of generality, we focus on the topical issue of greenhouse emissions, CO_2 in particular, because of the tie between CO_2 emissions and fossil fuel use.

Is Transportation Obese?

Transportation moves mass. To do so, energy is used to accelerate mass to cruise speed, up a hill, and so on. In theory, that does not matter because potential energy is recoverable when decelerating. In practice, of course, there is always energy loss when work is done. Energy is not recovered very well when decelerating; often it is wasted as heat when brakes are applied. For a given acceleration task, the amount of energy required depends on the mass to be accelerated. Because packages, containers, cars, and so on, of some sort are used to contain things to be moved, we need to be concerned with laden (gross) and unladen (tare) weights. Today's automobile, for example, weighs about 1,400 kg (3,000 lb) empty (tare weight) and moves about 1.15 persons, say, 90 kg (200 lb). A ten-wheel truck's tare weight is about 9,000 kg (20,000 lb) and the tare weight of a 120-ton rail car might be 25 tons. Sea–rail–truck containers have a 10:1 loaded/empty ratio, not bad comparatively, but containers must be carried on some vehicle. An intercity passenger rail car might weigh 80 tons. If it was not for acceleration–deceleration energy losses, gross weight would not matter, except that systems with a high ratio of gross to laden weight suggest that work is being done and material being used unnecessarily.

Energy is required to overcome air resistance (figure 19.2), rolling resistance (mechanical resistance), which includes the resistance to movement by bearings and seals, as well as resistance at the wheel–ground interface. Velocity-dependent resistance results from the work done as loads shift, couplers rub, and so on. Note that air resistance begins to become important at velocities between 40 and 70 km/hr, and dominates at high velocities. This figure uses the Davis equations, which understate air resistance.

Climate Change

Concerned about climatic impacts of greenhouse gases (sometimes called global warming), the UN has held conferences and appointed study groups. Many nations have committed to a Framework Convention on Climate Change (FCCC). Among other things, it calls for developing technologies, practices, and processes that control, reduce, or prevent anthropogenic emissions of greenhouse gases. Technology transfer is encouraged, especially to developing nations. For a variety of reasons, including doubts about whether global warming is actually under way, the role played by anthropogenic emissions, and the economic cost of reducing greenhouse gases, there is more talk than action.

For transportation, the gas of main concern is CO_2. As illustrated in figure 19.3, CO_2 in the atmosphere is increasing. While there are a number of greenhouse gases, we simplify our discussion by reasoning: transportation uses energy, which yields CO_2; therefore, we should examine reducing energy use in transportation. A 20 percent reduction in emissions is discussed. Can that be done in a reasonable way? This question is another reason for our focus on energy and CO_2.

Energy Use

Transportation is not the only user of energy. Petroleum constitutes about 39 percent of all energy used in the United States, and transportation uses only two-thirds of the petroleum (or about one-fourth of the energy consumed in the United States per year), as seen in figure 19.4. The reasoning that development induces lots of transportation which consumes large amounts of energy has to be tempered. Poorer countries are less efficient in their use of energy (or perhaps less efficient countries are poorer), as seen in figure 19.5. Transportation mainly uses petroleum energy, of course. But even if we narrow the problem to petroleum energy use, it cannot be cured by transportation-focused

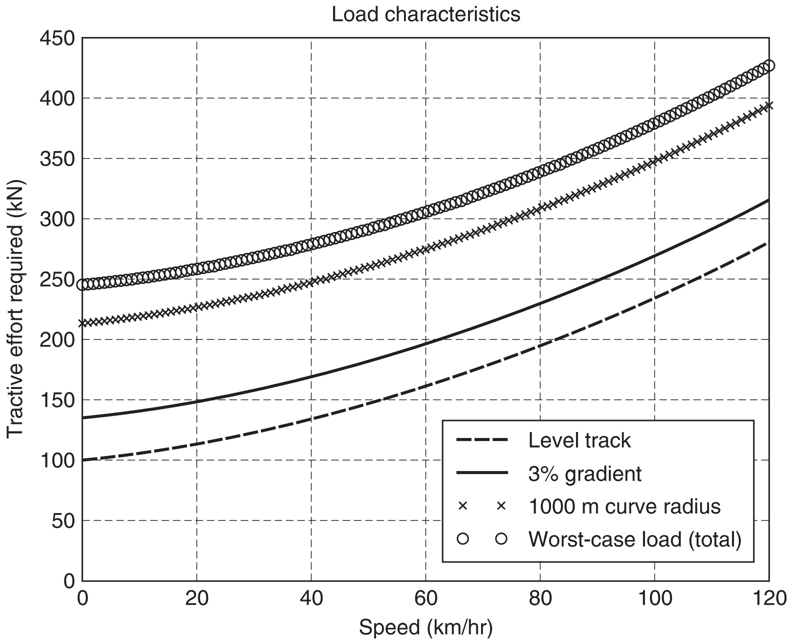


Figure 19.2. Illustrating resistances for a train. (Source: Lyovic, 2000.)

Assumptions in model:	
Locomotive mass	198,000 kg
Number of locomotives	1
Number of axles (locomotive)	6
Wagon mass	140,000 kg
Number of wagons	80
Number of axles (wagon)	4
Total train mass	11,398,000 kg
Speed range	0–120 km/hr
CSA of locomotive	11.3 m^2
Gradient range	0–3%
Gravitational acceleration	9.8 ms^{-2}
Curve range *(r)*	1000–3500 m
Acceleration range *(a)*	0.02–0.1 ms^{-2}
Rotating mass factor range *(x)*	1.07–1.12

actions alone. That is because about 33 percent of petroleum use is by nontransportation sectors, as seen in figure 19.6.

Some say there is no urgency because a good many decades of petroleum energy are available, and alternative fuels, such as LNG, add more decades of business as usual. All we need to do is to begin to reduce emissions and be more fuel-efficient. This may be true. But as we do not know either the severity of emissions problems, such as the CO_2 situation, or future political stability in regions holding petroleum resources, we think it is time to begin to seek new development paths for transportation.

Some hold the view that nontransportation energy use will be managed by transition to a nuclear, solar, or hydrogen society. It is argued that the public will discover and

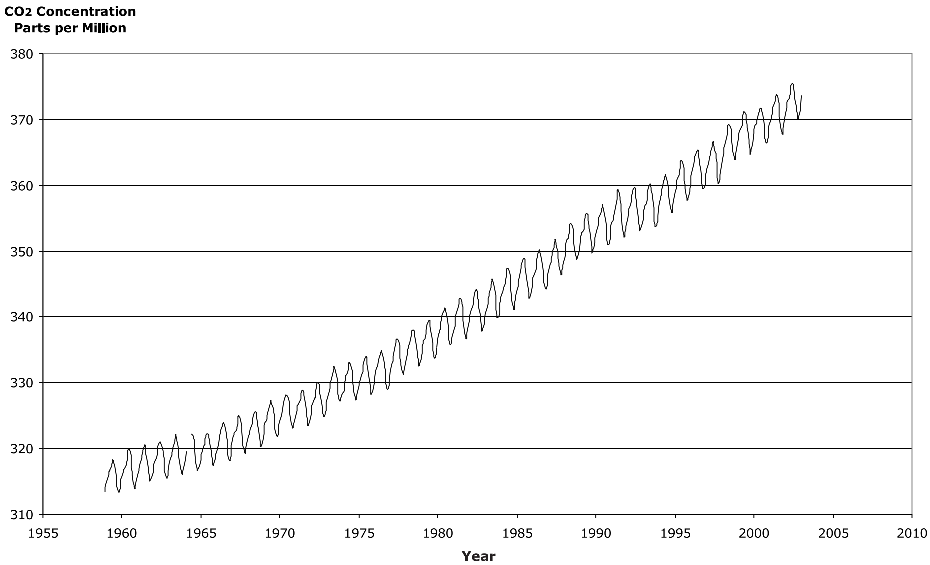


Figure 19.3. Concentration of CO_2 in the atmosphere measured at Mauna Loa Observatory, Hawaii. (Source: C.D. Keeling and T.P. Whorf, Carbon Dioxide Research Group, Scripps Institution of Oceanography, University of California, La Jolla, CA 92093-0444, http://cdiac.ornl.gov/ftp/maunaloa-co2/maunaloa.co2.)

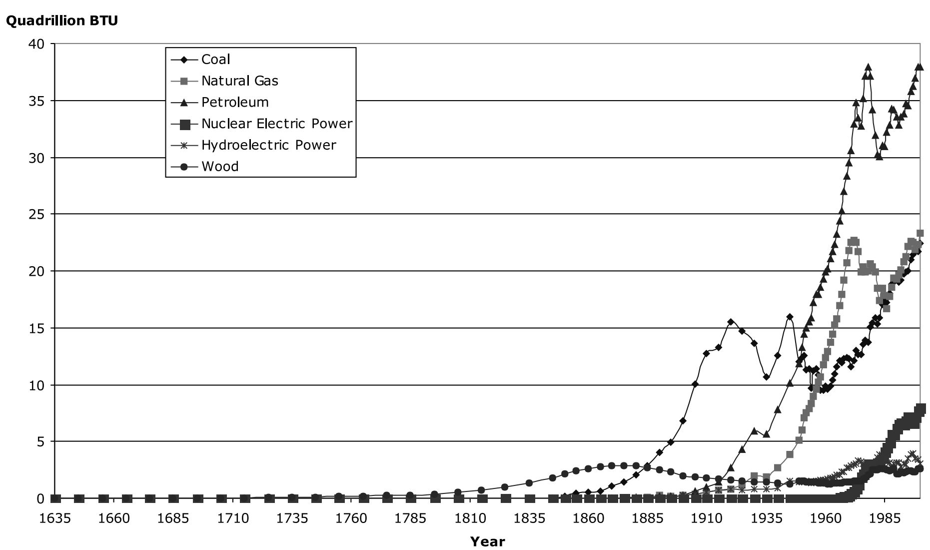


Figure 19.4. Energy consumption in the United States. (Source: Annual Energy Review, 2000.)

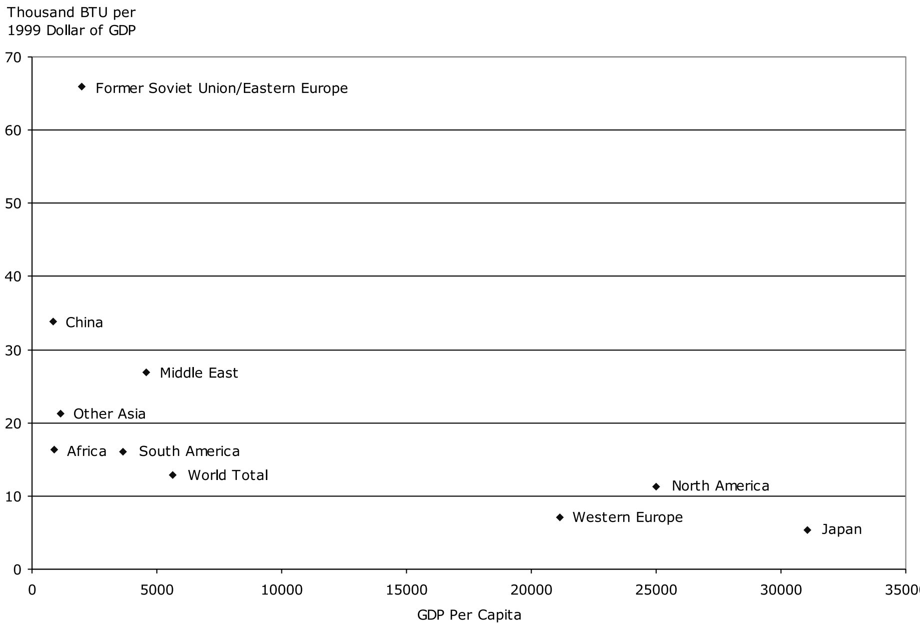


Figure 19.5. Relations between development and energy use. (Source: Annual Energy Review, 2000.)

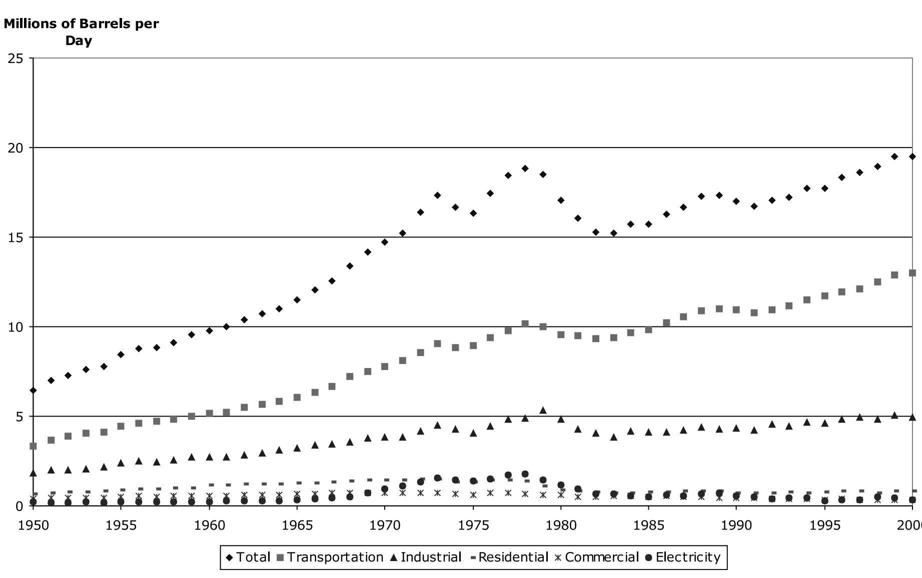


Figure 19.6. Petroleum use in the United States. (Source: Annual Energy Review, 2000.)

accept advances in nuclear technology. (Things get bad enough, something will happen.) Transportation may shift to electric power (either with fuel cells or batteries). In the absence of looking at other things, it may be a default strategy. Futurists speak of a "hydrogen economy," where electricity is generated by hydrogen-powered fuel cells.

Almost three-quarters of transportation energy use is by auto and truck. But curing auto energy use will not achieve sustainability because 16.2 quads (1 quad = 10^{15} BTU) of energy use would remain to be treated (figure 19.7).

Light trucks have two axles and four tires. They consume about 60 percent of total truck energy consumption. As we know, many light trucks are used for car-like purposes. Yet they are regulated like trucks and so face fewer energy regulations than autos.

Increases in automobile energy use have stabilized. Auto energy use has run 8 to 9 quads per year since the introduction of programs in the 1970s for improving vehicle fuel efficiency (in 1999 it was just over 9 quads).

Intercity bus and rail have concentrated their services and this has increased their energy efficiency. There is not much left to thin out, so the outlook is poor.

The urban rail, bus, and auto modes do not differ very much in their energy intensities. The outlook for improvements is pretty good for the automobile, at least technically. The outlook is not good for the transit modes under the present policy of expanding services to thinner markets. Commercial air transportation uses about 2.5 quads per year, and the new aircraft entering the fleet will continue improvements in their fuel efficiency. However, total energy use by air is increasing with demand.

Personal trucks are energy gulpers compared to the other passenger modes (figure 19.8).

We need to pay special attention to the big users—automobiles and small trucks, as shown in figure 19.7. What about the elasticity of demand as energy costs change? Table 19.1 suggests that higher gasoline prices result in the purchase of more fuel-efficient cars. It also suggests (loosely) that the amount of auto use increases with lower

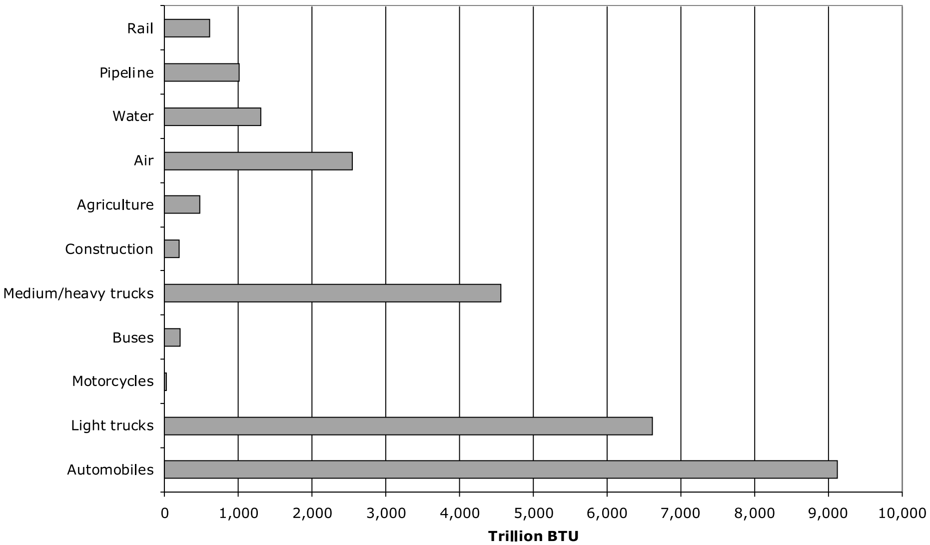


Figure 19.7. Energy use by mode, 1999.

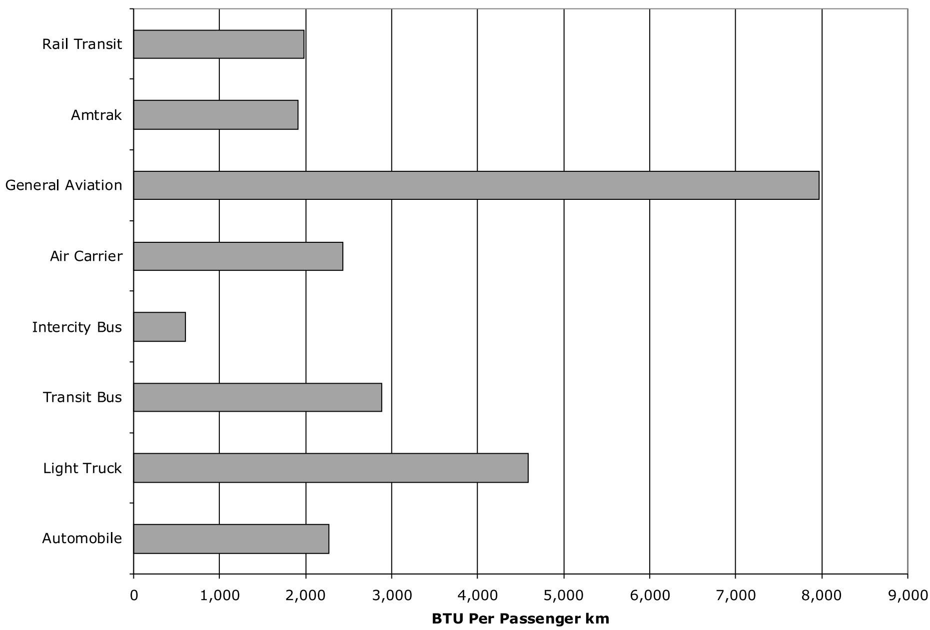


Figure 19.8. Energy intensities of the passenger modes, 1999. (Source: Davis, 2001.)

gasoline prices. We present these data and the conclusions because they seem to be in line with what one would expect and what studies strongly support. The table does not consider the extent to which variables such as the availability of transit, typical trip lengths, and so on, need to be in the calculus. It gives a first impression that is probably in the ballpark direction, but likely overstates the sensitivity of fuel economy and distance driven to fuel prices.

Intercity trucks are fuel gulpers, as seen in figure 19.9, but have improved by about 10 percent since 1970. It is said that about one-half of freight truck travel is in urban areas, and those trucks must be very energy inefficient because, in general, loads are light.

What about the diversion of freight from trucks to the other freight modes, especially railroads? This has been examined quite considerably, and the opportunity for intercity

Table 19.1 International Comparison of Fuel Price, Use, and Economy

Country	Unleaded premium ($/liter)	Average vehicle km of travel per auto	New car liters/ 100 km
Japan	$0.96	8,032	8
France	$1.06	14,629	7
Germany	$0.99	12,475	8
Sweden	$1.11	14,611	9.8
UK	$1.35	17,187	8
Canada	$0.54	15,578	9.8
United States	$0.39	19,099	10

Source: U.S. FHA (2002); Schipper (2001); Transportation Canada (2002).

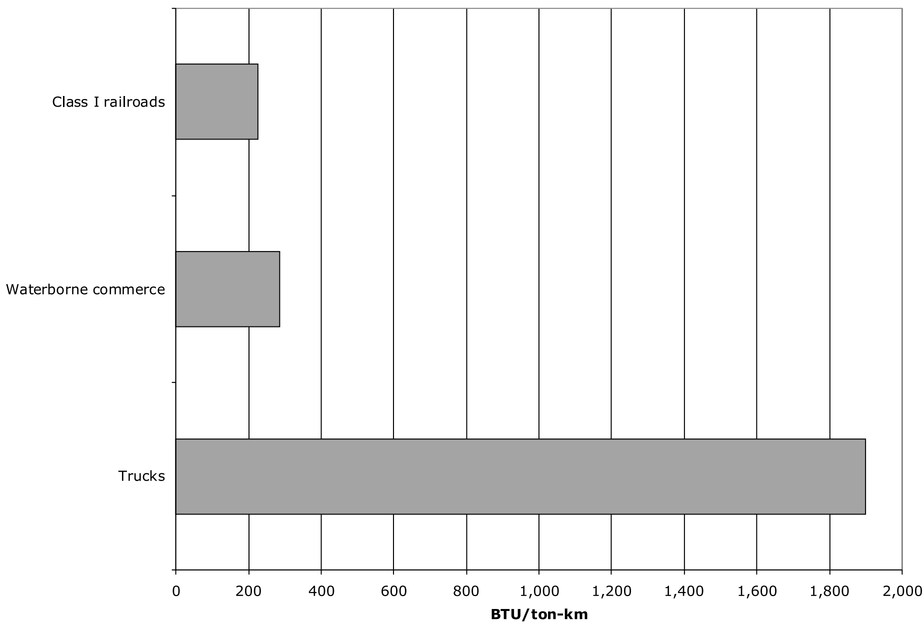


Figure 19.9. Intercity freight energy intensities, 1999. (Source: Davis, 2001.)

freight diversion from trucks to other modes is limited because of the shipment size and service difference among the modes. However, Trailer (Container) on Freight Car (TOFC/COFC) is diverting freight from trucks partly because of fuel cost savings. The problem is that this diversion is limited to dense freight movement corridors, such as Los Angeles–Chicago, because it is in such corridors that the railroads can offer good service.

Air Pollution

It is easy to document that numerous counterproductive actions have been taken in the energy and environmental arenas. More constructive public policy requires much better information than is available, an ability to set priorities and make tradeoffs, and a style that seeks satisfactory and workable paths for improvements as contrasted to the setting of standards that “hold actors’ feet to the fire.” We ought to have better information. We ought to view achieving safety, cleaner air, and reduced energy consumption as some of the many ethical needs of society. But to say that is not to say very much. The literature on the subject is not very helpful for it “curses the darkness” rather than “lights a candle.”

What are some lines of policy reasoning? One line might go this way: We are heavily committed to policy and programs; there are associated heavy political and emotional commitments that cannot be changed easily. Therefore, for a period of time we must let things go along as they are. When people become aware that things are not going well, then more efficacious policies might be put in place. We are not happy with that line of reasoning, although we hear it often. Can we think of something better?

Consider clean air. The air pollution emissions problem has been stated as a health imperative. The problem then becomes a "how to achieve" question and the broad issue is whether to use a command and control style or charge those who pollute. Presently, with a few exceptions, command and control style is in use. Perhaps a cost-based line of policy reasoning and policy formation might be useful. Such policies have been developed and applied within some niches (market trading of emissions from certain large generators, for instance).

It might be helpful if the policy debate would readdress the nature of the clean air imperative and how achieving it might conflict with other ethical needs or imperatives such as making a living, social interaction, housing, and so on. While switching from command and control to a decentralized market-based approach may be reasonable (and at least should be considered), we are not optimistic about it in the short term. The notion of an imperative defines and gives such priority to policies that they are not open to discussion.

Hydrocarbons, carbon monoxide (CO), and ozone (O_3) are associated with health problems, and automobiles are primary producers of CO. Automobiles appear to produce something like 60 percent of ozone precursors. From the violation of standards stance, ozone is the big problem. The federal standard for airsheds is 0.12 parts per million (ppm) daily maximum, averaged over a one-hour period (see table 19.2). To be in compliance with the standard, the standard may not be exceeded more than once per year on average.

Table 19.2 EPA Criteria Pollution Standards

Pollutant	Standard value	Standard type
Carbon monoxide (CO)		
8-hour average	9 ppm (10 mg/m^3)	Primary
1-hour average	35 ppm (40 mg/m^3)	Primary
Nitrogen dioxide (NO_2)		
Annual arithmetic mean	0.053 ppm (100 μg/m^3)	Primary and secondary
Ozone (O_3)		
1-hour average	0.12 ppm (235 μg/m^3)	Primary and secondary
Lead (Pb)		
Quarterly average	1.5 μg/m^3	Primary and secondary
Particulate (PM_{10}) particles with diameters $\leq$ 10 μm		
Annual arithmetic mean	50 μg/m^3	Primary and secondary
24-hour average	150 μg/m^3	Primary and secondary
Sulfur dioxide (SO_2)		
Annual arithmetic mean	0.03 ppm (80 μg/m^3)	Primary
24-hour average	0.14 ppm (365 μg/m^3)	Primary
3-hour average	0.50 ppm (1300 μg/m^3)	Secondary

Source: U.S. EPA (2001).

California has much more restrictive ozone standards, including the requirement that the standard not be exceeded at all. The San Francisco–Oakland area, with strong Pacific breezes, is usually in compliance with federal standards, yet it violates state standards from time to time.

Also with respect to the vehicle fleet, old cars are the bad actors. One policy would be to scrap all pre-1975 cars, often considered "super-emitters," and give their owners new cars. California is trying to phase in zero emission vehicles (electric vehicles or fuel cells), which have zero tailpipe emissions (but of course run on electricity generated somewhere). But the policy has met great resistance and has been stalled for more than a decade. In part the automakers complain about the inability to manufacture them, but are probably more concerned about poor consumer reception if the vehicles are not as good as conventional internal combustion engine powered vehicles, which have had a century to be perfected. GM, which produced the first electric vehicle for mass consumption in the Los Angeles region, the EV1, has been rounding up the cars (which were leased out) and is not building a replacement. However, Toyota and Honda have successfully marketed hybrid electric/internal combustion engine vehicles.

Despite the science about air quality and the technology used to reduce pollution and energy consumption, a moralistic rhetorical debate reigns. Box 19.1 illustrates the use of the automobile as sinful, while box 19.2 shows its comparison with drug addiction.

BOX 19.1 A Tax on Sin?

When it first appeared in the United States, the automobile was regarded as a "rich man's toy," just as today when Hummers are viewed as "Yuppie toys." Views of the automobile as a luxury have affected policy. In Europe, this resulted in a steeply graduated levy on engine displacement; only the rich had large cars. Early in 1989, Daniel E. Koshland, Jr., Professor of Biochemistry at Berkeley, proposed a tax on large engines: "A Tax on Sin: The Six-Cylinder" (editorial), *Science*, 243, January 20, 1989. A tax on sin, "where sin is defined on the basis of national policy rather than personal peccadillo. . . ." On March 3, 1989, George Stigler replied:

> Daniel E. Koshland, Jr. (Editorial, 20 Jan., p. 281), proposes a proportional or progressive tax on automobiles on the basis of their fuel consumption. The benefits he lists are numerous: smaller deficits in the federal budget and foreign aid, cleaner air, and better care of the needy (this last a fine example of double-counting).
>
> The same argument calls for progressive taxation of dwelling units: they too use fuel; and to paraphrase Koshland on automobiles, most rooms in larger homes have less than one occupant. He appropriately remarks that if this kind of policy becomes widely accepted, it could be extended to other areas (room temperatures? illumination? travel?).
>
> Koshland's editorial presents by example his distinction between "national policy" and "personal peccadillo." Could he have confused the two?

We have no clear understanding of why autos and auto travel have long been regarded as conspicuous consumption more so than other goods or services. We suspect that it has something to do with the breaking up of old arrangements and the creation of new ones (Berger, 1979).

BOX 19.2 The Automobile as an Evil—The Automobile as Drug

Let us consider the automobile and the environment. Newman and Kenworthy (1989) popularized the term "automobile dependence," analogous to drug dependence. By neat association of the automobile with the evils of drugs, the auto too, because of its environmental and social effects, becomes evil in their nominally scientific, public health-oriented worldview. As distasteful as it may seem, it seems that the drug problem and the environmental problem have much in common. Each moved from complexity to simplicity, each is treated in the moral imperative style of policy making. If the automobile is evil transportation, its alternatives must be good (the enemy of thine enemy is thy friend).

Discussion

An array of activities exist, some of which are leading to results already, or in the process of being, implemented: for example, more efficient diesel engines, better truck aerodynamics, and more energy-efficient aircraft. Some of the activities are intended to make ready technologies for use in the future, for example, improved batteries, inertial energy storage devices, use of lighter-weight materials in vehicles, and fuel cells.

An optimistic scenario says that over a period of decades we can move into a future that has the properties of the *polished present*. We say that is optimistic because higher energy costs make the introduction of otherwise relatively expensive technologies feasible. Chapter 26 will investigate some radical alternatives. If these alternative low-mass, low-energy vehicles can be implemented across modes, the problem of energy for moving things around, as well as the air pollution and CO_2 problems, will have been countered, but there remain other issues that demand improvements in transportation, for instance, growth of congestion, avoiding decreases in productivity, and enabling settlement and social and economic adjustments responding to population growth and migration and pressures from disparities in economic and social progress, as well as shifts steered by changes in resource conditions and new activities.

20

Finance

CosaNostra Pizza #3569 is on Vista Road just down from Kings Park Mall. Vista Road used to belong to the State of California and now is called Fairlanes, Inc. Rte. CSV-5. Its main competition used to be a US Highway and is now called Cruiseways, Inc. Rte. Cal-12. Farther up the Valley, the two competing highways actually cross. Once there had been bitter disputes, the intersection closed by sporadic sniper fire. Finally, a big developer bought the entire intersection and turned it into a drive-through mall. Now the roads feed into a parking system—not a lot, not a ramp, but a system—and lose their identity. Getting through the intersection involves tracing paths through the parking system, many braided filaments of direction like the Ho Chi Minh trail. CSV-5 has better throughput, but Cal-12 has better pavement. That is typical—Fairlanes roads emphasize getting you there, for Type A drivers, and Cruiseways emphasize the enjoyment, for Type B drivers.

—Neil Stephenson, *Snow Crash* (1992, p. 7)

Introduction

The automobile boom and the demand for roads led governments to seek a revenue source that would be "fair," one that would charge users for the benefits they received but did not have the disadvantages of tolls. By the late 1910s, vehicle technology had developed so that most cars used a gasoline-powered internal combustion engine. The gas tax was first established in Oregon in 1919 at 1 cent per gallon. The idea was quickly emulated and a decade later, the last state, New York, finally adopted a tax, then a bit higher, leading to total national collections of about $450 million (Burnham, 1961).

In 1932 the federal government followed suit, enacting a gasoline excise tax. Until 1956 with the passage of the Interstate Highway Act, funds raised by the gas tax were commingled with general revenue, though the amount of revenue was considered a benchmark for federal road spending (Buechner, n.d.). Between 1956 and 1983, all of the revenue went to the highway account (although in the 1970s provisions allowed the money to be spent on transit in cities that could not complete their interstate highways), but after 1983 1 cent out of the 9 cent tax went to the mass transit account. From 1990 to 1996, some of the revenue was further diverted to general revenue to assist in deficit reduction. By 1997, of the 18.4 cent tax, 15.44 cents were spent on highways.

The U.S. experience differs from that in other countries. Hypothecation, earmarking or dedicating fuel taxes for road use, is not nearly so common, since the revenue raised from fuel taxes far exceeds what is spent on roads. The practice is opposed by finance ministers, who want freedom to act, rather than having their hands tied. Great Britain effectively ended hypothecation in 1937 (Newbery and Santos, 1999) (though it maintained a fictional "road account" for a number of years) and Australia in 1959.

In the United States, earmarking of transportation revenues for transportation services is natural and expected, and complaints about taxing transportation services for non-transportation uses arise immediately. In other countries, a fuel tax of $4 per gallon is tolerated. Financing transportation, and using transportation revenues to finance other services, are highly charged topics.

This chapter explores how transport networks are paid for. The question of incidence, who pays what share, is difficult to resolve "fairly" because of incomplete information and disagreements about what constitutes "fair." This debate is replayed in different settings as urban versus rural, local versus through, cars versus trucks, general aviation versus commercial aviation, and so on.

The timing of payment for systems, especially for large capital, varies between "pay as you build" did "pay as you use." The first requires using present funds to pay for capital projects; the second requires borrowing money and repaying the debt out of future revenue.

The question of externalities also appears, as these are hidden, usually nonmonetary, costs that are borne by nonusers through degraded air quality, lowered property values, or increased risk to life and limb. These are treated elsewhere in the book (see chapter 27).

This chapter focuses on financing roads, with a brief degression into water transportation. Roads are a familiar problem and quite controversial, since roads, more than most modes, lie within the public sector. The chapter also discusses private financing, and mixes of public and private as a possible future direction.

Financing Roads (ca. 1920)

Counties levied the property tax (in lieu of having property owners devote work days to road repair, the corvée system discussed in chapter 12) to satisfy the demand for modern roads. With increases in the numbers of automobiles and trucks, the need for roads was seen as obvious, and in the early decades of the twentieth century increasing the property tax for roads presented no political problems. In a way, local governments solved the problem of building and maintaining the highway system in the same way the cities did—local taxes paid for local roads. As was the case in the cities, the property tax base was augmented by the development of vehicle fees and fuel taxes beginning in the late 1910s; these imposts were widely adopted by the 1920s. While the pattern of fees and taxes differed from state to state, in almost every state farm trucks received favored treatment in tax systems. Roads were popular, and the popularity of road improvements was pushed even before the auto by the need to get farm products to railheads and by use of bicycles. National level legislators responded warmly to the need for funds.

Figure 20.1 shows the share of revenue spent on urban roads in 1920. Fees for vehicles ran to about $10.70 for autos and $21.90 for trucks. The states had instituted gasoline taxes that amounted to about 4 cents per gallon. Imposts on trucks were running at about 1 cent per ton-mile. The situation varied from state to state, but in almost all states the cities (sometimes via the counties) were receiving income from these taxes.

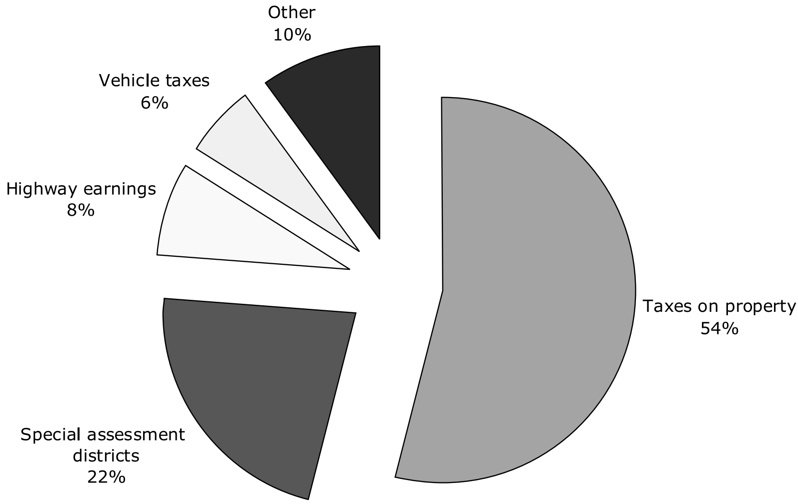


Figure 20.1. Urban expenditures on roads and streets, 1920.

For example, in California urban counties were receiving about 50 percent of the taxes and fees paid by urban vehicles. At the national level, highway expenditures were running at about $2 billion, and it was estimated that about $325 million was expended in cities. Special assessment districts were widely used, paying about one-half of the capital investment costs.

Issues at the time were the cross-subsidy of rural roads by urban vehicle taxpayers, urban congestion, and the large part of the urban highway bill being paid by general taxes. Although it was pointed out that urban vehicle owners used rural facilities for as much as 60 percent of their travel, it was thought that the urban to rural subsidy situation was unstable, that is, an adjustment would be made.

With respect to the contribution of general taxes on property to road expenditures, it was pointed out that urban street facilities had purposes other than carrying traffic. They were used for walking and recreation and they provided light and air to adjoining property. They provided right of way for utilities. Expenditures would be necessary even if there were no motorized vehicles.

But even in 1920, the contribution of general taxes to streets was on the decrease. In 1903, 28 percent of city expenditures were for streets, but this had declined to 17 percent by 1923.

Congestion was an issue in the 1920s, as it was before and as it is now. At that time its management was via improvements in the street system, although it was recognized that there were limits on what could be done because of existing properties and the political and fiscal costs of taking property. Zoning was held out as the solution; it would ensure property development that would allow adequate street spaces and distribute traffic-intensive land uses.

Jacob Viner, a well-known economist at the University of Chicago, discussed the control of congestion by "restricting the wasteful use of street space." He mentions systems of charges on parking and on traffic and restrictions on truck traffic. He predicted that "there will not be as much restriction on traffic as the prevailing conditions require," but added, "the public will submit in time to the painful necessities of the situation" (Viner, 1926, p. 268).

Financing Roads (ca. 2000)

The astute reader will have noted that the issues in 1920 largely remain unresolved. Land use is still considered a possible solution, as are pricing parking and traffic. The source of funds has shifted somewhat over 80 years, and varies somewhat by region, but figure 20.2, using data from the Twin Cities, is representative. A surprisingly large amount of road revenue comes from nontransportation sources. Students of federal level data will tend to miss spending on local roads. While it is arguable to what extent that road spending is required for the purposes of moving people, as opposed to accessing property, it is still spent on roads.

What has changed in 76 years? Property taxes are half as important. Special assessments are one-fourth as important. Gas taxes (highway earnings) from the state and federal government are about four times as important, and vehicle taxes are also four times as important. At this rate of change, in another century or so, road financing might actually be efficient.

Cars versus Trucks

The source of revenue between "user fees" and "nonuser fees" is one way to slice the financing puzzle. A second way is to consider the share of user fees borne by each

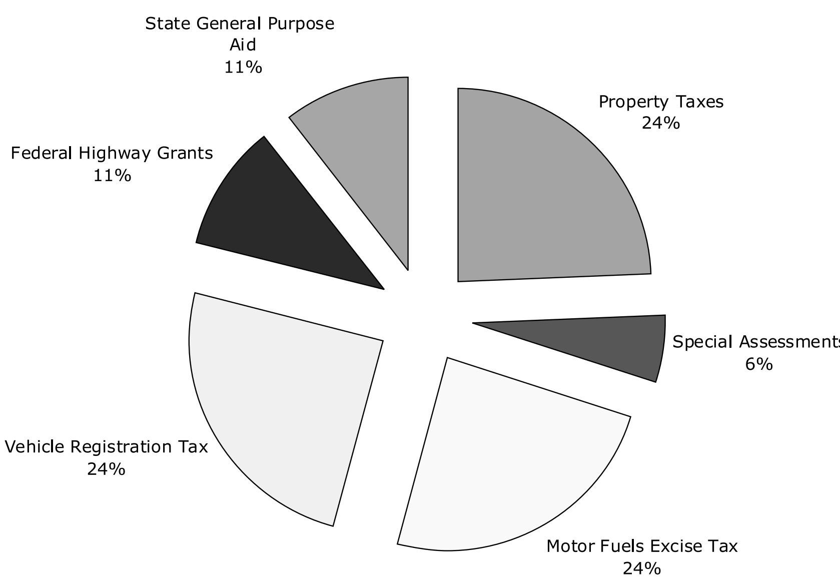


Figure 20.2. Total road revenues in Twin Cities Metro Area, 1996. (Source: Ryan and Stinson, 2002.)

user class. Figure 20.3 illustrates the distribution of revenue by vehicle class. Whether this is "fair" is the subject of tremendous debate, not simply car versus truck, but truck versus truck. The issue is how much of highway costs does each class of vehicle engender. Simple kilometers traveled or ton-kilometers traveled are insufficient. How, when, and where matter as well. *How* concerns in part the distribution of the weight across axles; *when* concerns whether the trips takes place during the peak (and thus require additional capacity) or in the off-peak (which can take advantage of excess capacity); and *where* concerns the degree of congestion.

Other freight modes have an interest in seeing that trucks pay their fair share. Railroads are quick to point out that they pay for the full cost of their track, unlike trucks, and thus are eager to ensure that trucks pay more. (Truckers will respond by noting that the railroads were often granted their right of way by the government at no cost.) This same issue faces general aviation and commercial aviation competing for airport space. Busy airports have managed to chase away most general aviation through high charges for landing and takeoff. Box 20.1 discusses the issue of freight competition.

Allocating Costs

Needs studies conducted as part of planning analyses address the question "How many dollars?" Having decided on the quantity of dollars needed, the question is that of the best way to get them: "How do we raise the money and allocate the cost?" Although not addressed in all planning studies, the funding question is a planning question.

Broadly, the cost allocation question has been answered so that users should pay, though, as noted above, there is property tax support of local roads designed to allow

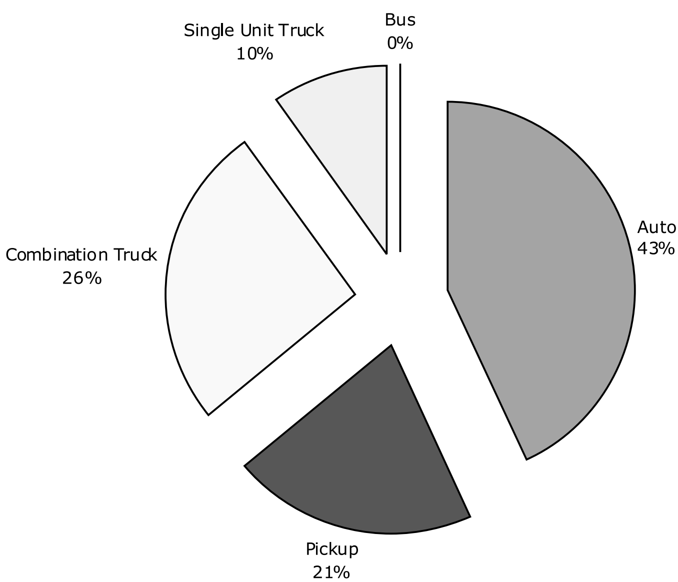


Figure 20.3. Distribution of federal highway revenues by vehicle class. (Source: U.S. FHWA, 1997.)

BOX 20.1 Freight Competition

The rail mode began to be deployed in the 1830s and railroads were pretty much fully deployed by 1900. Loss of passenger market share to buses and automobiles began in the 1920s. It was essentially complete by the middle of the 1960s when air transport captured long-distance passenger markets. Although in the United States there has been a continued growth of rail freight traffic, railroads have lost market shares to inland waterways and trucks.

The U.S. DOT's *National Transportation Statistics* (1995) reports that the freight transport system provided about 5.3 trillion ton-km (3.3 trillion ton-miles) of freight service in 1992, with the percentage breakdown for intercity freight movements as shown in figure 20.4. The present-day distribution of modal shares represents the extension of trends dating from early in the twentieth century when the railroads dominated domestic freight services.

Pipeline freight shares grew when petroleum shipments expanded early in the twentieth century. As U.S. petroleum production decreases, the extent of crude pipelines may decrease; needs for product pipelines will continue. Truck service began to capture market share during the 1920s and trucking had occupied its market niche by the end of the 1960s. Coastal domestic water transportation has increased mainly because of shipments of Alaskan crude. The Gulf Intercoastal Waterway has held market shares versus land-based rail and pipelines. New locks and dams increased Ohio–Mississippi River barge competition with railroads beginning during the 1950s. Congestion at locks on the upper Mississippi and Ohio Rivers and environmental constraints on dredging to enlarge channels and on constructing larger locks and higher dams cast doubts on the further expansion of these inland water services. Great Lakes market shares have declined in recent decades due to shifts in industry output and competition from railroads. Airfreight also began to grow in the 1950s, but its market share remains low. Over the years, the railroads have lost freight market shares, but at a decreasing rate. The situation is essentially stable today, although piggyback is regaining some market share from trucks in certain corridors.

The railroads provide service at about $0.015 per ton-km. Water and pipeline services are generally provided at lower cost. Truck services range upward from $0.06 per ton-km, and average about $0.15. Air services run to about $0.30 per ton-km, $0.60 for package freight. For revenue reasons, and considering market shares, it is no surprise that trucking services dominate modal revenue shares.

access to the network. (This is a user fee proportional to land value, assuming that everybody needs access to their property.) Almost all the states and also the federal government adopted the incremental cost method to allocate costs to users.

The idea is a very simple one. Every vehicle pays a fee: the fee is a "standby" charge; one needs a road system because there are vehicles. Next, vehicles pay depending on the system attributes required for them. There is the basic system sized to autos, and all vehicles pay for that basic system. The fuel tax ensures that vehicles pay according to the amount they use the system, that is, a mileage-related fee (see box 20.2).

Vehicles larger or heavier than the auto have additional requirements, and they pay the incremental costs of providing for them. The incremental cost concept is simple; the execution of a study is not. First, we need to know the costs that vehicles of different

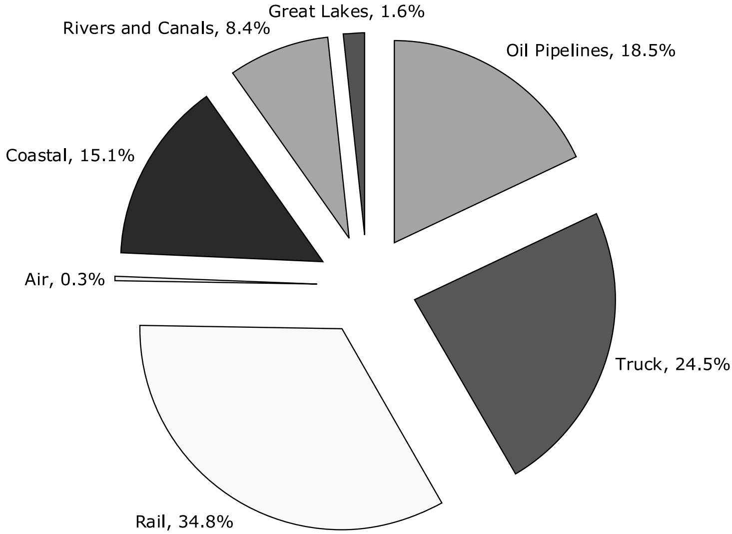


Figure 20.4. Freight movement (share of ton-kilometers).

BOX 20.2 Weight–Distance Taxes in Oregon

Oregon uses weight–distance taxes (Oregon DOT, 2003). In 1999 Oregon voters passed Measure 76, and placed in the state constitution the idea of "cost responsibility," ensuring that cars and trucks each pay their fair share:

> Revenues . . . that are generated by taxes or excises imposed by the state shall be generated in a manner that ensures that the share of revenues paid for the use of light vehicles, including cars, and the share of revenues paid for the use of heavy vehicles, including trucks, is fair and proportionate to the costs incurred for the highway system because of each class of vehicle. The Legislative Assembly shall provide for a biennial review and, if necessary, adjustment, of revenue sources to ensure fairness and proportionality.

Weight–distance taxes are not without controversy. At the behest of certain truckers, the Oregon Legislature repealed the tax in 1999, hoping to replace it with a more general gas tax that would favor heavier loads at the expense of lighter loads, but the bill was referred to voters who defeated it in 2000 and restored the weight–distance tax.

The Oregon Highway Cost Allocation Study is conducted biennially to support highway financing decisions. The 2003 report states that light vehicles (weighing 3,636 kg [8,000 lb] or less) should pay 66.6 percent of state highway user revenue, and heavy vehicles should pay the remaining 33.4 percent, which is within 0.5 percent of actual payments (Oregon DOT, 2003).

This measure represents a small victory for transportation economists.

classes occasion. The geometric-related costs are probably the easiest to calculate using sample cost data from projects. The weight-related costs are determined from pavement depth and bridge strength requirements, often estimated in the AASHO road test of the 1960s and sometimes from even earlier data. The data are valid for one case—climate, soil conditions, and so on—and do not fit the rest of the United States very well. Fortunately, pavement researchers are in the process of improving and updating this information along with their methodology.

Finally, we need a lot of fine detail, highway use data, because we cannot determine costs without knowing the kinds of facilities on which vehicles are operated. For example, if heavy trucks were only operated on certain facilities, one set of costs would result; if that traffic were partly on other kinds of facilities, there would be another set of costs.

Once costs are assigned to different types of vehicles, there is the question of a practical way to collect them. The fuel fees are easy to collect, and they match agency costs fairly well for autos. For heavier vehicles, a combination of fees and taxes on equipment purchases is used.

Arranging Expenditures

Needs studies say what is needed; cost allocation studies say how the money should be raised to do what is needed. How does the circle closes? Do the funds flow to needs? To a degree, funding streams are distorted by allocation–expenditure formulas.

As a result of expenditure formulas, expenditure arrangements have resulted in considerable differences between where funds are obtained and where they are spent. In the states, urban facility users have subsidized rural roads. Moneys collected by the federal government in states may be greater or less than the money returned through federal programs.

Each state has developed ways to allocate resources spatially. For example, in California there is a north–south split agreement, and there are county minimums.

Fiscal arrangements are in trouble today because the deployment of more fuel-efficient automobiles and the failure of the fuel tax to keep up with inflation have sharply eroded available funds. As a consequence, the debate today has to do with the financial crisis: schemes to get the money flowing again at the federal level and the desire by the federal government to slough off fiscal responsibility for noninterstate routes.

Returning to needs and cost allocation studies, it was remarked that these are now pretty much driven by federal programs, and that is truer for the needs studies than the cost allocation studies. The federal government outlines templates for data collection by the states, and then does the study. So by and large the studies are not tailored to state circumstances. There is a need to make these studies more sensitive to state concerns.

Financing Inland Waterways

While inland waterways may be roads of water, they are financed differently from roads, with a much greater federal role. Figure 20.5 shows the allocation of $62.488 billion of

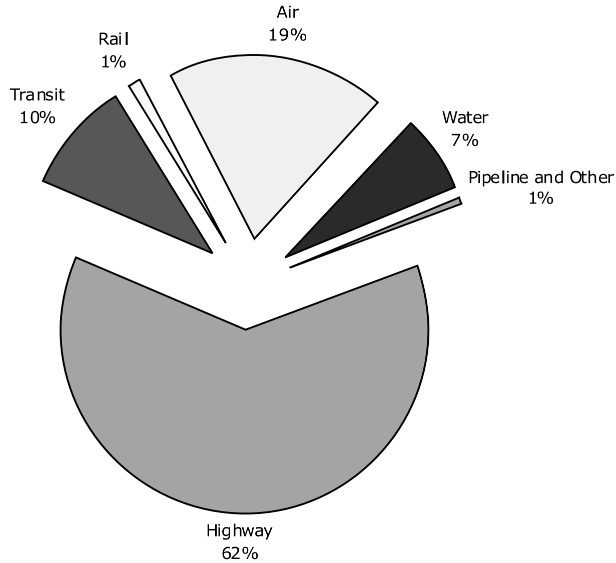


Figure 20.5. 2002 federal transportation budget. (Source: BTS, 2002.)

federal transportation funding. Of the $4.387 billion in water transportation expenditures, about $1.72 billion is for the U.S. Army Corps of Engineers; about half is for the U.S. Coast Guard, the remainder for the Maritime Administration, St. Lawrence Seaway, and the Maritime Commission. As would be expected, the Corps expenditures are not just for inland waterway improvements and operations—there is flood control, drainage, recreation, coastal waterway, and coastal port expenditures, as shown in figure 20.6. In light of user-pay concepts, we can compare revenue from taxes on water transportation earmarked as user fees with expenses. For 1999 water charges were bringing in $3.9 billion, compared with expenses of $4.6 billion that year. Local contributions are part of this. Figure 20.7 compares revenues by mode.

Asset Management

Debates about financing are now less about taxes to meet budget commitments and more about investments needed to manage assets. The thinking runs like this. Over the years investments have been made in water supply, transportation, and other infrastructure. These are society's assets. They are valuable and they need to be managed. Investment substitutes for borrowing or taxation. Taxpayers become investors and are compensated by the return on their investments.

This line of thinking has a certainly reasonableness from the experiences of individuals and social and economic organizations. It may overlay the cost allocation, needs, benefit/cost tests, user pay, and other of the financing conventions developed over the years. It picks up on management as the problem and opportunity in mature systems. In the United States it is consistent with the mercantilism theme that energized investments ranging from the Erie Canal to massive container ports.

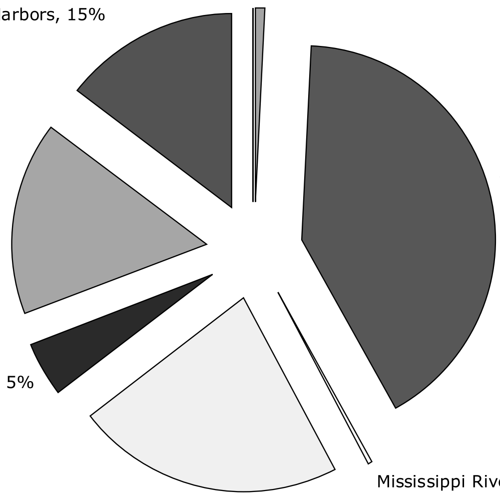


Figure 20.6. Federal expenditures for water transportation by agency and program from own funds, 1985–2001. (Source: BTS, 2001.)

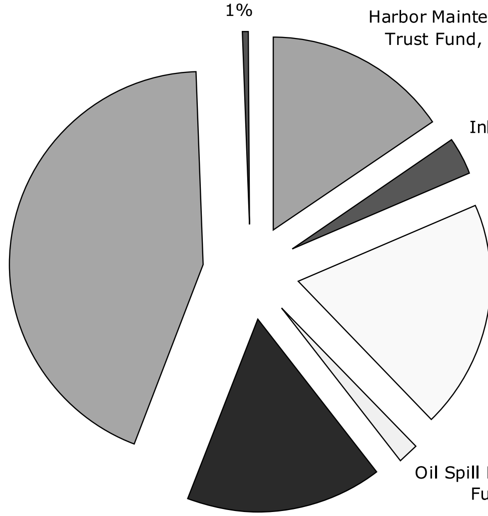


Figure 20.7. Transportation revenues and revenue-raising instruments by mode, 1999. (Source: BTS, 1999.)

This asset management approach may be problematic; for one thing, a good slogan may stifle thinking. As Wendell Willkie, one-time U.S. presidential candidate, put it, “a good catchword can obscure analysis for fifty years.” And there is the proverb “be careful what you wish for because you may get it.” Emphasis on preserving assets may further entrench the inflexibility and obsolescence resulting from historic path dependence. Cross-subsidies and many other features inherited from the experience may recede from view, along with the opportunities, such as alternative financing, suggested by the experience.

Alternative Financing

Up to this point, we have discussed the government role in financing as if it were the only role. However, with the widened attention to privatization in its many forms, one may think that private roads are just around the corner, that travelers will soon drive on commercialized streets and highways and bypass public sector arteries. That was the vision portrayed by Neil Stephenson in his novel of the near-future *Snow Crash,* quoted at the beginning of the chapter. Though creating fodder for science fiction authors, a world of unregulated private roads frightens those who currently control the roads sector. While the archetypal private road may include no public involvement, most recent private efforts in the highway sector to date have either been government contracts, franchises, outsourcing, or have required government assistance. They certainly require government permission and have been subject to extensive government oversight. These are often referred to as “public–private partnerships.”

As noted in chapter 12, private financing of roads has existed for centuries. The turnpike era illustrates a mix of public and private responsibility. In England, roads were organized as trusts, quasi-public corporations, chartered by Parliament, but with the aim of earning a profit. There was significant oversight, the right to operate turnpikes was not in perpetuity, but had to be renewed by Parliament. When turnpike organizations went bankrupt (often due to the rise of railroads), they were taken over by local government.

Toll farming, the selling of the right to collect tolls, was another aspect of private involvement, reducing public sector risk (in principle) by exchanging a lump-sum payment for the right to collect tolls (which were subject to the vagaries of demand and required entrepreneurship and incentive for enforcement). In England, Lewis Levy, nicknamed “Turnpike Levy,” controlled much of the toll collection (Turvey, 2003). Toll farming was common in other European countries as well, such as Poland, where it was often in the hands of the Jewish minority (Jewish Tribal Review, 2003).

In the United States, the turnpikes were more often fully private companies, yet they sold stock not only to citizens, but to the governments as well, which is a form of public–private partnership with the government assuming some of the risk and providing capital to the private sector (largely a mirror of the current situation). The Dulles Greenway, discussed in box 20.3, is a modern private toll road.

Many elements of the highway transportation system are already private. Drivers and passengers expend their own time in producing highway trips. Drivers generally own their vehicles, so those too are private. Roadside services (gas, food, lodging) are almost always private, and are necessary elements for many kinds of trips. While in some cases these may be concessions on government-owned land (rest stops on toll roads), on most

BOX 20.3 Private Roads? The Case of the Dulles Greenway, Virginia

The first private toll road in Virginia since 1816, the Dulles Greenway is a 22.5 km (14 mile) western extension of the Dulles Toll Road, connecting Washington Dulles International Airport with U.S. Route 15 in Leesburg. The Dulles Greenway originated in 1988 when the Virginia General Assembly authorized the private development of toll roads. Construction began in September 1993 and the road opened for service on September 29, 1995, which the owners (Toll Road Investors Partnership II) note was six months ahead of schedule and under budget. On opening, it comprised seven interchanges, 36 bridges, a toll plaza, 12 ramp toll barriers, an administration building, and four operational lanes. It further allowed for construction of two additional lanes, two additional interchanges, and for a rail system in the median.

Dulles Greenway is one of the first toll highways in the United States that was designed, built, and financed in the private sector since the end of the nineteenth-century turnpike era. Dulles Greenway is the fourth highway segment comprising the Dulles Transportation Corridor, Virginia.

- The Dulles Airport Access Road (DAAR) was built by the Federal Aviation Agency (FAA) and opened in 1962 along with the Washington Dulles International Airport. It is a no-toll, 12-mile-long, four-lane expressway serving only airport traffic.
- The Dulles Toll Road (DTR), which opened in 1984, was built by the Virginia Department of Transportation. It consists of four and six lanes paralleling both sides of the DAAR. It has full interchanges and no restrictions on vehicle size or type.
- The Dulles Access Road Extension (DARE), a no-toll, four-lane, 2-mile-long expressway extending eastward from the DAAR and DTR to I-66 by Falls Church with both truck and occupancy restrictions, was completed in 1985 (Kozel, 1997).

The initial toll was \$1.75 each way and did not vary with the length traveled along the highway or the time of day. In comparison, the toll on the Dulles Toll Road was only \$0.85. The volume of traffic averaged 11,000 vehicles daily, much less than estimates of 25,000 vehicles per day (*Washington Post*, Jan. 14, 1996). Suggestions for increasing patrons included lowering the toll for nonrush hours and weekends, pricing comparable for length traveled along the highway, better marketing strategies, increasing the speed limit, and establishing electronic tolling. The investors believed that the highway might have been five years ahead of itself, since development was just beginning along the project. Michael Crane, one of the proprietors, when asked what he would do differently next time, stated, “I would never do it as a totally private toll road. I would do it as a public–private venture . . .” (*Engineering News-Record*, Jan. 8, 1996).

The Virginia Senate, in February 1996, passed bills allowing the Dulles Greenway to have a speed limit of 65 mph and to obtain Federal Highway loans. The toll was reduced from \$1.75 to \$1.00 in 1996, and volume doubled, but the owners missed a \$7 million interest payment to its creditors and a \$3.6 million payment to the State of Virginia in July 1996 (*Washington Post*, Aug. 4, 1996). The owners were given time to refinance the \$350 million debt and succeeded in April 1999. A higher speed limit of 65 mph, electronic toll collection, and a frequent user program were credited with the highway having 40,000 vehicles per day in 1999 (PR Newswire, Apr. 29, 1999).

Development expanded significantly in 1999 with MCI WorldCom and America Online (AOL) having offices in the corridor. Tolls were increased for the Dulles Greenway

BOX 20.3 Private Roads? The Case of the Dulles Greenway, Virginia—cont'd

to $1.40 for cash and $1.15 for electronic payment. Loudoun County began analyzing large developments for the corridor (*Washington Business Journal*, Dec. 3, 1999). Future population projections resulted in the owners expanding the Dulles Greenway. Construction for an eastbound lane began in June 2000 and was completed in December 2000. The westbound lane began construction in the spring of 2001 and was completed in August 2001. Construction costs for the additional 5 miles of two lanes were estimated at $10.4 million (Sullivan, 2000). Usage of the Dulles Greenway increased to over 60,000 vehicles per day in June 2002, a 7 percent increase from a year earlier (Meehan, 2002). Loudoun County has experienced rapid growth in the last few years, which significantly increased highway usage.

The Dulles Greenway is one of the few experiments with private building and financing of a project that had in the past been accomplished with public resources. The risks that the private partners incurred were an extremely large leveraged debt, a long time frame before profitability, a project subject to economic downturns, and competition from untolled roads. In addition, Dulles Greenway could not raise its toll above $2.00 unless the Virginia State Corporation Commission (SCC) gave the owners permission. The main advantages that the Dulles Greenway highway realized were that the lenders were willing to negotiate and wait for payments and the highway was built in an area that was expanding. Though somewhat premature, the road may yet turn out to be profitable.

Table 20.1 Realms of Public and Private Involvement

			Private roles
Public ↑	Public	Federal government	None
		State government	None
		Local government	None
		Homeowners' association	None
		Utility quasi-public authority	Build, own, operate
	Outsourcing	Service contract	Operations and maintenance
		Management contract	Design, build
			Design, build, major maintenance
			Design, build, operate
	Franchise	Project franchise	Lease, develop, operate
			Build, lease, operate, transfer
			Build, transfer, operate
			Build operate, transfer
			Build, own, operate, transfer
↓			Build, own, operate
Private	Divestiture	Private entrepreneurship	Buy, build, operate
			Buy, operate

highways they are on private land. The origin and destination of the trip are also generally in the private sector; these trip generators (generation facilities) may be analogous to the generating plants in the electricity sector. The roads themselves, however, are not generally private. These network components are at issue in the discussion of partial partnerships to full privatization of roads.

When there are two entities (the public and private sector), there must be two objectives: welfare and profit. Those objectives, while not entirely coincident, may not be totally mutually exclusive. Broadly, we can think of a continuum of governance structures between private and public as suggested by table 20.1.

Discussion

Much discussion about private roads focuses on the flexibility and choices provided to travelers (who would have the alternative of taking an expensive fast road or an inexpensive slow one). A network with largely or entirely private elements would be very different from the one we face on a daily basis. Just as deregulation of communications created radically new products and services that were unimagined at the time, divestiture of highways may do similar things. However, unlike the American telecommunications sector, streets and highways are government-owned. Furthermore, highways are presently financed through gas taxes and general revenue, rather than priced according to use or a contract between service provider and consumer. Yet, there is clearly reluctance to privatize; otherwise we would already be living in a world with private streets and highways.

21

Forecasting

All forecasts are wrong, some forecasts are more wrong than others.
—Anonymous

Prediction is very difficult, especially if it involves the future.
—Niels Bohr

It has been said that he who lives by the crystal ball soon learns to eat glass.
—Zoltan Merszei, president of Occidental Petroleum

Introduction

Is the transportation planning model objective or subjective? Is it used to inform decisions or to justify them? Do forecasts predict the future or create it in a process of self-fulfilling prophecy?

In 1991 the Montgomery County, Maryland, transportation planning model (Travel) was being used to assist the county Planning Department in the development of a Master Plan for the suburban area of North Bethesda. Policy called for much of that area, which incorporated three Metro subway stations on the Red Line to downtown Washington, to receive higher density zoning, and thus more development. Policy in Montgomery County suggested that the additional congestion resulting from the development could be tolerated in areas with better transit service. The alternative of providing additional highway capacity was too costly, would undermine support for transit, and faced numerous environmental and other hurdles. Additional transportation demand management approaches (TDM) were also put in place, but were thought to be inadequate.

Citizens' groups in North Bethesda, led by activist and transportation safety engineer John Viner, were unhappy with the direction in which the plan was going. While the area would become more developed, existing residents would face many of the negative externalities (more congestion) and receive few of the benefits (since their own property was already built out and not eligible for rezoning). Informed by previous studies showing significant congestion with even less intensive land use, the community came to the belief that the model forecasts they were being shown would underestimate the amount of traffic produced by the proposed development. The consequence was that more development would be approved than the roads could handle at a given level of service (even a higher, or worse, level of service). If the model forecasts were low, the land use approved based on those forecasts would be high.

There are several possible reasons for an underestimate. First, the model could be flawed. Second, the modelers could be misusing the model, either accidentally or intentionally. Intentionally misleading the public and officials can be achieved by making unreasonable hidden assumptions. The reasons for this have been documented in a number of sources, including Wachs (1982, 1990) and Brinkman (2003).

After testimony by citizen in hearings before the County Council about the inaccuracy of the model, in what was dubbed locally as "The Trial of Galileo," County Council member (and future candidate for County Executive) Bruce Adams called a special meeting of the Council's Planning, Housing, and Economic Development Committee on the model. The community argued that the model was flawed rather than arguing that the policy was flawed (which they believed as well), or that the modelers were intentionally misusing the model under pressure from superiors. The strategy behind this was to go after the weaker target, the model. The Council, which established policy, would be more open to hearing a critique of the model than of its own directions or criticism of planners who were doing their bidding.

The "trial" involved numerous maps, charts, tables, and memos being prepared for Council consumption by both sides. The citizens compared forecasts against observed traffic and suggested that the model was prima facie wrong. Citizens argued that the model underestimated traffic (the forecast year counts were lower than today's on some links, and surely traffic will not decline if population increases). They also argued that officials buried earlier studies that produced different results (and higher traffic estimates). Planning staff said otherwise, and pointed out that they were assuming numerous travel demand measures that would be imposed on the new development, and also that a more congested level of service standards would be in place.

In the end, not much was decided; the community still opposed the plan, and still believed the model was flawed. The Council looked at the results and the plans with perhaps a more skeptical eye, but in the end did agree to a significant upzoning of North Bethesda, along with additional travel demand management policies. Few new roads have opened in the area, and some very large developments are now getting started.

How did a transportation planning forecasting tool, designed to predict traffic flows on freeways, get wrapped up in a land use controversy? As a successful technique in its market niche (estimating freeway traffic), transportation planning models got a foothold in forecasting, and spread to other niches (projecting land use impacts), just as transportation modes themselves do.

The technical, institutional, and conceptual frames for what is called urban transportation planning, but is really simply urban transportation forecasting, emerged in the Chicago Area Transportation Study (CATS), which was initiated in the 1950s. The CATS approach, which was adopted nationwide and, later, worldwide, has evolved over time; techniques have been refined, and often they have been renamed. Indeed, techniques have been so modified that many practitioners are unaware of their origins. The CATS approach has been modified to accommodate scales and circumstances that differ from situation to situation, mode to mode, and time to time. Creighton (1970) is an example of a textbook using the "pure CATS" approach.

This chapter begins by discussing the concepts incorporated in CATS and its institutional frame. We recognize seven technical steps in CATS analysis procedure, and the bulk of the discussion following the introduction of CATS will address those steps. Our view is broader than that of most forecasters who refer to a four-step process.

Birth of the Predominant Paradigm

It is useful to describe the modern Urban Transportation Planning System (or Model) (UTPS) based on CATS as a clean break from precursor urban transportation planning experiences, although some exceptions will be noted. As a clean break, the emergence of modern UTPS ignored the well-honed planning techniques for arterial roads and local streets lodged in urban public works offices, the transit experiences, and the beginnings of transportation and land use planning in the Nelson Lewis (1916) style lodged in emerging planning agencies. The UTPS also ignored some urban traffic analysis experiences to be discussed shortly. In this "ignoring," more than one kitbag of techniques replacing another was involved, for there were institutional and conceptual breaks.

There was a break, and we can think about that in two ways. Modern UTPS can be viewed as revolutionary compared to precursor planning, following the body of literature on how revolutions in analysis (science) occur (Kuhn, 1957). People who have discarded old dogmas develop new, more powerful ideas. The new drives out the old over a generation, as the bearers of old ways retire and the new move up the ladder. In the UTPS case, the rearrangements during World War II may have aided the displacement of the old by the new. The establishment does not change its collective mind; rather, young researchers who create and join new schools form a new establishment. There is evidence for this process in common experiences, as well as in the sciences.

On the other hand, there is evidence, especially in the transportation experience, that the new is built from the old. The new is built by putting existing building blocks into new designs that work, say two times better than the old. Adoption is pushed by this more effective construct. That is the way, for example, modern container shipping was developed. It put hard and soft building blocks together in a new way.

Actually, a close examination of change reveals that both behaviors are usually found. For example, a truck company manager, Malcolm McLean, who put liner company dogma aside, as well as assembling building blocks from the transportation experience, developed container shipping.

The actors involved in UTPS development, especially at CATS, had not been involved in pre-World War II urban planning endeavors, and they did not have the burden of existing dogma defined by those endeavors. They were not empty-headed, of course. They brought ideas to planning and they borrowed ways of thinking about the UTPS problem.

The realization of modern UTPS is often explained by saying that an analytic process pushed a weaker, less efficacious process aside. We do not find that explanation convincing. The analytic revolution was under way in social science and engineering, and we conjecture that no matter what the origins of modern UTPS were, an analytic process would have been developed. Indeed, as we shall see when we examine work by urban transportation planners of the "old school," they strove to work in an analytic fashion and sometimes to be more analytic than the UTPS innovators. We also may point out that the break was not just analytic versus nonanalytic, for breaks in concepts and institutions were involved.

As Boyce (2002) has pointed out, across town in Chicago a completely different analytic framework was being developed by Beckmann et al. (1956); however, these two approaches to modeling developed independently, and the Beckmann path remained academic. In part this is because CATS was uninterested in congestion pricing, which was a main point of the Beckmann et al. research. The divergence was also due to the practical matter that, at the time, equilibrium flows could not be handled within the planning models. The "not invented here" syndrome and differing conceptual bases also delayed interest on the part of agencies in the use of linear and dynamic programming.

Rather than building on the urban experience, CATS built mainly on the Bureau of Public Roads (BPR, now the Federal Highway Administration [FHWA]) and state highway department experience. CATS was sponsored by the Illinois Department of Highways, and it is easy to see why many of the UTPS building blocks were from the state–BPR experience, described in chapter 13 (and similarly, why building blocks from the urban experience were not used).

CATS as a Paradigm for Urban Transportation Forecasting

With the upswing in urban growth following World War II, a number of cities began to consider or engage in a new round of facilities planning. Even prior to World War II, the State Department of Highways in California had begun to construct freeway-like facilities in Los Angeles, and planning for a more extensive system was begun in the late 1940s and early 1950s. The Detroit Metropolitan Area Transportation Study (DMATS) developed an extensive freeway plan. Minneapolis–St. Paul did some preliminary work, as was the case in the greater New York City area.

Many of the actors who worked on the DMATS study moved to Chicago when CATS work was initiated by the Illinois Department of Transportation in cooperation with the Bureau, including the Director, Douglas Carroll, a sociologist. The CATS undertaking had the advantages that actors had already gone along the learning curve, resources were sized to the tasks, and it was the right style of study at the right time when the interstate program was initiated.

With respect to facilities, the CATS planning effort was a broad one. Attention was paid to the entire street network, as well as to transit, and over the years there was attention to freight and air transport topics. This breadth was in spite of the state–BPR sponsorship and their limited responsibility for urban facilities. CATS investigated a wide breadth of research topics, as a review of CATS reports will reveal.

In 1956, when the Interstate Act was passed, CATS was in place and engaged in a widely scoped study in the BPR style. Although broad, it did not extend to institutional and financing matters. Also it did not interact with existing urban institutions: public works agencies, city planning departments, the metropolitan planning department, and public interest organizations such as the Metropolitan Planning and Housing Council of Chicago.

Federal legislation and the 1955 General Location document gave the centerline mileage of the urban interstates. The technical questions about the urban extensions were their final locations including interchanges and how many lanes to provide. To answer these questions, seven analysis steps were adopted from CATS:

- Economic and demographic forecasting.
- Land use forecasting.
- Trip generation forecasting.
- Trip distribution forecasting.
- Mode choice forecasting.
- Route assignment.
- Economic evaluation.

To answer questions about the concepts adopted, one must refer to the CATS planning scheme (figure 21.1). Careful attention was given to the unfolding of the physical future of the city and of travel demand: do X in year 1, Y in year 2, and so on. The analysis involved putting the traffic on the network and determining needs for lanes. The plan was to be a one-time thing based on one-time analysis. A 20-year time horizon was taken. The technology was a given (freeways, vehicles, etc.) as was policy (agency responsibilities, funding source, revenue source [new toll roads were not an option], fixed lane mileage, etc.).

It is important to see this planning scheme in a larger frame. It suggests how the planner/forecaster apparently imagined that the worlds of policy, technology, and institutions worked: there is no feedback from the plan to policy or technology. It also suggests how planner/forecasters were thinking of urban growth and development and its relation to transportation: there is no feedback from the implementation of the plan to forecasts. It was imagined that the plan (a map based on the study of "facts") was a one-time project rather than an ongoing process. It was accepted that an outside institution would draft the plan. Finance and control of facility development resided with the state and federal governments, largely external to the city. The plan aimed to satisfy demand rather than manage it, or balance supply and demand at an optimal level. It was a given

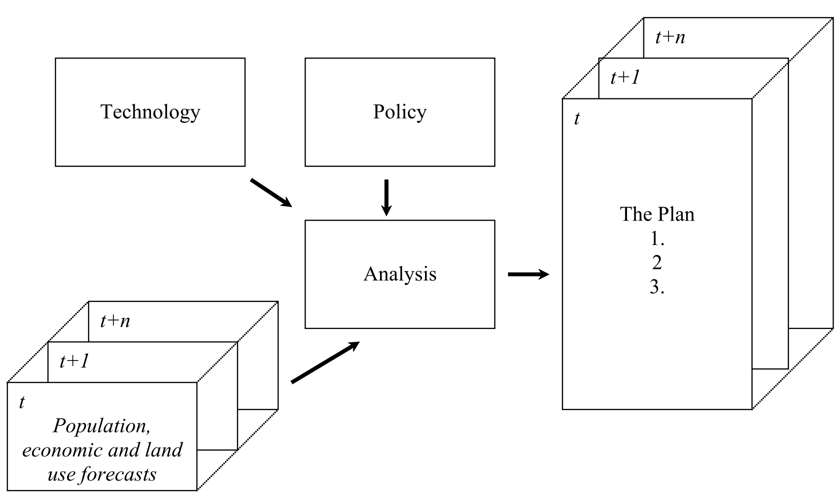


Figure 21.1. CATS planning scheme.

that the freeway was the technological solution, and the problem was the journey to work (other travel purposes and freight were ignored).

Transfer of CATS Concepts, Style, and Methods

In 1956 the states were ready to build many rural interstate links, and were thinking about the urban extensions. CATS was ready to be emulated, and it was. Emulators took from CATS what they needed. The institution was copied, as was the size of the effort. But all this took time. Studies were initiated here and there as the states became organized. Some studies involved cooperation with local agencies, especially metropolitan agencies where they were available. Even so, the local agencies were hardly full partners in the activity, for the Bureau and the states had control of funding and personnel.

Many leaders in CATS moved to positions of responsibility in the newly initiated studies. Some of the studies relied heavily on consultants, and previous CATS actors turned up in that context.

The Bureau pushed urban planning in the same way that state planning had been pushed, and the Federal Aid Highway Act of 1962 required long-range comprehensive planning in cities of 50,000 or over in population as a condition for the receipt of federal funds. The Bureau began to offer technical assistance, and these steps greatly increased the transfer of CATS concepts and techniques. By the 1970s, freeway type facilities were being planned in cities worldwide, and there was more and more emulation. By this time, of course, CATS experience had been modified by experiences in other cities.

It needs to be noted that institutional and "size freeways" aspects of the planning endeavors were modified as time passed. The Federal Aid Act of 1970 required that planning integrate highways into other transportation plans and the evaluation of the social, economic, and environmental impacts of highways. The Act of 1973 opened highway trust funds to use by mass transit. It emphasized highway safety and completion of the interstate.

Critique

The UTPS, including its land use and transportation components, has been heavily criticized. The critiques of the land use models (e.g., Lee, 1973) have been sufficient to significantly diminish application in that realm. However, despite criticism, the "four-step" transportation planning model remains. In his writings on systems analysis, Churchman (1979) makes the point that defining and analyzing systems without considering their interactions with and changes in their environments yields an environmental fallacy. With this point in mind, we begin by positioning UTPS within its broad environment.

A project sponsored by the American Public Works Association (Armstrong et al., 1976) recorded the history of the interstate highway system.[1] One strong feature of the study was the recording and interpreting of the oral histories of many actors engaged in the building of the system. At the descriptive level, the study does a pretty good job of reporting how institutions, financing, and knowledge were used to deliver the system. On size, dollar, and other scales that is a remarkable story.

It is not a unique story, for there are many examples of social agreement and organization for the delivery of products and services for the common good. Perhaps the interstate pales as a relative effort in comparison to the churches, defense walls, and markets produced in medieval cities and the canals and walls in China, where commitments were made over decades for the investments and large fractions of social surpluses were invested.

Considering those instances and others, as well as the interstate, the notion that the experiences are unique obscures the search for systematic ideas. Ideally, we should like to formally know how society can find agreement about and construct and manage infrastructure systems in acceptable and efficient ways. Such systematic knowledge is elusive; it remains hard to see how medieval churches and the interstate are variations on a theme.

To give a specific highway example, one motive of the sponsors of the interstate history (AASHTO) was that it would provide systematic understandings useful to the debate about postinterstate highway programs. It is not at all clear that such understandings were developed. Actually, the writers of the history were skeptical about achieving such findings.

The problem here was that the interstate was only a snapshot of the larger processes of the growth and development of systems. We see it as the penultimate phase of deployment, more growth than development, and oriented to economies of scale. The UTPS follows the period when most emphasis is given to *product* (deploying highways), and it falls in the period when greatest attention is given to the *process* of delivering the product (planning highways). Considered in that light, the UTPS is essentially what would be expected. It is a process for delivering a standardized product. If something is said to be wrong, it is not with the UTPS, but with the overall product cycle.

Our second consideration will position the UTPS process within the environment of legislative actions, policy debates, and the economic mood of the times. We have already reviewed the evolution of the idea of some sort of interstate system and the toll roads versus free roads debate. There was the decision to build facilities at service level C, rather than B as in rural areas. That was to keep the cost down. Finally, there was the decision to stick with limited mileage. That, of course, was also to keep costs down. So the UTPS was oriented to supplying routes "on the cheap," and that is what it did.

The result was the construction of a limited mileage freeway system. Many people, the writers included, wish that a larger mileage of environmentally benign facilities with designs suited to their situations had been provided. They were not, but that is not because the UTPS was faulty. It was because of the environment and the running of the transportation development cycle.

Consideration of the achievement of scale economies relates to the two previous sections. Considering the positioning of UTPS within a particular environment at a given point in the life cycle, we expect that as the market grows, suppliers standardize product and process technologies to achieve economies of scale. The on-the-cheap, high-capacity, limited mileage facilities are consistent with that expectation. Partly because of this search for scale, we observe as a general proposition that long-run average costs decrease. For example, something like figure 21.2 holds for railroads.

The modes differ in the relation between short-run and long-run costs. Some modes, such as railroads, can adjust quickly as traffic increases locally but others cannot, especially the highway system. A surge of traffic on a railroad tomorrow will increase congestion

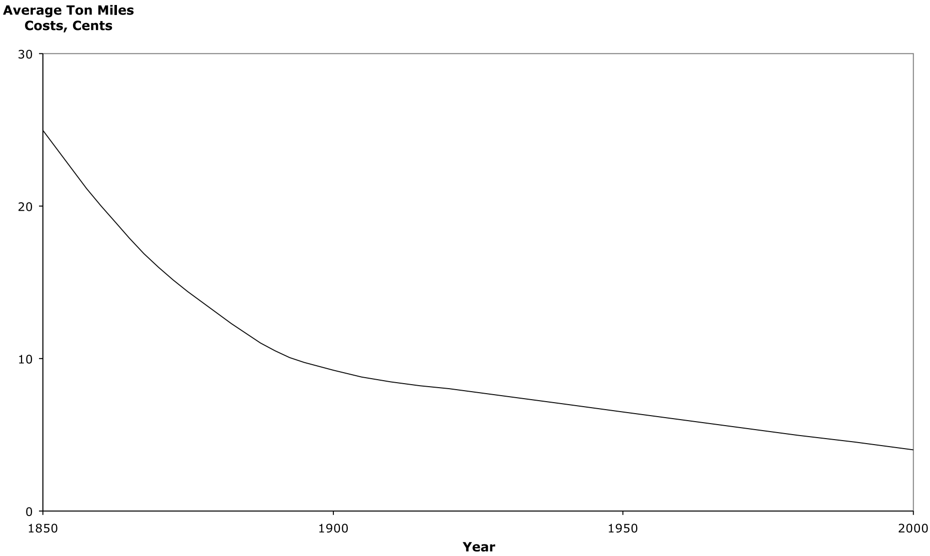


Figure 21.2. Railroad average ton-mile costs, in cents, 1850–2000 (current dollars).

and unit cost because railroads tailor facilities and operations to existing traffic. But by increasing train powering and weights, adding sidings, and improving signal systems, the traffic may be accommodated at decreased cost in a matter of months.

The structure of systems confuses the issue. Viewing the cost unit as the bus, train, or the airplane gives one picture of cost at this level and another for the system. For an example at the operating firm level, it is asserted that deregulation has decreased the cost of air travel. (It likely has, but not nearly as much as is claimed.) But the air transportation *system* has not been deregulated (airports, air traffic control, and safety are hardly free markets), and no one addresses the cost trends in the system.

An interesting, but not unexpected, feature of the UTPS was the use of scale economies to decrease supplier (highway agency) costs. It may have been neutral with respect to equipment supplier costs, and its effect on user cost was mixed.

Scale in the highway enabled improved service, so users got something from scale. However, that scale was achieved in such a way that as traffic grew, diseconomies set in. Unlike the other transportation systems, highway designs are such that adjustments are difficult. We are observing long-run average cost increases for new construction. The highway system differs from other systems in this important economy of scale way, but this is not due to the UTPS.

There is another point about scale, a simple one. The scale at which the highway suppliers' product is efficient does not seem to fit the scale of the city very well. Scale creates conflicts with the environment.

That positioning complete, we strive for a level of criticism where UTPS bashing is in order only to the extent that we wish to illustrate undesirable outcomes. Examples of UTPS bashing include: unrealistic assumptions, human behavior cannot be reduced to numbers, failure to deal with fine detail problems, and conflicts with community goals. These examples are ad hoc, and are surely drawn from some bounded but not closed universe. The point we wish to make is that we have no systematic way to deal with bashing messages when considering them on their own. But we can begin to make some sense of bashing on three dimensions: the UTPS within its immediate environment, the UTPS in relation to analysis know-how, and the UTPS within the larger system logic.

Chapter 3 has prepared us for this criticism, for we have discussed the way urban problems were viewed just before the development of the UTPS, and we discussed transportation developments for the same period (BPR surveys, city traffic studies). These considerations are not quite sufficient for what we want to do, for we also need to consider the state of the art of analysis (figure 21.3). The UTPS analysis was state of the art early on, but it is now much less so. It did not fit the city very well at the beginning and the situation is worse now. (Understand that trajectories are not independent: UTPS affected the state of the city and also of analysis.)

As the UTPS was developed, the urban transportation system was drifting into the mature phase where attention is given to tailoring service to markets, to the extent that unitary products can be tailored to markets. In the urban environment, that was realized under the transportation system management (TSM) rubric. No discussion is needed to conclude that the UTPS was disconnected from TSM.

There is an interesting bit of history. TSM was triggered by UMTA and the lack of money to fund the flood of transit capital proposals. The FHWA was a reluctant partner in its development. We would say that UMTA's action was a triggering event and not the reason for TSM. TSM would have come along without the event; it was the next step in the logic of system development.

Our summary statement, as indicated in figure 21.3, is that the UTPS was very state of the art when first developed, and especially in its CATS incarnation. It dealt with the behavior of aggregates, was a logical or rational approach to problem solving, used numbers and statistics, modeled formulas on the physical sciences, and used serial steps. It used normative ideas. It was state of the art for social analysis and normative planning, and it was state of the art for transportation technical analysis too. The latter is because it built so closely on BPR work.

There are additional critiques of these types of modeling processes. Box 21.1 illustrates the observation bias that downtown-based planners and politicians face. Box 21.2

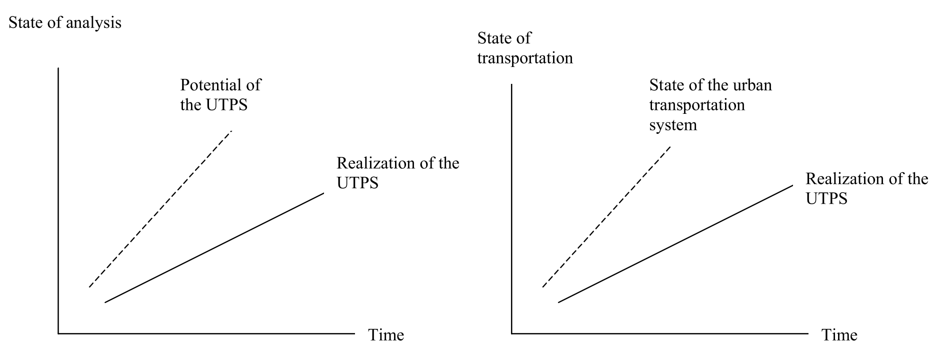


Figure 21.3. UTPS, state of the art, and state of the urban transportation system.

describes the problems of forecasting in general associated with limits to knowledge. Box 21.3 reminds us of Lord Kelvin's curse, which condemns us to a search for numerical precision even where it is not warranted.

Discussion

We have stressed the notion that present-day planning concepts and techniques are the result of interacting previous experiences with the problems at hand. An interesting aspect of modern UTPS is the way it drew on the rural road, Bureau of Public Roads, and state experiences rather than urban experiences.

BOX 21.1 Influence of World Views

There is an interesting, but difficult to find, study by James Hillman (1979) (*Psychological Fantasies in Transportation Problems*), which points out that transportation problems are in the minds of the beholders. Hillman notes that the typical transportation planner is trained in rational analysis, works about 250 days a year in a white-collar job, and typically drives to work at some place in or near the CBD. It is no surprise, says Hillman, that the urban transportation problem is a problem of the journey to and from downtown work from the residence, and attributes of the problem to be managed are things such as facilities that are not big enough or have potholes and making sure that other travelers are more "rational."

Hillman also points out that the transportation planner gets "marching orders" from politicians who share the planner's lifestyle.

Hillman's remarks lead to two conjectures. First, the problem to be managed is the state of travel when commuting. That problem and its context aligns more closely with the latter steps in the UTP process than with early steps, so one might expect that latter steps are less ad hoc in concept and technique than early steps. Also, the journey to work gets priority. Second, there is the rational view of processes. One would expect that formulations of processes similar in style to what is taken to be rational analysis would predominate. Finally, one would expect planners to think that transportation plays a key role in processes. For instance, most transportation planners think of access to the workplace as the key consideration in household location decisions.

BOX 21.2 Transportation, Meteorology, and the Limits to Knowledge

Previous chapters have discussed a number of attributes of systems, for example, the presence of slow and fast variables, life cycle, level of contingency, and within-system decision-making. Taken alone or together, these may assist in forming perspectives on planning and the system to which planning is applied. This note will not restate those system attributes and ask about the insights they offer. Rather, we attempt to respond to the often-heard comment that these systems are social ones and analysis will not work.

BOX 21.2 Transportation, Meteorology, and the Limits to Knowledge—cont'd

Suppose these were physical systems. How well could they be studied? How well could forecasts be made? Garrison was once a meteorologist, and he still follows that literature in a casual way. What does the meteorology experience tell us? Meterological or weather processes are completely understood in broad outline. Processes are those applicable to systems, and, given initial conditions, laws describe changes in states due to changing energy flux. Given that situation, there would seem to be two tasks. First, fill in gaps in the science and data. Recent work has clarified the relations between sunspots and weather. Second, improve the calculations required when large systems are analyzed. Larger computers allow us to solve those equations in a more precise way and in a shorter period of time, so there should be more precision in weather forecasting than previously.

There is a parallel to work in UTPS. UTPS workers take the processes to be well known, for example, traffic assignment. A lot of effort is going into numerical methods for solving equations and forecasting, and work is being done to polish up empirical details.

Returning to meteorology, large computers began to come along in the 1970s, and for a time there was a flurry of effort in numerical weather forecasting. But with experience, it was found that this forecasting was no better than forecasting using previous techniques. What seems to be the problem? After all, the meterological system is a physical system. It obeys laws, so one ought to be able to predict states.

Now, it is pretty much agreed that numerical forecasting cannot be done. The reason is that the initial state is not known. Observations at weather stations measure the initial state from which the forecast is made. There just are not enough weather stations. Is the solution to the problem to open more weather stations? Some rough analyses suggest that while that is the solution in theory, it is not practical. Doubling the number of stations would not make much difference; rather it would require a mind-boggling number of stations to make much difference.

There is a parallel to the UTPS. We have some exact techniques for (parts of) the UTPS, but they are applied to systems where the initial state is far from known.

There is another aspect of the weather forecasting problem. There has long been the assumption that the system could be described with continuous, well-behaved functions. Now researchers think that chaos and its mathematics are an inherent part of system behavior. There is some parallel to that in the UTPS.

We find the weather forecasting perspective useful because it suggests quite a lot. There are problems that would exist in the UTPS even without the complications introduced by the social elements in urban and transportation systems. Do we know initial states? Do well-behaved functions describe the dynamics?

We have observed that the steps toward the end of the UTPS process involve rather exact task statements and methods for doing calculations. We know exactly how to assign traffic to networks, make mode choice studies, do economic analysis, and undertake zone-to-zone traffic distribution analysis. One might claim that exact calculations are also made in earlier steps, but on comparison, problem statements and calculations are rather fuzzy. One could suggest several reasons for this. The one we usually state is that the steps near the end of the process are more exposed to clients and general publics and thus beg precision. One could also suppose that the content of these steps is closer to the peer group interests of workers and/or that the earlier steps treat inherently more difficult topics.

This of course implies that we have precision without accuracy, which is not very useful at all.

BOX 21.3 Lord Kelvin's Curse

> *I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter may be*
>
> —Lord Kelvin, Addresses (1883)

We have sometimes referred to the precision called for by Lord Kelvin as Lord Kelvin's curse, for it yields a perspective that too often generates work with much attention to numbers and little attention to thinking. Even with its dangers, a small dose of analytic thinking and number crunching may offset planning steered by advocates and assertion.

We have also stressed the role of CATS. It was there to be emulated when the need for urban interstate planning emerged. That emulation was selective. CATS was a broad-based undertaking, and emulators took what they needed.

It is important to understand the task posed by urban interstate planning. Interstate designs were rural designs; the interstate involved space-consuming, limited-access designs. These designs were imposed in urban areas; centerline mileage was limited. So the central question became "How many lanes?"

Why limited access? Land development and accompanying turning traffic had unwanted impacts on state highways, and the Bureau wanted to avoid that. Also, abutting structures and curb cuts had made it difficult to add capacity when needed.

The Bureau's rural experience had been to make plans and implement. Twenty years was the expected life of pavements, so they made 20-year plans. At the end of 20 years, more planning and implementation would be undertaken: renew pavements, add more lanes, straighten curves, build new bridges, and so on. That sort of thinking was taken into the urban area where it was inappropriate. Essentially, the interstate built out so far as the capacity of areas allowed.

Previous remarks have said that the UTPS was a product of its positioning within the environment: the general environment said "do it on the cheap" and the transportation environment said "do it this way at this stage in the life cycle." In a sense, UTPS was "what had to be," and we can understand it completely. If we were to do it again, or if another situation comes along in which something similar is called for, it would seem that improvements would have to be addressed to the working of the system logic rather than to UTPS logic.

So we leave the UTPS for the moment and jump to the model we have in mind for large system planning or planning working on the system logic. In our ideal, one operative word for planning would be "inquiring"; another would be "design." We would like analysis that scoped from all building blocks (knowledge, available technologies, physical facilities, institutions, etc.) and that produced designs.

We imagine such designs having physical content, and extending to institutional, policy, and other "soft" matters bearing on the working of a design. The designs should be consistent with deep-running social and economic trends and constraints of all sorts. They should open options (development pathways) rather than exhaust options. They should offer choices to the public. It is by offering choices about pathways that planning is inquiring.

Let us be clear about what we saying. In previous discussions we presented the system logic. It has a disjoint character, and the micro-processes at work yield a macro-realization of an S-shaped sort. There is no reason to think of that realization as having optimal properties, but there is reason to think that it is very stable.

We are saying that UTPS-like activities are an outcome of system properties, and the way to improve UTPS-like activities is to develop a scope and style of planning that changes system properties, rather than simply forecasting within the constraints of existing system properties.

The UTPS did not fit the state of the city when the UTPS was born. The gap is now greater. That is an impression we have stemming from two thoughts.

Our first thought requires that we distinguish between growth and development. If we look at a city at time t and then at $t + n$, to what extent is the difference due to development and to what extent is it due to growth? Suppose a city is small at time t, and its shopping is mainly downtown. It is larger at $t + n$, and there are non-CBD shopping centers. Our impression is that the decentralization of shopping is simply because cities are larger, it is a matter of growth. We suspect that is true of many things that are purported to be fundamental changes in the ways cities are developing.

But there are surely some development-like changes. There is the moving of "back office" transactions from the CBD, and the development of transactions generally. We need a modeling process for a transaction economy.

Our next thought asks the question, what is the city for? The UTPS answers that question when we examine its product—the UTPS focuses on work travel, a city is a place to work. There are 8,760 hours in the year. In the United States, those who work full-time do so for about 2,000 hours (40 hours a week for about 50 weeks a year, discounting vacation and holidays). Fewer than half the people work (the rest are children, retired, stay-at-home parents, unemployed, or independently wealthy) so the average person works about 800 hours. So about 9 percent of urban time is used for work.

Average work travel runs to 0.66 hours per day (maybe a bit more, but in most cities, much less than an hour's round trip), and about 240 hours per year. Say a third of that is spent in congestion, 80 hours. That's about 0.9 percent of urban time.

What all this rough arithmetic says is that UTPS is concerned with a small percent of urban life. To be sure, there is leverage in that focus because the ease of the work trip bears on choices of housing and jobs. Also, the peaking of work trips is the time of the worst congestion—the point when people see the transportation system "failing." Even so, we should like a UTPS that is at least more explicit with respect to the leverage and that scopes to things like housing and social and recreational travel.

We should like a UTPS that focuses on the city as a place for living. Perhaps the work trip orientation was the appropriate focus at the beginning of the UTPS, but it seems less so now.

22

Time

Time is the longest distance between two places.
—Tennessee Williams, *The Glass Menagerie* (1945)

I feel the need, the need for speed.
—Maverick, from the movie *Top Gun*

He who wastes my time takes my life.
—Unknown

Introduction

On December 30, 1940 (just prior to the Tournament of Roses parade), the Arroyo Seco Parkway connecting Los Angeles and Pasadena, California's first freeway, opened to traffic. The road was perceived to be so successful that a full-fledged freeway network followed. The Santa Monica Freeway (I-10) in Los Angeles appeared on planners' maps as early as 1956 (as the Olympic Freeway) (Faigin, n.d.), saw its first segment opened to traffic in 1961, and was completed by 1966.

Transportation requires a number of inputs. We have noted communications, energy, clean air, and information as some of those inputs. Transportation is produced both by agencies and organizations that build infrastructure and operate vehicles, and by travelers who contribute their own time in making trips. Individuals are thus producers as well as consumers of transportation. While freeways were still widely (though not universally) lauded, transportation professionals recognized that different vehicles had different values of time, and there might be some gains in giving priority to those with a higher value. To that end, High Occupancy Vehicle (HOV or Diamond) lanes were first deployed on the Shirley Highway (I-95) in Virginia outside of Washington, D.C., in 1969 as an exclusive bus lane. Today there are over 3,200 km (2,000 miles) of HOV lanes in the United States. By restricting traffic and ensuring freeflow speeds, HOV lanes provide an incentive for travelers to form carpools, and thus reduce the number of vehicles on both the freeway with the HOV lane, as well as on the roads leading to the freeway. They also reward existing carpools, as well as users of buses and vanpools, who take advantage of the faster routes. By privileging these high-value vehicles, total social benefits are supposed to increase (see box 22.1).

Following on the success of HOV lanes such as the Shirley Highway, and with little advanced warning to motorists, in 1976 the California Department of Transportation (Caltrans) converted a lane of the Santa Monica Freeway to a HOV 3+ lane, requiring 3 or more persons per vehicle to use the lane. This did provide an incentive for carpoolers. By converting a lane, Caltrans made the time difference between the HOV and other lanes greater, but thereby punished those who did not use HOV by reducing the available capacity and increasing their travel time. Evidence showed rising HOV use and transit ridership soon after. However, this "take-away" strategy led to vociferous protests from motorists, and within a few weeks Caltrans relented and reverted that lane back to general-purpose traffic. The lesson that was learned (and learned perhaps too well) is that "take-away" strategies are unacceptable, and HOV must be the result of additional capacity. While HOV users can benefit, other users must not be harmed.

The consequence is that when an HOV lane opens, bus passengers and carpoolers of course benefit, but those who drive alone also benefit because there are fewer carpools congesting their lanes. This greatly diminishes the potential time savings that HOV provides. Dahlgren (1998) shows that HOVs only work well (better than general-purpose lanes) within a small window. If the mainline is uncongested, or will be so after the HOV lane is added, there is no benefit. If the HOV lane itself becomes congested, there also will be diminished benefit.

An example of this is an experiment that took place on the El Monte Busway demonstration project, along the San Bernardino Freeway in Los Angeles. The Busway was opened in 1973, and HOV 3+ were permitted to use the facility in 1975. Still, the lane had the appearance of being below its vehicle-carrying capacity. In 1999 the California legislature instructed Caltrans to lower the vehicle occupancy required to use the facility. A study of this experiment found that the addition of HOV 2+ carpoolers caused congestion in the carpool lanes, worsening reliability and increasing travel times for both cars and buses, yet freeway travel times in the general-purpose lanes did not see significant improvements. In July 2000 the road became HOV 3+ again.

BOX 22.1 The Slug Line

The HOV lane enabled a new transportation phenomenon, dubbed the "slug line" in metropolitan Washington (or "instant" or "casual carpoolers" in somewhat more jargon-laden transportation talk). Slugs, or members of the slug line, are commuters who wait at known locations (typically bus stops) to be picked up by Single Occupant Vehicles (SOVs) hoping to use the HOV lane, but lacking a passenger (Spielburg and Shapiro, 2000). The phenomenon emerged as SOVs cruised bus stops looking for passengers, but soon individuals with no intention of riding the bus would queue up. The phenomenon emerged spontaneously, without government organization or posting of signs. Whether this is a good or bad idea we shall leave to the reader's judgment. However, the slugs on average double the value of the cargo carried by passenger vehicles. Whether this process eliminates another vehicle on the road, or a passenger on the bus, depends on the slug.

It is now becoming increasingly likely that HOV lanes will be converted to high-occupancy/toll (or HOT) lanes. This somewhat alleviates the perception of the HOV lane as being underutilized, which has led to reversion of HOV lanes in New Jersey to general-purpose lanes. HOT lanes were conceived of by Ward Elliott (1975) at Claremont McKenna College in the 1970s, and reinvented in the 1990s by Gordon Fielding and Dan Klein (1993) as part of a Reason Foundation study. As of 2004, while only a few HOT lanes are operating, a number are being planned for deployment (see box 26.3).

The understanding of transportation is incomplete without the understanding of the use of time. The use of time for travel cannot be understood without the complementary use of time for activities. This chapter explores the rise of time, the use of time, the peaking of traffic, and how advancing technology affects speed and thus the use of time and space in turn.

The Rise of Time

We have always had time, of course, but its importance has changed over the centuries. Before attention to time was imposed by the industrial revolution, and standard time invented by the railroads (Blaise, 2001), lives ran on time measured by the days and seasons and benchmarked by church and state holidays, seasonal fairs, and other events. Work was organized by the job, for example, contracting to bring in the hay, for a two-year trip on an India voyage, or for a midsummer (between planting and harvesting season) raid on neighboring kingdoms.

Factory work and the spread of precursor and modern transportation systems restructured the daily, weekly, and annual activity paradigm. Employers imposed time contracts (much like the corvée which required peasants to give 6 days a year or more to the government to maintain the roads, although nominally these contracts were voluntary). These contracts said: be there at ____, stay until ____. A weekly rhythm emerged, and people had to learn to work in tandem with others at specific times and places.

For transportation, the operation of scheduled services as on rail required time coordination to ensure reliability and safety, though earlier ships had "watches." Rail service also learned from the military, which heeded time's defeat to defeat the enemy.

Transportation was no mere user of time, the transportation sector fashioned tools for time. While the clock and calendar are old, transportation required precision time-keeping and coordination. Measurement of longitude required precise portable time-keeping devices (Sobel, 1996). The issue was so important that the British Government established the Longitude Act in 1714, and a Board of Longitude, which would award a prize of £20,000, a nice sum today, but huge for the time, to anyone who could develop an accurate and practical measure of time at sea. The timekeeping devices developed by John Harrison would evolve into the portable watches required by train conductors.

Standardized railroad and air services need Greenwich Mean Time. Of course, such time was an arbitrary invention, established as standard by the Prime Meridian Conference in 1884. That Conference followed on the heels of Sunday morning, November 18, 1883, which was dubbed the day of "two noons" in the United States, as those in the eastern parts of the four time zones had a second noon to comport with the western part of those zones. Today's Global Positioning System (GPS) provides sufficiently accurate time and location that people are considering using it, or at least the next generation of GPS, for vehicle control, for instance keeping cars in their lanes.

This mode of living—activity scheduled by time and requiring specialized inputs, extensive use of capital (machinery), and requirements for tandem or sequential activities—emerged in the nineteenth century and now dominates life and thinking. Consider for example the public school system, which teaches students to live and work in the mode established by the industrial revolution.

So transportation (and the industrial revolution) framed the modern perception of time, and thus our daily schedules. Daily schedules were also affected by the rise of rules, described in box 22.2.

Time Use

Figure 22.1 summarizes some long-term trends in time use in the United States. Despite the differences in methods, some clear trends emerge. In 1990 adult Americans are working more on weekdays and less on Saturday than in 1954. The weekday rise is principally due to the larger number of women working outside the home. Although Schor (1991) has argued (controversially) that time at work has risen for men as well, this may not show up in a travel or activity survey, but rather in wage data. The Saturday drop reflects the widespread adoption of the five-day workweek since 1954. The amount of time spent shopping has held remarkably steady, although even small time differences in this category represent larger percentage differences. Americans would

BOX 22.2 Organization by Rules

As would be expected from our discussion of technology and as we have seen, the railroads borrowed policies from previous experience. For example, the first charters for railroads were modeled on those for canals, as already mentioned. Temporal organization was also borrowed.

With respect to embedded policies, management and operations policies were borrowed from military and industrial experiences. Military borrowing resulted in style or corporate cultural features. Such borrowing was necessary because of the geographic span of railroads and requirements that systems operate in a reliable fashion—in order to take an action, the actions of others elsewhere must be highly predictable. The railroads borrowed from the military, and especially from industry, the policy of operations by rules. Clear, carefully stated rules were necessary for predictability, for the training of labor, and for ensuring task responsibility.

Workers who had lived for years with nature's clock and contracting for independent tasks (I shall bring in your crop this fall) had to be trained to do coordinated things at specific times. To accomplish this, *The Law Book of the Crowly Iron Works* (late eighteenth century) contained 100,000 words. Modeled on such rules, especially Josiah Wedgwood's chinaware factory rules, the Liverpool and Manchester opened for business with a well-developed *Rules and Regulations* book. The *American Standard Code of Operation Regulations* of 1887 illustrates the heavy hand of early beginnings.

appear to be shopping more on weekends. This in part is due to Sunday shopping, which was rare in 1954 due to Blue Laws, but this also seems to be true on Saturdays.

The two most curious categories are home and other. Given the increase in female labor force participation, time spent at home from 1954 to 1990 should be expected to decrease on weekdays. This is supported by the data. However, several interacting factors make the issue more complicated. Saturday work has decreased, which makes more time available on Saturdays (for home and shop), while the opening of stores (and other activity locations) on Sunday enables people to get out on Sunday.

Figure 22.1 suggests that the amount of time spent in travel is almost identical between 1954 and 1990. It raises the intriguing possibility that there is some form of "travel time budget." There are 24 hours, or 1,440 minutes, in a day. Thus, per day, there is a fixed amount of time to do things. Consider a typical childless adult. Taking out

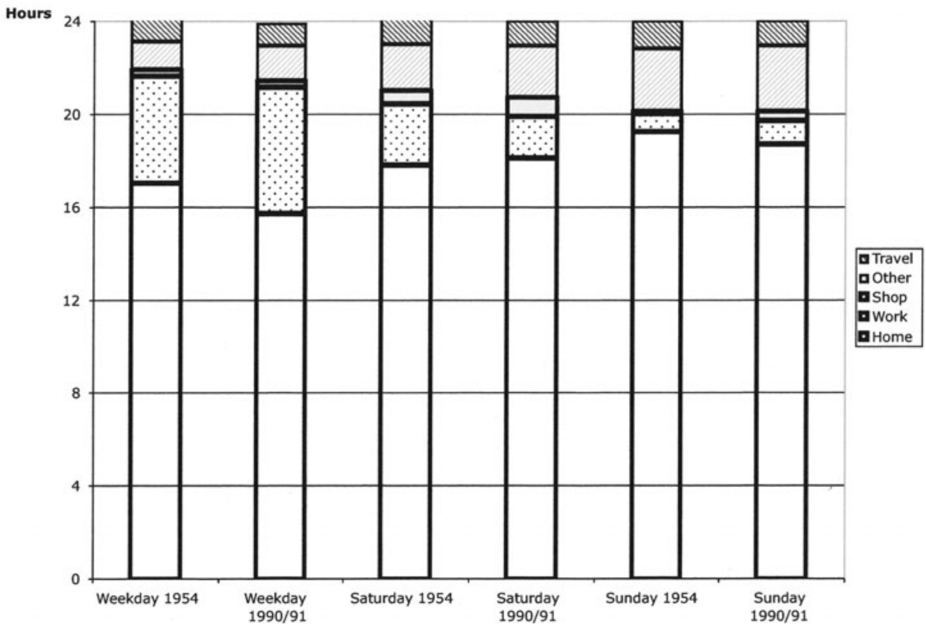


Figure 22.1. Mean activity durations per day, in hours, U.S. national data, for 1954 and 1990. (Source: de Grazia, 1962; Levinson and Kumar, 1995b). Note: The 1954 results are reported by de Grazia from an unpublished study, "A Nationwide Study of Living Habits," conducted for the Mutual Broadcasting System by J.A. Ward. The Ward study used quarter-hour diaries during March and April 1954. The 1954 sample was quite large, 7,000 households and 20,000 individuals. The diaries were collected from 6 A.M. to 11 P.M.; we have assumed the remaining time to be spent at home. Results from 1966 (not shown) were drawn from tables reported by Robinson and Szalai in the monumental 1966 international use of time study. The sample was much smaller, over 2,000 adults, primarily as a day-after diary. The data from this study were cross-classified in numerous ways and tables. Some of the tables, such as for travel, shop, and work, were directly comparable with the other two studies. However, the results for home and other had to be inferred from several tables and adjusted by us to get a best estimate. This is because a number of activities that could occur at either location (home, other) were reported by type of activity (for instance watching television or socializing with friends) rather than location.

8 hours for work (production) and another 8 hours for sleep (Marx's reproduction) reduces flexibility. Another portion of that time must be spent on consumption (shopping and eating). There are further household maintenance activities that must take place (cleaning, hygiene, medical care, etc.). Thus there are maybe 4 discretionary hours per day. If that is the case, there is a practical upper limit on the amount of daily travel one can undertake (4 hours) that is split between travel to work, travel to nonwork activities, and other discretionary activities.

A lot of evidence supports the idea that individuals spend a fixed amount of time per day (just over one hour) in transportation (Zahavi, 1974; Zahavi and Ryan, 1980; Zahavi and Talvittie, 1980; Chumak and Braaksma, 1981; Barnes and Davis, 1999) (see profile of Yacov Zahavi below). Yet aside from the fixed bounds of the problem, the theoretical causal mechanism for a fixed budget is weak.

Marchetti (1994) suggests that humans have a nesting and a roaming instinct. At night we return home, by day we stake out a territory for a fixed time. When people walked, the distance was short. But as technology has allowed us to move faster (horses, streetcars, automobiles, airplanes), we stake out a larger area.

Other researchers (Prendergast and Williams, 1981; Tanner, 1981) disagree with the notion of a travel time budget, echoing Becker (1965) who argued that tradeoffs are made between travel time, other time, and expenditures for the full gamut of activities depending on relative price and income changes and the valuation of time.

To provide evidence refuting the daily travel time budget, table 22.1 shows that time spent in travel in metropolitan Washington has increased between 1968 and 1994 due to the rise in nonwork trips and the increase in workers. Similarly, table 22.2 shows that

Table 22.1 Mean Activity Durations per Weekday, in Minutes, for 1968, 1988, and 1994, Washington, D.C., Metropolitan Area (Consistent Geography), Adults 18–65

Activity	Year	Male worker	Female worker	Male nonworker	Female nonworker
Home	1968	786	831	1,120	1,225
	1988	799	826	1,143	1,165
	1994	761	795	1,093	1,155
Work	1968	515	487	0	0
	1988	472	447	0	0
	1994	499	476	0	0
Work-related	1968	NR	NR	NR	NR
	1988	NR	NR	NR	NR
	1994	20	10	0	0
Shop	1968	7	10	27	52
	1988	10	13	31	50
	1994	8	13	33	47
Other	1968	44	29	217	101
	1988	61	62	187	140
	1994	47	47	220	154
Travel	1968	88	82	76	62
	1988	99	92	80	85
	1994	104	99	93	85

Note: NR, not recorded.

daily travel time in the Twin Cities has risen between 1990 and 2000. In Washington this increased time is not, as has often been supposed, due to a longer duration of work trips, but rather increased nonwork activities and more workers (table 22.3). However, in the Twin Cities the difference largely is due to longer work commutes. In the Twin Cities, though distances have risen, a large part of the increase in travel time is due to rising congestion; times have risen for trips between a given origin and destination.

Levinson and Kumar (1994, 1995a) note the stability in journey to work times over a long period in metropolitan Washington, D.C. (the 1968 to 1988 data shown here as well as similar numbers from 1958 by William Whyte). They posit that *rational locators* act to shift jobs or homes to maintain commute times. Thus, for instance, suburbanization of jobs helps solve the problem of long-duration commutes by bringing work nearer

Table 22.2 Mean Activity Duration per Day, in Minutes, for 1990 and 2000, Twin Cities Metropolitan Area (7-County), Adults 18–65

Activity	Year	Male worker	Female worker	Male nonworker	Female nonworker
Home	1990	777	816	1,092	1,176
	2000	777	802	1,044	1,122
Work	1990	485	466	0	0
	2000	494	476	0	0
Work-related	1990	29	11	83	14
	2000	14	9	96	33
Shop	1990	7	15	21	41
	2000	8	14	26	36
Other	1990	53	55	144	131
	2000	56	56	168	161
Travel	1990	88	77	101	78
	2000	90	84	106	87

Table 22.3 Average Commute Travel Time in Minutes for the Metropolitan Twin Cities (7-County) and Washington Regions by Mode

	Auto-1	Auto-2	Auto-3	Transit
Twin Cities region (home-based work trips)				
1990	22.6	23.1	24.2	32.9
2000	27.2	24.6	23.8	42
Washington D.C. region (home to work trips)				
1968	28.3	32.3	40.7	44.3
1988	29.6	31.6	37.8	43.2
1994	29.6	33.8	41.7	47

Source: Levinson and Kumar (1994); Levinson and Wu (2005).

Note: 1968 data, details in Levinson and Kumar (1994); 1988, 1994 data, details in Levinson and Wu (2005). (Differences in reported data for 1988 are due to minor differences in sample selection.) Data for weekday A.M. and P.M. peak period only, adults aged 18–65.

to labor. Further, while congestion is rising almost everywhere, roads in suburban areas are still generally faster than roads in urban areas. As a greater share of travelers uses the faster roads, the average overall speed rises. That hypothesis provides a mechanism for stability in commute times despite both rising congestion and longer distance commutes. The stability in commute times might be consistent with Marchetti's notions, since it is the longest trip which stakes out territory; the shorter trips typically operate within those bounds.

However, some data from other cities (e.g., the Twin Cities) show that commute times are increasing over time. Can that be reconciled with a commute budget notion? We recognize that larger cities do have longer duration commutes than smaller cities, if only because there are more opportunities (jobs) farther away that have some probability of being taken. Further, the equilibration process noted in the rational locator hypothesis, the movement of jobs and homes, also requires time. If there is a budget, which is on average at least as large as the commute times in the city with the longest commute times, then residents of smaller cities may not have consumed their travel budget yet, and travel could be expected to rise.

Mokhtarian and Chen (2003) suggest that the aggregate data mask individual variations. And although individuals may have personal budgets, those budgets are not necessarily the same. As different mixes of people comprise the population, the aggregate may shift, but if similar people occupy similar shares of the population, on average, the aggregate number will not move. The most important information for travel behavior analysis, the amount of time spent traveling, is ironically the least clear. There are, needless to say, many ways to interpret the data.

Profile: Yacov Zahavi

Yacov Zahavi (1979) developed UMOT (Unified Mechanism of Travel) in an effort to deal with supply and causal model issues. His first work was with aggregate data; before his death he began work on micro underpinnings.

With respect to causal argument, Zahavi notes that the travel money budget runs to about 12.5 percent of household expenditures for households that own cars, and it runs to about 4 percent for households without cars. He also observes time budgets (see Table 22.4a–f). His analysis brings these "demand" measures to the supply of travel facilities to yield travel information.

The data Zahavi musters have a "things are the same everywhere" character. Time and money expenditures are similar across nations, implying that participation levels are market clearing in the same way everywhere. Household aspirations and capabilities tend to be similar, as do opportunities.

Zahavi observes that the travel time budget ranges from 0.8 to 1.1 hours, and the TT/HH (travel time [TT] per household [HH]) is a function of household size and cars per household. As mentioned, the travel money budget (TM) varies between car-owning and noncar-owning households.

What did Zahavi accomplish? Zahavi starts with household income and size and the notion of a travel time budget. He examines the attributes of the supply of facilities. From these considerations, he calculates travel quantity measured in time, distance per traveler, and velocity dimensions. Time varies little. It is the daily travel distance that is

Table 22.4 Daily Travel Time per Motorized Traveler (hr)

(a) By income

	High	Low
Bogotá, Colombia	1.05	1.78
Santiago, Chile	1.09	1.52
Singapore	1.14	1.36

(b) By mode

		Car	Transit
Washington, D.C.	(1955)	1.09	1.27
	(1968)	1.11	1.42
Twin Cities	(1958)	1.14	1.05
	(1970)	1.13	1.15
All United States	(1970)	1.06	0.99

(c) By car availability

	0 cars	1 car	2 cars	3+ cars
St. Louis (1976)	1.06	0.99	1.05	1.06

(d) By household size and cars

	HH size	1 car	0 car
Nuremberg Region (1975)	1	1.22	1.41
	2	1.25	1.42
	3	1.28	1.36
	4+	1.27	1.35

(e) By days

		Survey day
Munich (1976)	1st day	1.15
	2nd day	1.16
	3rd day	1.16

(f) Total

Toronto (1964)	1.09
Calgary (1971)	1.11
Montreal (1971)	1.18

the main variable explained. His argument is very convincing from an empirical, among cities and households view. It gives satisfaction also because it is based on a utility maximization scheme. (As stated earlier, Zahavi had begun work on within-city relations, and first within-city empirical results are convincing.)

Put another way, households may be thought of as being in one state or another: with auto or without. The decision to shift from without to with is based on distance and not time considerations. More money is spent if the household has an auto, so money is traded for distance. What does the household gain from distance? That is the question, and its answer must have to do with access to more options for work, shopping, and so on, and/or opportunities to specialize.

Time of Day

When activities are undertaken is another key determinant in the need for transportation facilities. We typically observe peaks in travel demand on weekday mornings and evenings (as well as other times on select facilities: Friday late afternoons leaving town, Saturday afternoon on shopping streets). Figure 22.2 illustrates this information. From 1968 to 1988 there was a spreading of the peak in Washington; as roads became more crowded, people were willing to start work earlier or later.

But why does travel peak at all? A commuter could save travel time by leaving for work at 10 A.M. (or 4 A.M.), for instance. The first answer is that workers show up when their firms want them to. So why do firms want all of their employees at work at the same time? The reason that firms have for setting a regular schedule both internally for their employees and externally in common with other firms is an "economy of temporal agglomeration." A firm needs to coordinate activities internally and to deal with customers and suppliers at the time when both are open; this is all made easier if everyone is at work during approximately the same time frame. This does not apply to every organization: bars (which coordinate schedules to serve customers after work) may have later hours; police, who need to arrest rowdy bar patrons among others, must be on the job 24 hours a day.

This economy of temporal agglomeration has benefits that outweigh the congestion costs they impose. Programs to introduce flextime and variable work schedules have had some effect, but not enough to flatten out the curve at a regional level.

Yet the congestion effects are not small and, in the absence of road pricing, are not fully considered by the travelers who create them. The congestion externality drives capacity investment. Without peaking, major roadways would not need to be as wide; capacity would be more evenly utilized throughout the day. Pricing roads higher during

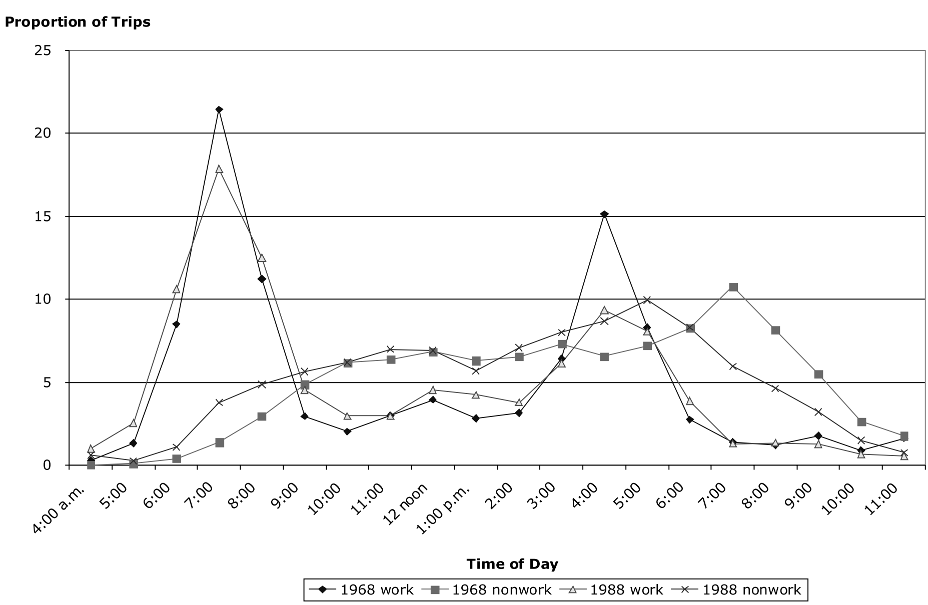


Figure 22.2. Diurnal curves for work and nonwork trips in Metropolitan Washington, D.C.

the peak hours (and lower during the off-peak) would provide incentives for travelers to consider whether peak-period travel was necessary.

Another point to note from figure 22.2 is that nonwork travel also peaks during the afternoon, only slightly after work travel. Many of the travelers at a given time are nonwork oriented. These tripmakers presumably have, in general, somewhat fewer time pressures than those making work trips. Pricing may provide sufficient incentive for trips with a high "elasticity of demand," or sensitivity to price, to move to an alternative time, smoothing out the peak and reducing the need for new construction.

In a sense, peaks in time (rush hour) are like peaks in space (downtown). Both exist to obtain economies of agglomeration—the ability to do business with others because they are nearby and open. Both produce costs, and make it more expensive for others to do business, but hopefully the gains outweigh the losses. Peak spreading is the temporal equivalent of suburbanization, without putting the same demands on creating new infrastructure.

Value of Time

The value of time varies by person, time of day, mode of travel, purpose (business or nonbusiness), and quality. Furthermore, it depends on the amount of time saved; the amount I am willing to pay to save an hour may be more than 60 times my willingness to save one minute. The condition under which time is experienced also affects how it is perceived, and thus valued.

Research to predict how time value varies for different components of transit trips suggests that time waiting at a bus stop is more onerous than time on the vehicle. However, the amount of that wait time penalty that is due to waiting (the lack of progress) and how much due to uncertainty (will the next bus ever arrive?) is an active area of research. Levinson et al. (2003) have conducted similar research for drivers waiting at ramp meters. Analysis of data gathered by placing subjects in a driving simulator and having them wait at a ramp, and then allowing them to drive in simulated traffic, suggests that not waiting at a ramp and driving in stop-and-go traffic may be worse than waiting at a ramp and driving in near free-flow conditions. On the other hand, a computer-administered stated preference asking questions consistent with those conditions suggests that ramp time is 1.7 times worse than time on the road. We still do not know as much as we should like on this subject.

There are a number of approaches to valuing travel time, ranging from utility theory to marginal productivity. The values range widely, for intercity business trips from $10 to $67 per hour and for nonbusiness trips from $0 to $45 (Miller and Fan, 1992). For freight transportation, Kawamura (2000) found a value around $26.80.

The Rise of Speed

The observation of a relatively constant time spent traveling (or traveling to work) despite rising distances notes that the speeds of technologies have risen significantly over the past centuries, since at least the industrial revolution. Speeds of modes have been getting successively faster, and while a particular technology may have an upper limit, soon (it seems to happen every 50 years or so, and by the graph below we are due) a new faster technology will come along. This is illustrated in figure 22.3, which primarily considers long-distance modes.

We can draw an envelope (which may be a macroscopic S-curve for all transportation modes), which is either continuing to rise (if rocket or other high-speed transportation takes off for transportation rather than just exploration), or leveling off, if the jet plane is the practical upper limit (and the Concorde story told in chapter 17 would seem to indicate that air transport is not getting faster anytime soon). The changes in short-distance transportation are not as stark (we can take out the fast air and slow maritime modes). Yet clearly the auto is faster than the horse-drawn carriage, which was faster than the pedestrian. Similarly, the metro (subway) is faster than the streetcar. We have observed that the speed gains over time are leading primarily not to time savings but rather to distance increases. Recall that speed equals distance over time. If there is not quite a budget, there is still a tendency that should be noted.

The ability to cover a longer distance enables greater access to "the country" (parks and farms) and larger yards. This increase in speed has been reshaping urban regions for over a century, and will be discussed in the next chapter.

The changes in speed are also among the dominant factors in mode choice. It was noted in chapter 11 that passengers for transit modes have been declining steadily. One reason is that rising income enables people to buy cars, but the reason people want to buy cars is that they are faster. At best rail transit or bus rapid transit (bus on HOV lanes) are faster in the very specific corridor they serve, but unless travelers have their origin and destination on top of the corridor, it is likely that the costs to access and egress the transit system will be high. In contrast, cars are parked at home, and for the vast majority

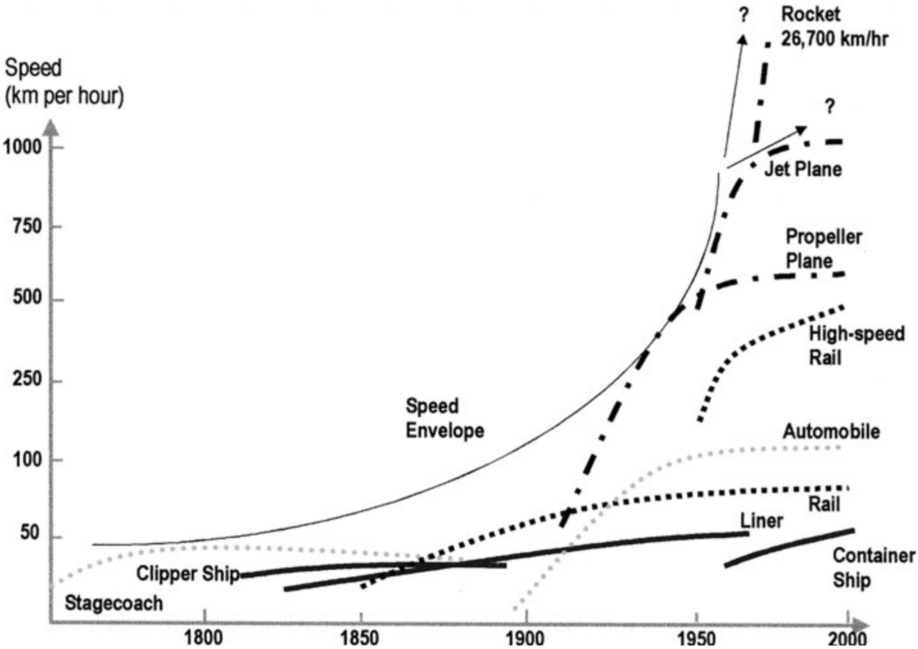


Figure 22.3. Operating speeds for major transport modes, 1750–2000. (Source: Rodrigue, 2002.)

of U.S. residents at least, can be parked very close to the final destination. Time, which includes time in vehicle as well as access, egress, and waiting time, is the main measure of convenience, and is central to all travel choices. It explains some of the difficulties with getting people to carpool. If individuals have different home or work locations, a carpool requires at least one of the parties to go out of their way to pick up or drop off another. The time savings on the long-haul part of the trip must be significant to overcome this inconvenience.

The Need for Speed

The simplest explanation one can give for the need for speed is that value of time is proportional to income. As incomes rise, the disutility of time expended in travel is greater. Travelers need speed to decrease the time wasted in travel. Similar reasons apply to freight transportation: higher valued goods, just-in-time inventory systems, and higher real wages to vehicle operators are manifestations of the issue.

Such explanations are quite satisfactory to many. They are simple, and that is a virtue. They also allow the analyst to go one step backward in the reasoning. In the case of the value of the individual's time, for example, one can cite the relations between the wage rate and the value of time, reasons for higher real wages, and so on.

Yet speed is being consumed not in time savings, but in distance. This phenomenon of induced demand is explained in box 22.3. The trend is toward lower residential

BOX 22.3 Induced Demand

Transportation forecasts often implicitly assume that demand does not respond to capacity increases. Yet when capacity is added, drivers switch routes, times, and modes to take advantage of the more desirable capacity (Downs, 1992). When capacity is taken away, or congestion rises, people divert from those routes, the peak spreads, and use of alternative modes (which are not caught in the same congestion) increases. After some time, people move or change jobs to take advantage of new infrastructure or to avoid rising congestion. As transportation professionals, these shifts are what we want and expect; otherwise, why would we build new capacity, or have any hope for policy? Capacity (highway or transit) may be added for multiple reasons. It is often sold on "congestion relief," that is, this piece of infrastructure will save existing commuters time. It may further be promised as opening up areas for development or redevelopment (the latter being especially important for transit promoters). However, the issue of transportation doing what it is supposed to (that is, move people quickly between two points) creates problems for those who value the negative externalities of travel (pollution, land consumption) more highly than the benefits of transportation. They ask whether capacity expansions provide net costs or benefits to society, as additional travel generates negative externalities.

Figures 22.4 and 22.5 show the theory behind induced demand. When time is saved in travel, it can be used for more activities, as shown in figure 22.4, as total time must remain fixed. However, time saved in travel for one trip may be used for more travel in another trip (or to another destination); this is shown in figure 22.5.

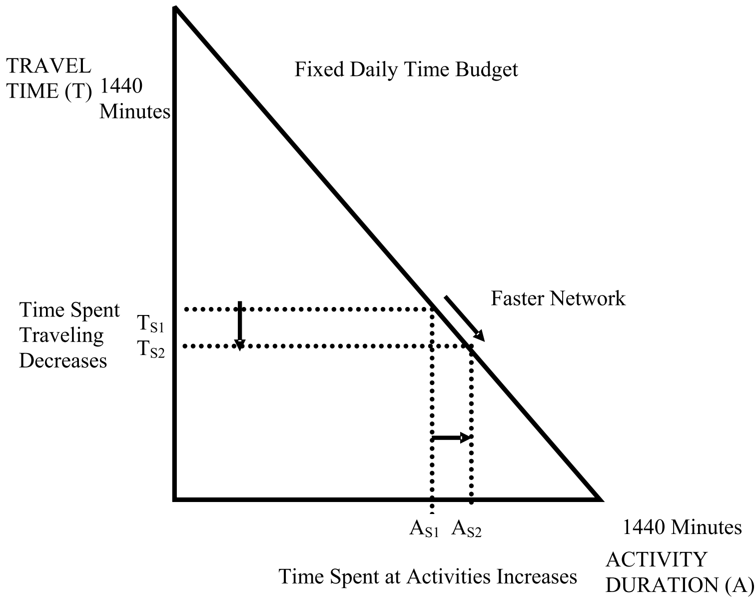


Figure 22.4. Time spent at activities versus time spent in travel.

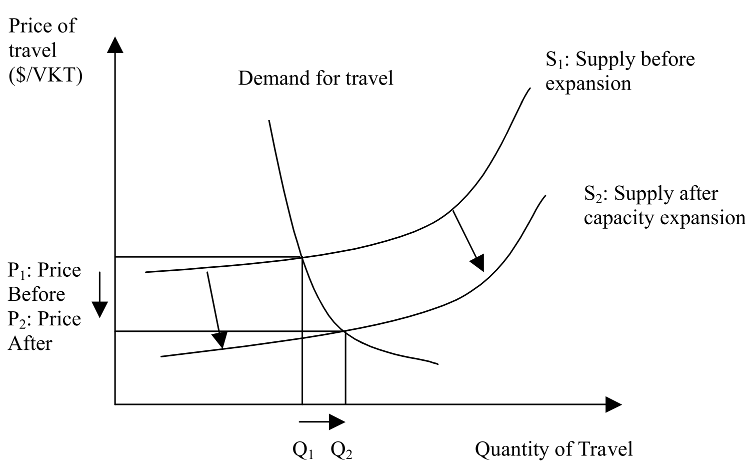


Figure 22.5. Classic induced demand curve.

densities within cities, at regional scales, and at sites of activities. We see more space consumption per person both at home and at work.

Perhaps the better explanation is that specialization of activities and places is enabled by higher speeds, and is a source of higher incomes. So there is a positive feedback loop: specialization → income → speed → specialization.

This loop, while positive, is not exponential, rather it may have limits. Consider the marginal velocity gain that early automobiles gave over horse-drawn vehicles, say, from 8 to 24 km/hr (5 to 15 mph). That 16 km/hr (10 mph) added to, say, 88 km/hr (55 mph) hardly compares in the magnitude of relatives. But we also observe that there is a geometric relationship at work. In a simple form, we observe the increased quantity of space accessible as the radius of a circle is increased. Here, we would think of the radius defined by velocity. How far can we travel in some amount of time? As speed tripled from 8 to 24 km/hr, time spent traveling 1 km dropped by 5 minutes from 7.5 minutes to 2.5 minutes. As speed increases 16 km/hr from 88 km/hr to 104 km/hr, the time drops from 41 seconds to 35 seconds—a mere 6 seconds—which hardly seems worth discussing.[1] There are diminishing returns to our positive feedback loop, and they may be at work at the urban scale.

Now, consider the problem of structuring causality. We could just as soon say that higher velocities result from the desire to use more space as to say that they result from higher incomes. Furthermore, we could tie the specialization trend to either of the bases for causal reasoning. What is the bottom line from this discussion? We need to engage in empirical work exploring causal models. That work would make a difference in practical affairs and could guide planning.

Suppose we want to engage in research tied to the higher velocity trend. We have some alternative technologies in mind, for example, using high-speed rail as one building block in a system or using high-velocity automobiles as a building block for another system.

What to do? Unless we can be wise about the causes of the velocity trend, there is little to guide us. If it is more space that is at issue, then perhaps line-haul velocities are not as important as collector-distributor ones (that is, we want to make our areas that can be accessed work more like circles). If the issue is the higher value of time, then we might want to look at some places where velocities are low and where marginal changes will make a big difference (a difference like that which the Model T made over horse systems). Eliminating waiting in the system, places where the speed is zero, is a good place to start.

Discussion

Friedlaender (1965) found the interstate to be a good investment because it saved time overall. She noted that urban efficiencies offset the high cost of time saving by rural travelers. Yet we suggest that that ignores all of the externalities and effects of the urban freeway, discussed in chapter 14. Simply considering time forgets the human cost of those displaced and replaced as the urban freeway restructured the urban activity system.

Still, a time calculus is very handy for transportation analysts because often faster is better and the time value of capital and labor is considered when designing facilities, buying equipment, and such. Prior to the interstate, road improvement calculations ran on the savings in equipment cost, usually just wear and tear. (The UN and pavement engineers still use such calculations, ignoring the effects of their designs on users' time.) Facility maintenance cost was also considered. But even without traffic, pavements experience wear due to weather.

The consideration of time for users is critical in understanding the reason we have transportation. As one of the opening quotes said, "He who wastes my time takes my life." To argue against transportation improvements because they "induce" more demand is to argue against transportation projects because they do what transportation projects are supposed to do, connect people with their destinations. It would be instructive to compare the lives cost by the additional pollution generated when a new project is constructed with the lifetimes lost stuck in traffic, or the opportunities lost stuck at home.

Deregulation, increased specialization of transportation services, and developments in communications and control are enabling changes in procurement and distribution to which we have attached words such as "just-in-time manufacturing." Deregulation has been important because shippers, and customers can now bargain with transportation carriers and suppliers. Logistics managers consider inventory costs, size of shipment, and many other things. As with any transportation changes, there are two impacts. The first is the reduced logistics cost (doing the same things faster and cheaper). The second is the improved quality, resulting from an increased variety of goods and services offered by both being able to reach new markets and being able to do new things. The explosion of logistics activities and the reshaping they occasion serves as a model for changes in the ways people live and work.

Our discussion above described schedules in the late twentieth and early twenty-first centuries. The status and future of such scheduled living is at question because of the changing nature of work, improved communication, and other things. The requirement to work (play, learn) at an appointed place and time lessens as intellectual capital replaces physical capital as the standard. The web and the wireless are much less cruel taskmasters than the factory and the field. As life in the advanced countries becomes more flexible, the rigor of the weekday becomes weakened and the schedule flexibility of the weekend becomes the daily norm. Freedom is achieved when citizens regain control of their schedules. There is an important corollary: freedom is lost when schedules are tightened.

23

Land

If the universe is expanding, why can't I find a parking place?
—Anonymous

Introduction

In 1950 the National Capital Planning Commission proposed an outer circumferential freeway (Outer Beltway) for the Washington, D.C., area. This beltway was to fall beyond the radius of what later became the Capital Beltway (I-495/I-95). Importantly, the Outer Beltway was placed on land use maps, so that residents would know where the right of way of this route was to be. Local government began to acquire the land in the right of way of the road so that it would be preserved.

However, some parts of the Outer Beltway appeared incompatible with local land use plans, in particular building new roads through an area designated as rural. Further, Virginia residents in the wealthy district of Great Falls opposed the interstate highway in their neighborhood, where the bridge would land. Thus, in 1968 the Maryland National Capital Park and Planning Commission (a bi-county agency serving the Maryland suburbs, and distinct from the National Capital Planning Commission) took sections of the Outer Beltway connecting what become I-270 with Virginia off the map. Still, the sections connecting I-270 in Montgomery County, Maryland, with I-95 (and nearby U.S. 1) in Prince George's County remained on the plan, and were renamed the Inter-County Connector (or ICC—not to be confused with the former federal agency of the same letters). This is about a 29 km (18 mile) highway, depending on the final right of way chosen.

> Near the New Hampshire Avenue interchange, Maryland Governor J. Millard Tawes cuts a ribbon officially opening the Capital Beltway around Washington, DC. He calls it a "road of opportunity." Administrator Rex Whitton calls it a "huge wedding ring for the metropolitan area" while Representative Carlton R. Sickles (MD) makes the day's briefest speech: "I'm so happy, I can't express myself."
>
> —*FHWA By Day*, August 17, 1964 (U.S. FHA, 2004)

The Capital Beltway was completed in 1964, and by 1979 transportation officials were beginning to seriously consider the ICC. The Maryland State Highway

Administration (SHA) initiated the first of two project planning studies for the ICC. By 1983 the first Draft Environmental Impact Statement (EIS) was issued and public hearings were held. A small section of the road, I-370, connecting eastward from I-270 to the Shady Grove Metro Station, was constructed; however, budget and environmental issues kept most of the road as proposed.[1]

Another study took place in the 1990s, and in 1997 the SHA issued a second Draft EIS. But the road remained controversial. The opinions of residents were mixed; some sought the road to relieve congestion, others opposed the road for its environmental impacts, in particular its crossing near the headwaters of otherwise protected stream valleys (the road runs east–west, most streams in Montgomery County run north–south). Proponents claim "The ICC is not about promoting *tomorrow's* growth—it's about providing for *yesterday's* growth."

The Army Corps of Engineers, which regulates wetlands, was a major player in the EIS, and proposed a number of new alignments for consideration that were not in the master plan right of way. Their objective was to protect the streams, and the spawning grounds of German brown trout, which were introduced at the beginning of the twentieth century and now reproduce naturally.

The additional rights of way greatly increased opposition, as now more people would be affected by a possible road than previously; moreover, people had bought land and homes believing they would not be affected by the road because of Montgomery County's longstanding practice of building roads at the place they were on the plan.

In 1999 Maryland Governor Parris Glendening halted the ICC planning study and canceled the middle section of the road, while keeping the eastern and western portions on the map. "I will not build the Inter-County Connector. As far as I'm concerned there is no ICC."[2] His "Solomonic" decision did not have the effect hoped for (killing the road). Democratic Lt. Governor Kathleen Kennedy Townsend, running for Governor when Glendening's term expired, was more politic: "If I had an answer, I'd give it to you. . . . But with the legal impediments to the ICC, you have to cut your losses and build all of these other roads."

In 2002 Townsend lost to Republican Robert Ehrlich, a road proponent. A third Draft EIS is being conducted by the SHA, which, under Ehrlich, has made this Maryland's highest priority new project. The federal government has promised to fast-track the environmental review process.

The road, on the map for 50 years, in serious consideration to move forward for 25 years, remains on the map, and on a map more complicated than previously. This is not because of a lack of information, or a lack of public participation, but because of a lack of political will and *paralysis by analysis*. If you can't win on the facts, you propose another study. As researchers, we think that studies and information are good things, but studies should not be used to justify, rather to inform. It is the decision makers who must decide.

Like time, land uses and is shaped by transportation in several ways. Foremost, *transportation creates access*, and by creating access, transportation embodies that land with value. Second, *transportation consumes land*; it does this for the linear facilities themselves (roads and rail networks) as well as the nodes (ports, airports, and parking). In urban areas, the land devoted to parking is surprising. This is a cost of transportation facilities, but it is paid for during construction. Box 23.1 looks at the issue of parking, which is a microcosm of transportation land issues. Third, *transportation causes negative externalities* for those who are adjacent to facilities, including noise, pollution, the potential for fire (from steam-powered trains), and severing communities (both human and ecological) along their routes.

The debate about the Inter-County Connector touched on all three issues, and basically asked the question "Does the improved access offset the negative externalities?" Proponents would argue that the negative externalities from the road are offset by reduced negative externalities on other routes. Opponents would argue that the gain in relative accessibility in Montgomery County is offset by the loss in relative accessibility to places not on the route. Further, the road would encourage workers in Prince George's County to work in Montgomery County (thereby making the rich richer, since Montgomery would get jobs without the cost of supporting residents). How these qualitative arguments balance quantitatively depends on where you sit.

This chapter considers transportation's use of land, the conflict between land for access and land for activity, the access created by transportation, and the capitalization of that access into property values in turn.

"Right of Way"—Land as an Input to Transportation Services

Consider early roads, trails, ways, and river or beach landings. Services were ubiquitous and suited the traffic. A "way" was a zone along which the public had right of movement, the right of way. It was a path that, perhaps, shifted seasonally and was suitable for people and their pack animals, as well as other animals walking to market. "Way" describes many routes (Webb and Webb, 1913; Lay, 1992).[3]

A "way" is important, but as property rights are established, one needs a "right of way" in order to build a transportation system. What was government's involvement in obtaining land, what did government learn, what policy evolved?

Property conflicts occurred as landowners sought to fence property for field crops and restricted the amount of way available. In many places the abutting property owner had an obligation, but little incentive, to maintain the road.

The idea of a way emerged in the United States when the Midwest and plains states were being settled. The government retained title to mile-wide strips (sections). These sections would be used as ways for long-distance movement, an important matter when animals walked to market. TV westerns often featured conflicts between cattle drives and settlers in their plots.

Turnpikes and canals required land being taken by trusts and firms. These were typically small undertakings. The enabling acts passed by central governments endorsed local agreements and contained details on the land to be taken and prices to be paid. Large landowners typically were actors in the promoting organizations, and would not use land ownership to hold up or block development.

We have some evidence that the tramway land-taking problem was more difficult, perhaps because mine and transport operators were often not part of the landed gentry. For example, the first charter for the Stockton and Darlington (the tramway charter) was requested in 1819 but not obtained until 1821, and the delay was because of opposition by the local hunt.

BOX 23.1 Free Curb Parking, or Who Controls the Roads as Commons?

Does prohibiting parking in neighborhoods respond to objections to the "outsiders using the roads we labored to provide" theme reported by Webb and Webb (1913) when they discussed outsiders using roads improved by local farmers—the situation when commerce was increasing and the toll road movement had not yet flowered? Is the concern that of protecting local communities from outside merchants and other influences as reported for Rhode Island when toll roads were proposed (Jones, 1990)?

In his "My Own Private Idaho," Steven Gofman (1997) used the subtitle "Staking Claims to the Public Streets." For years public streets have been just that, public, and rights to use have been highly valued, and Gofman asks why the turnaround, why are local residents now able to take public or communal property (streets) for their private purposes? He reviews court cases and highlights a 1977 Supreme Court decision that is taken to allow almost any resident-only parking program on the theory that such programs reduce air pollution.

That is interesting, but is reduced air pollution the motive for residents promoting restricted parking? Does restricted parking increase transit use and decrease emissions from vehicles? If it does, why are residents generally able to purchase parking permits for their visitors? Does restricted parking exercise local residents' feelings against commercial or other traffic attractions near their neighborhoods?

Being interested in property rights, Moshe Adler (1985) has made the case for streets as communal property. He observed that streets become semiprivate when residents implement restricted parking programs, and they have a private aspect when driveways require curb cuts and take space that could otherwise be used for parking. There are variations on communal and semiprivate when time limits on parking are applied and when parking rights are restricted to neighborhoods or are applied citywide.

Adler imagines a traffic destination (shopping, religious, school, or employment center) where there is parking spillover into neighborhood streets. As a matter of policy, is it in the public interest for those streets to be private, semiprivate, or community property? Adler observes that welfare is maximized if streets are regarded as communal property and used by nonresidents for parking. To engage in activities at the center, nonresidents have driven some distance and that effort implies the values that they place on parking. Unrestricted parking allows society to realize those values.

Donald Shoup (1999) argues there is no such thing as "free parking" and asks for cost-based parking fees or "cash out" payments, say for employees who do not use the company parking lot. He suggests that by giving control of on-street parking to neighborhoods, revenue can be raised for many neighborhood public goods such as street landscaping.

The London and Birmingham posed a new problem. It was not a local undertaking: Birmingham businessmen largely promoted it. It was strongly opposed by the owners of canals serving that market and points between. Its enabling Act could not be an endorsement of proposed deals. It said that market value would be paid for land and treated the matter of partial takings. This protected investors as well as those whose property was taken.

That is what the enabling Act said, but there is a good deal of evidence that acts were obtained by buying off opposition. In an address to the British Institute of Civil Engineers, Stephenson remarked (with perhaps some rhetorical flourish) that the costs of obtaining the enabling Act for the London and Birmingham was not much less than the cost of constructing the entire line. He remarked (in Smiles, 1858, p. 471), "Great was the ingenuity of the agent who discovered the use of the word SEVERANCE," and went on to call it a system of "spoliation, permitted by Parliament."

If the opposition could not be bought off, the railroad had to avoid the property. That requirement caused the building of long tunnels on the London–Birmingham and building the Liverpool–Manchester through the Chad Moss.

Two things seem to have muted the conflicts between rural landowners and the railroads. First, with experience, rural landowners found that railroad construction was to their advantage, and began to try to attract routes. For instance, Lords Derby and Sefton, who, by their opposition, had forced the Liverpool and Manchester through the Chad Moss, became patrons for a rival line, on the condition that it would pass through their property. Chad Moss, which had been worthless, suddenly became valuable.

The second matter is the productivity improvements the railroads offered. They could afford to pay "through the nose," if needed. The profits were there.

The construction of railroads into cities posed very difficult property-taking problems. The railroad map of London, for example, shows that railroads were unable to penetrate into the urban core and that the railroads were more successful in taking land from the poor and powerless than from the rich. (Workmen's trains were one consequence. The poor had to move to the suburbs, and were given low-cost commuter trains.)

Conflict Between Land for Access and Land for Activity

The situation yesterday was no different from today. Many of today's urban transportation problems, such as the location of the Inter-County Connector, are conflicts in the location of fixed facilities. For example, debates about roads, docks, and airports stress undesirable visual, noise, and air pollution; congestion spillover to adjoining areas; destruction of neighborhoods, and so on. What did we learn from the railroads when the conflicts being debated were between people and their possessions and activities and the new kid on the block, the railroad? Not much!

Every city has its own story, and much that is in these stories is idiosyncratic. The influence of city morphology differed because of site differences among cities, and there is a contrast between those cities that were well established prior to the coming of the railroad and those where the turf was not so occupied. The conflicts differ by facility type: passenger and freight terminals, yards, routes, facilities such as shops, and so on. Finally, the situation changed with time. Some railroads invaded cities on public street property. Electrification was pushed by the need to use tunnels and the problems with urban environments, as in Baltimore and Paris and, later, New York and London. The "rail terminal problem" is a longstanding consequence of this situation.

As a result of differing temporal and morphological situations, the literature tends to be city specific. One can find multiple books on London and Chicago. Chapter length discussions often appear in rail or city histories. Many cities have studied location problems, penned reports, and have sometimes taken action. Simmons (1986) treats places large and small in England. To compress his remarks on London:

- Railroad passenger facilities penetrated into the city in varying degrees. During the 1830s, only three of six went well into the built-up area, and only one placed its terminal within the Corporation of London, the City proper.

- Construction was costly, and additional costs were incurred as traffic grew. Fragmented land ownership was especially a problem.
- Many small properties were demolished and "the process . . . was generally thought salutary in clearing away noisome dwellings that fostered disease and crime" (p. 32).
- Viaducts and cuttings became barriers.
- Replacements for housing demolished became a requirement in 1874 as did compensation to those forced to move. However, these requirements were not enforced very well.

Facilities were needed for car storage and sorting, transshipment of less-than-carload-lot (LCL) traffic, teaming yards, and access to large shippers. Although it was very demanding of land, little is said in the literature about freight transport conflicts in cities. In many cities, long viaducts were built across yards. These were a precursor experience for limited access highways. Pressure was exerted to elevate or tunnel heavily used routes. This was a force for the electrification of railways. Many cities wanted "union stations." In the absence of union stations, interline transfers were arranged in difficult ways, for example, through the use of the Underground in London and through circumferential rail routes in other cities. Yet the rail experience did not influence other urban facility policy, such as freeway policy, as strongly as it should have.

Opportunities to improve facilities and take advantage of improved and larger vehicles emerged (see chapter 12). A critical point is the changing relationship between fixed facility costs and operating costs. Costly but more efficient and higher quality facilities emerged—seaports and airports, limited access roads, and carefully engineered rail facilities, subways, and elevated transit. Nowadays the rule is to achieve lower door-to-door travel times, carry heavier loads, go safely with less stress, and save money.

Traffic has been concentrated and accommodating that traffic has required land—land for container and bulk shipment ports, for multilane freeways, and for airports and railroad yards. Graceful abandonment and reuse of land has generally not been achieved.

Concentration and growth of traffic has also deepened issues of externalities: noise, air pollution, and so on. In principle, one can tunnel for highways just as one tunnels for deep subways. Disruptive cut and cover is not required. Gerondeau (1997) describes French highway planning taking advantage of tunnels (segregated to separate cars and trucks, and thereby allowing more vehicles in less volume) linking districts of Paris, for instance, being used on the Paris beltway (orbital expressway A86). A similar suggestion for the widespread use of small tunnels was discussed by Garrison (1974).

Externalities, especially those generated by traffic, make transportation land use undesirable for neighbors; construction of facilities has its downside also. Dust, mud, noise, and disruption of traffic have their costs. Sheriff (1996) points out that the construction gangs and others associated with the building of the Erie Canal were not good neighbors.

We need to improve our ability to remember and use experiences. The rail experiences in urban areas continued through the decades. Problems did also, and many remain today. New construction is not so much at issue today. But there remain local issues of routes around cities, consolidation of terminals and lines, noise and congestion at yards and terminals, grade separation, and the provision of workmen's trains (today's commuter service). Still, with respect to land taking and environmental insult, the highway designers failed to learn from the rail experience.

The Urban Wheel

Concerns about decentralization and accessibility to the central business district (CBD) have long dominated urban transportation planning. Wheel-like radial routes and circumferential routes have been seen as the facility need. The concentric circle theory of urban form consistent with these notions affected urban freeway planning.

Wheel-like language described the streetcar city of 1920 very well: at the hub lies the CBD, arteries of transportation radiate to the rim where housing is found. But "what is" became "what ought to be," that is, descriptive language became normative language. Plans began to prescribe radial routes and circumferential routes.

Daniel Burnham made the "normative wheel" the theme in his work, and seems to have been most responsible for the normative leap. In the general theory section of his 1905 study of San Francisco, he noted that the finest examples of cities of the old world (Paris, Berlin, Vienna, Moscow, and London) consisted of concentric rings separated by boulevards, with the smallest ring (inner circle) around the civic center. From the inner boulevard ran diagonal arterials. Having presented his findings about the finest European cities, he said, "It is on this study that the proposed system of circulation for a larger and greater San Francisco is based."

Ten years later, Werner Hegemann, a leading German planner who at one time worked on Oakland and Berkeley, undertook a critique of Burnham's theory. Burnham had given credit to Eugene Henard's (1905) study of Paris. Indeed, he used Henard's figures in his report. Hegemann and Peets (1922) pointed out that Henard was dealing with the deficiencies in the Paris circulation system; his was hardly a scheme to be emulated. He went on to say that concentric boulevards were the result of the elimination of city walls as medieval cities expanded; radial streets started out as paths from outside the city through city gates.

Hegemann did not reject concentric boulevards completely. He saw an inner concentric boulevard as distributing traffic downtown. Also, he thought radials were desirable. Henard, who advocated traffic circles, pointed out that blocks formed between radial streets gradually shrink as radial streets approach the center of the city. This creates problems.

There is more to Hegemann and Henard's works, and no one would say that either writer claimed a complete theory of streets and circulation. Burnham did, and he influenced U.S. practice.

Burnham represented "city beautiful" thinking, and one might think that the rise of the "city practical" movement would have questioned Burnham's construct. It did not. Thomas MacDonald looked to Paris for inspiration, and referred in 1937 to competent French engineers having planned a circular highway enclosing the city and radial arterials; the underlying soundness seemed self-evident. Following MacDonald, the 1957 AASHO policy on arterial highways in urban areas referred to a wheel-like basic pattern.

By 1950 there were three widely known theories or generalizations about urban form. Ernest Burgess's *concentric zone theory* (1925) argued that cities grow outward in concentric circles through a process of invasion and replacement. Jobs and other central city functions would be located in the CBD, and these rings were the product of a competitive economic process. The rings were the commercial center, the zone of transition, working-class residences, middle-class residences, and the commuter zone.

In contrast, Homer Hoyt proposed *sector theory* in 1939. Each sector, or wedge, of the city would have different economic activities. Hoyt made specific predictions of which type of activity would show up where in the city.

Harris and Ullman (1945) suggested the polycentric or *multiple nuclei theory.* They noted that cities do not always have a single center, but many mini-centers. Because of economies of agglomeration, similar activities group together in these mini-centers.

The wheel metaphor seems most compatible with the concentric circle theory. Examining freeway plans, Horwood and Boyce (1959) compare three cities and their radial, circumferential, and enclosed cellular areas. They make no normative claim for wheel-like designs.

Today, there are two approaches to urban morphogenesis. One is an urban modeling approach in which rents and market activities steer toward a unique equilibrium pattern of activities. The other acknowledges increasing returns and the kinds of processes studied by George Polya in the 1930s (Arthur, 1990).

The Land Value Metric

Transportation makes it easier to reach places. A transportation improvement may increase the value of a site for production (decrease the costs of consumption), that is, increase its economic rent. Thus we expect that land value reflects the benefit with a higher market price.

There is longstanding interest in measuring development impacts by observing land value changes. Speaking of a road opened in 1756, Rev. Arthur Young observed, "It was no sooner completed than rents rose from 7s. to 11s. per acre; nor is there a gentleman in the country who does not acknowledge and date the prosperity of the country to this road . . ." (1813, p. 418). Today, improved analysis techniques are aiding estimates of land value changes (Anas and Armstrong, 1993), and value capture to aid infrastructure financing is an attractive option to public agencies short of funds. Value capture dates at least from port financing efforts when French royalty first strove to develop colonies and expand maritime trade (Konvitz, 1978).

The theory is simple in outline—all other things being equal, land derives value from its location. A change in transportation costs thus has a direct affect on the location-derived value of land. That simple mechanism is attractive to analysts. It fits very well with the view that benefits may be measured as user cost reductions.

Analysts armed with benefit–cost or similar ideas are cautious about claiming more than user cost savings. That is partly because of the experience as the interstate highway system was constructed. Many studies were made under the rubric "highway impact." They were motivated by the notion that increments in land values might be captured to aid in financing the interstate (U.S. Congress, 1961). While impacts were often indicated, these tended to be modest, and there were double-counting issues—counting both user cost savings and increments in transportation rents. Critics of study designs and workers concerned with theory stressed that what was mainly observed was the shifting of development from here to there. That is, development, which would have happened somewhere, was focused on areas proximate to newly constructed facilities (Mohring and Harwitz, 1962).

The same story holds for urban transit development. Analysts have long known that as deployment winds down, development impacts are modest. Edwin Spengler found in his 1930 study in New York City that trends overrode impacts. If an area was declining, it continued to decline as transit service was improved; stagnant areas remained stagnant; and growing areas continued to grow. Spengler's findings appear almost word for word in Walmsley and Perrett's review of the situation (1992, p. 127). Other studies tracing transit development impacts have managed to find them, yet they are small (Knight and Trygg, 1978). To magnify impacts, cities are encouraged to use zoning and other tools to concentrate development at transit stations (Garrison and Deakin, 1992).

As stated, the transportation rent–land value notion is simple, but in real world contexts there are the workings of land markets, agglomeration economies, and historic path dependence. It is partly for these reasons that Mohring (1993, p. 267) remarks that very little can be said "unless a great deal is known about . . . [households and] . . . the production processes of business firms."

Yet, we can show that the value of land is intimately tied to its accessibility to other pieces of land and their associated activities. If a transportation or land use change enables people to reach activities that are more desirable in less time, then the value of their land increases. Hedonic theory suggests that individuals do not purchase goods, but rather the bundle of attributes composing the good. Someone does not buy a house, but rather the qualities of that house: location (accessibility), size, type of construction, appliances, noise from nearby roads, and so on. Every house combines the various attributes slightly differently. Hedonic models are used to pull apart these attributes, and develop demand curves for the various attributes (goods or bads). However, these attributes are interrelated; houses with high accessibility will be more expensive, which will lead to more investment in other attributes, leading to better maintenance and more frequent remodeling.

The hypothesis of the standard urban economic residential location model, that individuals trade housing costs for transport costs, has been tested in numerous studies. *Ceteris paribus*, housing prices decline as one retreats from the center of the region (the location with highest accessibility) (see box 23.2).[4]

Land rents influence land uses because the market asks that land be put to its highest and best use—uses have to pay the rents. From this observation we derive the notion that transportation improvements may change patterns of land uses. Some years ago, Garrison and colleagues (1958) engaged in extensive analyses of this proposition. Economies of agglomeration, central place theory, and some of the other processes bearing on land use patterns were considered. The general conclusions were (1) patterns did change and (2) benefits were present (termed reorganization or structural change benefits), although they were not easy to measure.

Although the term "reorganization benefits" did not come into wide use, the ideas that one pattern of land use may be better than another and that transportation improvements might change land use patterns remains popular. We hear that transit investment will yield "better" land use patterns than will highway investment. Of course, better is in the mind of the beholder. We have some difficulty with the notion that the station-focused accessibility of transit improvements would produce a better stage for the running of consumer sovereignty than the more diffused theater given by highway investments.

BOX 23.2 Accessibility and Land Value

Accessibility measures the ease with which activities can be reached. It increases with the number of destinations that can be reached at a given distance (travel time) away, and it decreases with travel time. A typical formulation is given below:

$$A_{im} = \sum_{j=1}^{J} O_j f(C_{ijm})$$

where A_{im} = accessibility to opportunities from zone i by mode m;
O_j = number of opportunities (employment, residences) in zone j;
$f(C_{ijm})$ = function of cost/time between zones i and j by mode m.

The equations below show the impedance function for a work-trip gravity model estimated for metropolitan Washington, D.C. (Levinson and Kumar, 1995c). Thus, the greater the travel time, the smaller the value of f. For auto trips ($r^2 = 0.94$, $N = 19$):

$$f(C_{ija}) = e^{-0.97-0.08C_{ija}}$$

For transit trips ($r^2 = 0.98$, $N = 19$):

$$f(C_{ijt}) = e^{-1.91-0.08C_{ijt}+0.265C_{ijt}^{0.5}}$$

where C_{ija}, C_{ijt} = peak hour travel time between zones i and j by auto or transit.

Below we predict the average sales price of houses by traffic zone, computed from the Montgomery County, Maryland, Sales Transaction Automated Recording System (STARS) as maintained by the Montgomery County Planning Department. No adjustments for the size or quality of the home, aside from it being single family (attached or detached), are made. The independent variables are the auto and transit accessibility to houses and to jobs by traffic zone as computed using the methods described in Levinson (1998). Here we consider competing houses (workers) as a factor. In theory, if jobs and houses were uniformly distributed, the positive accessibility value of an additional job would be offset by the negative accessibility value of an additional worker (house) who might also take that job. This analysis considers job accessibility and housing accessibility for each traffic zone at both the origin (home) and destination (work) ends of trips.

The OLS regression shown in table 23.1 suggests that higher accessibility by auto to jobs is associated with higher home prices. Individuals will pay more for homes if there are more opportunities (and, therefore, shorter average commutes). Similarly, accessibility to other houses resulted in lower home prices, as they can be viewed as competition, and reduce the value of accessibility to jobs. These findings support the standard model; however, the overall r^2 of 0.28 suggests that other factors unrelated to location also influence the price of housing.

Table 23.1 also shows the elasticity of home values to changes in accessibility. Taking \$198,000 as the mean home price in 1991, a 1 percent increase in origin job accessibility by auto increases home price by 1.6 percent or \$3,168. The ratio of the coefficients of housing to job accessibility is –0.52, suggesting that each additional unit of housing accessibility is not as detrimental as each additional unit of job accessibility is positive.

(continued)

BOX 23.2 Accessibility and Land Value—cont'd

There may be offsetting benefits to being near other housing; it implies nearness to schools, church, friends, family, and shopping.

The transit data are contradictory, however; the higher the job accessibility by transit, the lower the average price. Given the relatively low transit share, nearness to transit may be viewed as a negative attribute, just as transit as a mode is not always seen favorably. Alternatively, transit accessibility may be a surrogate for other factors (age of housing, crime rate, etc.) that were not captured in this brief analysis. Accessibility by transit to housing was not statistically significant.

Table 23.1 Regression to Predict Mean Housing Value (in Thousands of Dollars)

Accessibility to	Mean	Coefficient	*T*-statistic	Elasticity of home price
Housing by car	39,460	–0.0032	(–2.73)	–0.638
Housing by transit	1,647	–0.0134	(–0.66)	–0.111
Jobs by car	52,857	0.0061	(9.23)	1.628
Jobs by transit	3,290	–0.0278	(–3.11)	–0.462
Constant	1	134.33	(5.12)	
Sample size (N)	279			
r^2	0.28			
F	28.28			
Significance of F	0			

Reasoning from the dynamics of transportation system development, the expansion of today's transportation infrastructures would not be expected to have much impact—the developments triggered by investments have already run their course. To put the matter at the extreme and use an overworked metaphor, observing land value changes is similar to observing the deck chairs sliding on the sinking *Titanic* and measuring changes in their comparative (location) advantages.

Discussion

Some difficulties in transportation modes obtaining right of way arise from the resulting negative externalities. An externality is an effect that occurs to a third party. While the railroad and its passengers engage in an economic transaction, an externality (positive or negative) is what happens as a result of that transaction which befalls other individuals. The gains in accessibility must offset the costs, including environmental costs.

The discussions above imply some conflicts between transportation and the environment, and a few instances were mentioned. Trains were dirty and noisy compared to previous modes, and they were broadly disruptive of previous ways of life. Highways bring construction, which disturbs parks, and cars, which spew filth into our skies.

Siddall (1974) argues that as something new, railroads were viewed as an environmental insult. Later, they were accepted as part of the landscape. Siddall remarks on landowners' opposition to canals, "the thought of having their land cut through and separated by canals was far from appealing to them." He goes on to say, "In general, though, the canal was soon appreciated as an attractive addition to the landscape . . . 'these stately roads,' as Wordsworth . . . called them."

With respect to railroads, he goes on to refer to a "torrent of opposition in England." It is not clear how much of this opposition was related to disruption of the natural environment and how much was addressed to the broad changes induced by the railroad. Charles Dickens, for example, was very antirailroad, as noted in chapter 6. Elsewhere, he complained about smoke and noise. Siddall traces how complaints gradually declined, and how the railroad was gradually accepted as part of the rural landscape.

Conservatives (not in the American political sense, but in the maintenance of the present world sense) oppose change. New facilities, and especially new technologies, bring change. Eventually the change is brought and the new facility becomes old, a part of the environment. Opposition before evolves to acceptance after. That is not saying that, given time, we should sweep environmental problems under the rug. It is what we learn from the rail and previous experiences.

This page intentionally left blank

Part V

The Creating Experiences

Our objective is to provide insights into the ways transportation systems are innovated, born, or created, as well as insights about their early development. Further, the discussion will suggest how policies might be crafted to improve birth and early development processes. Our approach is to examine some situations and, aided by the literature on innovation generally, to strive for generalizations about processes.

"System" is a key word. Concern is with systems as opposed to components of systems. For instance, the innovation of the automobile and subsequent innovations improving it are not of central concern. Rather, concern is with how the system—roads, vehicles, and operations techniques and protocols—emerged. Insights about system changes are sought because we know that it is the workings of systems that provide for social and economic advances. We know that today's lack of system innovations is a barrier to dealing with social, economic, ecological, and energy problems. Policies that attempt to manage such problems with less than a system focus have little efficacy and may impose much cost.

We shall achieve our process insights objective in only limited ways. That is partly because the transportation experience provides only a finite number of cases for our examination. Who knows how well these represent all possible cases? Policy suggestions have even less to build from. True, there is a considerable literature on policies supportive of innovations. But little of that literature deals with the effectiveness of policies. It appears that the large socioeconomic system innovation process is somewhat different from the processes that the literature addresses. Indeed, it may be that transportation thinking has applicability to a larger class of systems.

The limitation on what we can do with our topic should be underscored. We just know enough to treat it in a conceptually satisfactory fashion. But that doesn't mean we shouldn't try.

This part has four chapters. The first, on innovation, largely looks back at innovations in the past. The second, on technology, considers more current issues, such as the adoption of intelligent transportation systems. The third, on imagination, looks forward at some alternative technology and policy paths that can be created with today's building blocks. The final chapter, on benefits, shows how gains from new investments, especially less conventional ones, can be assessed as enabling innovations elsewhere in the economy.

24

Innovation

The reasonable man adapts himself to the world; the unreasonable one persists in trying to adapt the world to himself. Therefore, all progress depends on the unreasonable man.
—George Bernard Shaw

Good artists copy, great artists steal.
—Pablo Picasso

Introduction

The present chapter will not treat the entire modern transportation experience. It will be restricted to situations where single individuals or organizations innovated a system in a market niche, for instance, Pease and Stephenson working in the Auckland coalfields. This contrasts with situations where the components of systems come together in many places and ways, as was the case in the auto-highway system. We restrict the discussion to events as the steam engine began to be used in transportation. This reduces the amount of background material that needs to be treated.

The literature on the history of technology emphasizes equipment (e.g., Stephenson's locomotive, Fulton's steamboat), and we shall say a good deal about equipment. Yet the discussion will question the tendency to see equipment as the leading component in the innovation process; the extent to which that emphasis is warranted is at question.

After a background note on the steam engine, this chapter makes comments of a general sort from place to place as the discussion proceeds. The discussion will close with more broadly scoped comments, some of which address policy innovations. A "blind giant" metaphor characterizes the system innovation process. Box 24.1 distinguishes innovation from invention.

A Background Note on the Steam Engine

The idea of a steam engine to pump water from mines originated on the Continent when Christian Huygens, a Dutch mathematician, and Dennis Papin, a Huguenot exile from

BOX 24.1 Invention Versus Innovation

We have used the words invention and innovation and should remark on them and use them carefully. Though the words are often used synonymously, the difference between invention and innovation is slippery, but important. An invention, from the Latin for "to find," is a new process; usability is not at issue. (But usability must be in the back of the inventor's mind because inventors are social beings.) An innovation, from the word for "introducing something new," is new in that it puts processes together so that they work in markets. An innovation has both soft and hard technology aspects. Some say that invention differs from innovation because the latter is clearly derivative (Basalla, 1988). We prefer to think of them as creating building blocks (invention) and bundling building blocks (innovation) into a larger assembly. Of course, today's bundled building blocks serve as components in tomorrow's even more complex system.

We would say that the transducer, a device for translating sound to (and from) electricity, was an invention. Based on study and physical principles, a new process was created. The telephone was an innovation that used the transducer, along with some other things. Returning to the telephone example, Bell was both an inventor and an innovator. He invented a number of component parts, and assembled them into a telephone, a composite invention. The telephone itself was then a component part (along with wires and switches and people on either end of the lines) in the telephone network, which he, along with many others, innovated.

Did Fulton invent the steamboat? The credit for invention should go to William Symington or others who worked earlier, for instance, James Rumsey of Sheperdstown, West Virginia. (In 1784, Rumsey built a rather advanced steamboat, and it steamed just fine. It had a tube boiler and water jet propulsion.) Fulton innovated a rather crude design suited to a market niche. As in Bell's case, social innovation followed.

Both invention and innovation can be contrasted with *discovery.* A discovery is finding something that existed but was previously unknown, whereas both invention and innovation create things that did not previously exist.

France, experimented in Germany with piston engines. First, a successful device was operated using gunpowder to create a vacuum (1673). Later, steam was condensed to move the piston. Papin continued to work on the steam engine.

However, Papin was never able to develop a practical engine. Thomas Newcomen (1663–1729), a blacksmith, and his partner John Cawley, a plumber, did develop a practical engine (in about 1704), and their engine began to be used in tin, copper, and lead mines in 1712. Coalmine use came later. It is unclear whether Newcomen knew of Papin's work and of even earlier work. It is a question of interest because we should like to judge the extent to which the fruits of the scientific revolution and workers in that tradition (e.g., Papin) influenced technology development for transportation, and we shall be concerned with this question in the pages to follow.

Newcomen's engine worked as follows (see figure 24.1): Rigged to a weight, the piston rested at the top of the cylinder. Steam from a boiler could then be introduced into the cylinder, and then cooled by a water spray. The resulting vacuum would pull the piston down. The reintroduction of steam then breaks the vacuum, and the piston returns to its rest position until reintroduced steam is cooled by the reintroduction

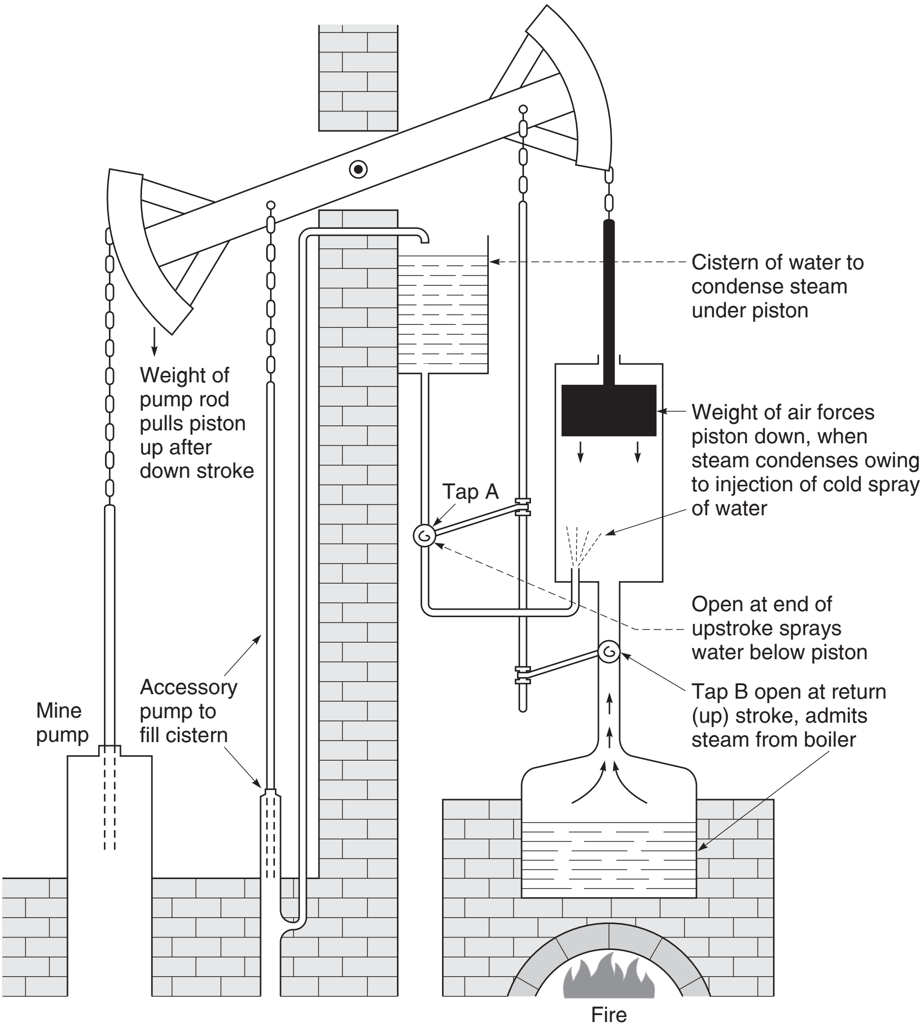


Figure 24.1. Diagrammatic view of Newcomen's atmospheric or fire engine, 1712. (Source: Csele, 2003.)

of water. This was a low steam pressure, atmospheric engine. Steam pressure was not sufficient to push the piston upward; atmospheric pressure pushed the piston down.

Automatic control was one key to Newcomen's success: control of water and steam was automatic, and a centrifugal governor controlled velocity. Such governors had long been used on windmills.

John Smeaton (1724–1792) seems to have been the first engineer to consider improvements in Newcomen's steam engine. In about 1770 he examined a number of engines and their efficiency. The engines used more steam than was required to fill the cylinder, and Smeaton reasoned that this was because the water cooled the wall of the cylinder, and that three-fourths of the steam was wasted in reheating the wall. Using analysis, he developed some differing geometric shapes for the boiler and the cylinder, and these had the potential of being more than twice as efficient as the Newcomen design.

Smeaton was England's first engineer-analyst. Trained as an instrument maker, he became interested in larger-scale engineering, and studied engineering works on the Continent. His first major commission was the lighthouse on Eddystone rock near Plymouth. To solve the problem of a cement that would harden despite being flooded by tides, he engaged in careful experimentation and measurement and developed a successful hydraulic cement, the first since Roman times.

This was an example of rational analysis, and Smeaton applied similar analysis to waterwheels and other topics of current interest. Smeaton had studied Newton's *Principia* (1687), and engaged in careful measurement and comparison of theory and reality. He wrote extensively, and was in contact with fellow workers on the Continent. Through the model provided by his work and his writing he stimulated rational analysis. One result was the founding of the Society of Civil Engineers in 1771, and early members were referred to as Smeatonians. Smeaton and his associates provided the know-how for the extensive civil engineering works of the times.

James Watt (1736–1819) also began his career as an instrument maker, and, like Smeaton, he became interested in the steam engine and measured the excessive steam consumption because of the wall heating requirement. In 1765 Watt had the idea of a separate condenser, that is, a condenser was attached to the cylinder and kept cool. Access to the condenser was blocked off as steam filled the cylinder, and opened when the cylinder was full. The steam then condensed in the condenser, providing the vacuum for the downstroke of the piston in the cylinder.

The condenser concept was patented in 1769, and in 1774 Watt entered into an agreement with Matthew Bolton (1728–1809), a Birmingham businessman, for the construction of Watt–Bolton engines. The factory constructed some engines. It provided designs and erection assistance to others, and payment was received via a royalty for the use of the condenser. The mine-pumping market for the engine was growing, and extensive developments in other sectors were important. It is of interest that pumps began to be used in urban water supply projects.

The factory market used much rotational power from waterwheels, and to extend his engine to that market, Watt began to work on what would now be called the kinematics of machinery. He developed flywheels and sun-and-planet gears to transform the reciprocating motion of the piston to rotary motion. He also developed other kinematic devices, and he protected all of his inventions by patents. Watt's developments made moot Smeaton's work with the steam engine.

Watt, Smeaton, and other engineers were by this time in touch with developments on the Continent, and there seems to have been a good deal of two-way information exchange, and exchange to and from engine and construction engineering and within factory engineering.

Society changed greatly within the sweep of time we are viewing. Factory development, the Corn Laws, enclosure, the American and French revolutions, all were causes and reflections of those changes. Smeaton's ideas of civil engineering drew attention to the social impacts of engineering and the social services that engineering might provide, and the developing cadre of engineers responded. Watt was regarded as somewhat of a political radical, and some engineers worked on designs for workers' housing and fireproof factories. A few were engaged in the debate over child labor laws. (Watt's radical political leanings died from disappointment with the French Revolution.)

Watt and Smeaton had similar backgrounds; both were instrument makers and capable of careful measurements. Later, both paid very careful attention to details. Smeaton wished to spin off his style of work, ideas, and knowledge. Watt wanted to protect his. He protected his intellectual property with patents, even if he had no plans to use the ideas. (For instance, he patented the double acting engine in 1782, but never used the idea nor did he plan to.)

Application of the Steam Engine to Transportation

In previous chapters we emphasized the building block nature of innovation. As knowledge and techniques emerge, the possibility of using new building blocks also emerges. For instance, the developments in physics and physical chemistry in the 1930s and 1940s have yielded possibilities for the use of today's electronics and materials technologies. Does yesterday's experience with the use of the steam engine in transportation tell us anything that may be useful today?

Watt had protected himself with many patents, as mentioned, and to the extent he could, he extended that protection by obtaining new patents or minor changes in old ones. Even so, patents began to run out in about 1800, opening opportunities for other innovators. By that time, the Watt–Bolton engine was widely used on the Continent. Indeed, as early as 1735, there were precursor Newcomen engines in Sweden, the mining districts of the Austrian Empire, and at Liège near Brussels. Hands-on knowledge of the engine was widely dispersed, so many had the opportunity to try new ideas.

Water Transportation

Watt seems not to have been much interested in transportation, and the engine he marketed was so heavy relative to its output that applications were limited. Early trials in road vehicles were attempted, but the first lasting applications were in the water mode and at docks where steam engines pumped water for the operation of pneumatic systems. Stationary steam engines were also used to pump water to the heads of lock systems during periods of low water.

One water mode application was William Symington's (1763–1831). He constructed the *Charlotte Dundas* in 1802 for use as a canal tugboat (figure 24.2). We know little about Symington. He had built some stationary engines and at least one unsuccessful tugboat prior to the *Charlotte Dundas*, and by 1801 had taken out patents on the use of a crosshead and slide bars to control piston movement in a horizontal cylinder producing rotary motion.

Symington used a double acting engine, and a single paddle wheel was set within the stern of the boat in order to minimize generation of waves that would damage the canal bank. The knowledge that had been developed about waterwheels was directly applicable to boats.

The *Charlotte Dundas* was used on the Forth and Clyde Canal for a year or so and then converted to a dredge. It seems to have been successful, but not successful enough

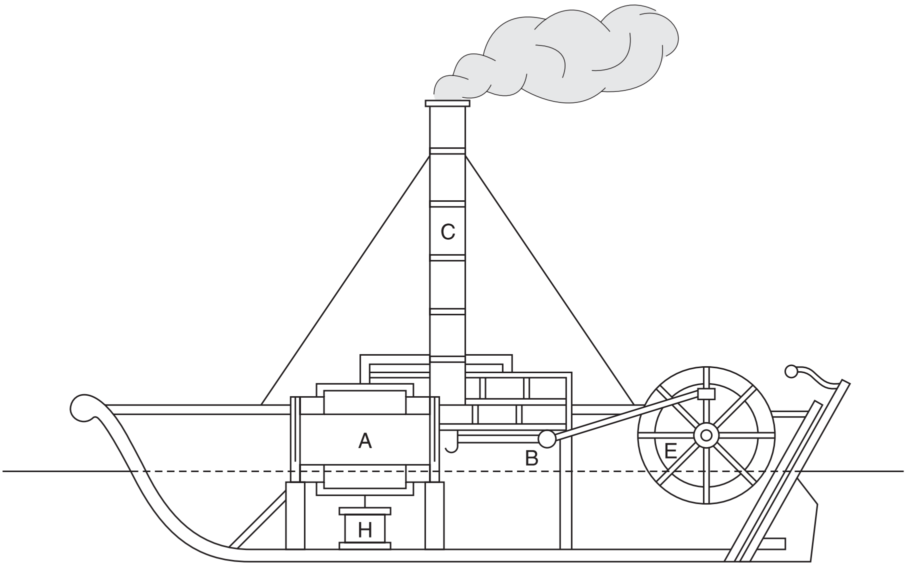


Figure 24.2. *The Charlotte Dundas,* 1802. (Source: Thurston, 1878.)

to drive widespread adoption. It came close. The Duke of Bridgewater ordered a number of boats from Symington for use on his canals, but Bridgewater died in 1803 and the order was withdrawn. No other orders came along, and Symington drops out of our story.

In addition to Symington's work, in at least two cases innovators in the United States had mounted steam engines on boats and had offered service for a time. In particular, James Rumsey built a steamboat in 1784 for use on the Potomac River. It was technically advanced for the times, having a tube boiler and water jet propulsion. However, Robert Fulton (1765–1815) is recognized as the innovator of the steamboat. He introduced steamboat service on the Hudson River in 1807, and he and that date are associated with the beginning of the steamboat era. Fulton's application was not as advanced as Symington's. Fulton used a Watt–Bolton engine, side paddle wheels, and a rather complex arrangement to obtain rotary motion. Fulton's steamboat also used sails. The engine was neither fuel efficient nor powerful. Even so, he found the market—the passenger market—and finding the market is part of the innovation puzzle.

Comment 1: *The perfection of the new building block* (*steam engine*) *is not the key to the innovation*. The key seems to be obtaining an adequate design serving the right market niche. Fulton's key action was getting the market niche right. What do we know about the innovator? The son of a farmer in the Philadelphia area, Fulton was largely self-educated and early showed talent as a painter. This took him to Europe in the 1790s, first to London where he studied with an American painter. He had some funds from his painting, and moved in society with those who were stylish and good at conversation and who visited on country home social circuits. Innovation, industry, and commerce were much discussed, and Fulton's peer group extended beyond the landed gentry.

Small, tub-sized canals interested Fulton. He developed and published many ideas about them, and patented his ideas in France in 1798. Fulton developed the idea of submerged tunnels, and he also developed an idea for a submarine. Unable to sell the submarine idea in England, then at war with France, he went to France and got support for development and testing there. The submarine was to be used to break English blockades of Channel ports, but development was not brought to that stage. While in France, Fulton developed a steamboat and held trials on the Seine at Paris. However, his boat was burned by bargemen and never saw service. Returning to England, Fulton was able to interest the English in submarine actions against the French fleet, but that scheme also went only part way. Before leaving England and returning to the United States, Fulton ordered a Bolton–Watt engine, and this was the engine used on the Hudson River. The Hudson River service demonstrated feasibility and the existence of a market, and by 1820 there were about 300 steamboats in the United States. Service was available on the Ohio–Mississippi system.

The English Admiral Earl St. Vincent commented on the Fulton submarine: "It was a mode of warfare which those who commanded the seas did not want, and, which if successful, would deprive them of it."

Comment 2: *An innovation has to be consistent with market* (*client*) *values*. The navy was the client for the submarine, and its use was not consistent with the paradigms the navy held about the correct ways to do battle. Perhaps if Fulton could interest Napoleon and build on his wish to eliminate the English blockade, he would have been successful. Note that the steamboat on the Hudson was not consistent with the values held by sailboat operators. That didn't matter, for the passengers were the clients.

Fulton moved to Pittsburgh and built the *Washington* for service on the Ohio–Mississippi Rivers, where there was a growing market. A low-pressure steamboat, it was a failure—not being powerful enough to steam upriver. But current was not the Ohio–Mississippi problem, for more powerful steamboats where within the state of the art and were soon in service. The problem was the state of the rivers: low water on the Ohio during much of the steaming season, lack of navigation aids, logjams blocking rivers, and snags (water-soaked logs, often not visible) that would damage boats. It took many years and innovation by people like Captain Shreve to remove snags and improve the Ohio–Mississippi system. *Comment 3*: *For a system to work, all components have to function appropriately*.

Rail Transportation

Richard Trevithick (1771–1833) developed the first practical locomotive. He began experiments in 1803, and his locomotives were operating on colliery tram-like roads at Leeds and on Tyneside in 1812 well before the 1824 opening date of the Stockton and Darlington. Trevithick grew up in the Cornwall mining region where he obtained experience with Watt engines. A self-taught engineer, his first innovative effort conflicted with Watt's patents. To evade those, he developed the idea of strong (high-pressure) steam. The steam expansion drove the piston, and once expanded, the steam was exhausted into the atmosphere. Watt's condenser was no longer needed.

Other ideas then came quickly. Strong steam required a strong boiler, but the boiler could also be made smaller. To increase efficiency, Trevithick made boiler improvements, and the steam was exhausted via the chimney to improve draft. Safety valves and fusible plugs were developed. The smaller, more powerful engine was much better than Watt's for transportation uses. Trevithick developed a steam road carriage in 1801 (not the first, Watt engines having been tried on vehicles, first in France), a gear-driven plate-way locomotive in 1804, and a dredge in 1806. Later locomotives used connecting rods to crank pins.

In addition to the carriage that was operated in London, Trevithick demonstrated a railroad-like system. The single cylinder was set horizontally within the boiler. These and additional transportation efforts did not yield successful business ventures, and Trevithick lost interest in transportation and began to concentrate on mine machinery. That work yielded still another important improvement—the early cutoff of steam flow to the cylinder. Some others experimented with locomotives at the time, but Trevithick was clearly the leader.

Now we are ready for George Stephenson (1781–1848) and his son Robert (1803–1859). A craftsman-mechanic, Stephenson began to build locomotives in 1814, and he brought that experience, plus all that had gone before, to the Stockton and Darlington. However, the *Locomotion* developed for the Stockton and Darlington was a crude locomotive compared to Trevithick's. A craftsman, Stephenson's contribution was the way he placed the building blocks into a successful format, a matter emphasized before. Later, and working with his son, Stephenson developed a successful line of locomotives and he was an important promoter and developer.

Innovators, who are "unreasonable men" in Shaw's words that open the chapter, do not take the situation as given: in Trevithick's case, the constraints posed by Watt's patents. *Comment 4*: *Innovative people abound.*

Road Transportation

As just mentioned in the discussion of Trevithick's work, there were efforts to apply steam propulsion to road transportation. Back in the days when presidents signed patents, George Washington issued a patent to a man named Reid who had proposed mounting a steam engine on a wagon. Trevithick developed and demonstrated a steam road carriage. Goldsworth Gurney developed a successful steam coach and a tow for coaches (a drag) in 1825; in 1831, and using a Gurney drag, Charles Dance offered coach services with a 75 percent reduction in coach fares, and Telford proposed wide-spread services using plateways (tracks consisting of flanged strips that were used in some early railroads). A Hancock steam van was offering service in the London area during the 1830s.

Steam-powered road vehicles never received much of a trial; they were resisted by road providers who wanted to protect their facilities from heavy vehicles. Road policy (then as now) emphasized the protection of road surfaces using limits on weights, widths of wheels, and so on. No doubt, too, providers of wagon and carriage services strove to protect their businesses from interlopers using new technology. David Beasley (1988) puts forward the theory that there was a conspiracy to block steam vehicles on roads, and he includes the railroads as part of the conspiracy.

In spite of this resistance by road providers, someone might have found a niche and gotten the design right. But the clock ran out. The window for development was closed when markets were coopted by rail service. That is one explanation for what happened. Less general explanations point to the low horsepower per unit of weight of then steam engines and the high rolling resistance of then road surfaces.

Comment 5: *Technical or regulatory reasons can always be found why things can't be done*. For example, in 1940 the Gas Turbine Committee of the U.S. National Academy of Sciences said, "even considering the improvements possible . . . the gas turbine could hardly be considered a feasible application to airplanes, mainly because of the difficulty in complying with the stringent weight requirements. . . ."

And social reasons as well:

> The rapid movement of trains must inevitably generate in travellers a brain disease, a special variety or the Delirium Furiosum. If travelers are nevertheless determined to brave this fearful danger, the state must at least protect the onlookers, for otherwise these will be affected with the same brain disease at the sight of the rapidly running steam wagon. It is therefore necessary to enclose the railway on both sides with a high, tight board fence.
>
> (Bavarian College of Physicians, 1832)

Another reason why developments did not occur was the debate over who would get the transportation rents—the coach or wagon operators or the road providers.

Comment 6: *An innovation needs to include ways to finesse existing constraints*. Existing constraints (policies, regulations, standards, etc.) are in place for good purposes. An innovation must adapt to those constraints or bend the constraints to adapt to the innovation. Brunel, profiled in chapter 16, poses a good case study, facing constraints in both rail and shipping.

Comment 7: *It is important to get the scale right*. Brunel seems to have overshot, so to speak, when sizing the *Great Eastern*. We do not know exactly why it wasn't a success: not enough passengers, too long a turn-around time in port? Yet for some reason, it didn't fit the market situation. Even so, the kinds of ships imagined by Brunel were successful in the liner trades—the *Great Eastern* was "too soon."

What about his 2.1 m (7 ft) gauge railroad? It was "too late." By logic copying, English railroads had already committed to standard gauge—a *bandwagon effect* and networking requirements forced Brunel to join.

On Blind Giants and Rational Analysis

Comment 8: *Large system innovations are the work of blind giants* (a term used by Paul David, an economic historian at Stanford). We call them "giants" because it takes a giant to create something big and "blind" because the giant cannot possibly know the consequences of actions and how a system will grow and develop.

Comment 9: *Rational analysis can aid blind giants in only limited ways*. It goes without saying that we should like to improve innovation processes. Does rational analysis get in the way, and how might it be helpful? Those are good questions, and we can only speculate about them.

As mentioned, Smeaton was very much a rational analyst. He took the steam engine as a given, and applied his rational, linear thinking to improve it. That contrasts with the more integrative approach taken by Stephenson and Pease and Fulton. Another case was the analysis Brunel applied to the *Great Eastern*. In the development of container liner services, both Malcolm McLean and the Matson Navigation Company used integrative approaches. But Matson's was backed up by considerable analysis. Did analysis provide risk information that dampened Matson's entrepreneurial efforts? Does too much analysis provide excuses for limited action? Should we conclude that rational analysis has great strengths if the task is to improve an existing system, and integrative analysis has its advantages elsewhere?

Pacey (1974) addresses the rational-linear analysis versus integrative-design thinking issue, and concludes that integrative thinking breeds innovations. However, we think this is not an either/or issue, for the ways of thinking might be complementary. Consider Brunel and the *Great Eastern* again. Brunel thought widely, and then took advantage of analysis.

As we see it, integrative thinking may run the risk of not using enough analysis to bound feasible spaces. It may generate ideas that will not work "because the numbers don't add." Rational analysis may conclude that something will not work because of inability to consider possibilities. "[E]ven if the [screw] propeller had the power of propelling a vessel, it would be found altogether useless in practice, because of the power being applied in the stern is would be absolutely impossible to make the vessel steer" (Sir William Symonds, Surveyor of the British Navy, 1837). With a little innovation, steering became a nonproblem.

Comment 10: *Essential knowledge may be developed after the innovation occurs*. Many innovation paradigms exist. These can be used for either basic or applied research, and applied for individuals or large organizations. The end-driven paradigm, such as used by NASA and the U.S. Department of Defense, states the desired end, and applies the resources to get there (including the resources to perform R&D). Examples include the U.S. space program, which was tasked with putting a man on the moon before the end of the decade. In more conventional transportation, the Automated Highway System program (described in the next chapter) adopted this paradigm.

In contrast, the means-driven paradigm, followed by government science agencies like the National Science Foundation and the National Institute of Health, says encourage and support research in promising areas, with a nominal goal, but don't worry too much about the goal, and social advances will follow. This is a widely held view by individuals in universities and industry laboratories. The Defense Advanced Research Programs Administration (DARPA) used this when funding the development of what became the Internet.

Another is the "innovator in the garage" view, a view that things just happen. Government support or policy is not required, except to the extent of providing a legal framework and ensuring a civil society. Table 24.1 gives a typology of alternative innovation paradigms.

Experience says that these and other views are correct. It also tells us some things that many do not want to read. The first is that "in certain situations and for certain sorts of outcomes" ought to preface statements of principles. Second, that technology is after all a creature of society, and improving on the success of an innovation is very much a desired social activity. Therefore, successful innovations stimulate research to improve them.

The people orientation in the above discussion was deliberate because we should like to know what kinds of activities and actors yield consequential change. What is the conclusion? In what ways does rational, linear thinking (e.g., Smeaton's) occasion progress? What about more integrative thinking, such as that by Stephenson and Pease?

Table 24.1 Typology of Innovation Paradigms, with Examples

	End-driven	Means-driven	Undriven
Basic	Superconducting-Supercollider, Human Genome Project (DOE)	Grants to researchers (NSF)	Discovery of gravity (Issac Newton)
Applied	Automated Highway System (FHWA), Apollo Program (NASA), Telephone (Alexander Graham Bell)	Internet (DARPA), Transistor (Bell Labs)	Development of the automobile (Henry Ford)

Should we conclude that rational analysis has great strengths if the task is to improve an existing system, and integrative analysis has its advantages elsewhere? We hear that some things cannot be done because we lack basic knowledge, and that there is a process that works this way:

- Inquire—acquire knowledge.
- Invent—apply knowledge to new technology.
- Innovate—adapt technology to market niches.

But does our analysis say that is the way things work? The basic knowledge for the steam engine is thermodynamics, and it had not been developed. Yet practical men were working with the laws of thermodynamics.

The First Law of Thermodynamics has to do with conservation of energy. Total energy was the sum of work plus loss. Efficiency was the percent of energy devoted to work. Inventors like Watt and Smeaton were working to convert lost energy into work.

The Second Law of Thermodynamics says that efficiency rises by increasing working temperature and pressure, and that is what Trevithick did. So our discussion also illustrates how what practical men did was suggestive to scientists and did not depend upon them.

The idea of the electron did not appear until after innovators figured out a lot of things about power transmission, transformers, and multiphase power. We are not saying that research and engineering do not contribute to building blocks for innovation. We object to the principle that research must be done first and argue that innovation may suggest directions for useful research.

Hippel (1988) provides a good discussion of the loci of innovative activity. Which actors in a system are motivated to innovate, and what do they do? For a more general discussion and stress on the cultural context, see Pacey (1974).

Comment 11: *The race goes to the first off the starting line and not necessarily to the swiftest*. We imagine a blind giant who is unable to imagine the future and understand the consequence of actions. That would not be much of a problem if trial and error was disciplined by the "tooth and claw of the marketplace," or put another way, if pure evolutionary processes were at work. That is not the case, for blind giant decisions are subject to strong *lock-in* because of networking requirements.

Lock-in can occur in several ways. If one choice is as good as another in situations, *tipping* may occur. It just happens that when things went a certain way, others then saw that they were better off if they went that way too. The choice of driving on the left or right side of the street may be an example (actually, it isn't that simple—see Lay, 1992). Such a choice may be pushed by regulation, and it may force acceptance of second best. That is the case for television standards in the United States and Japan, which yield an inferior picture to the standards adopted in Europe. Why did the Betamax format give way to VHS in videocassette recorders? Video rental stores certainly disliked having to stock two formats, and were to quick to jump on the bandwagon when VHS market shares marched ahead.

In the early days of systems, there are very rapid performance improvements—operating know-how, hard technologies, and so on. As the market begins to grow, economies of scale begin to be achieved. Pressures for standardization emerge in order to support production efficiencies (e.g., standardized employee uniforms and operating protocols) and also to support efficiencies to be gained by networking. The length of time the *window* is open for changes is small. Once the window is closed, it is hard to reopen even if something better comes along. After lock-in makes an option moot, it is often forgotten.

The pure lock-in case is illustrated this way. Suppose there is a technology that will cost C_1 as economies of scale play out. Another innovation comes along later that potentially would reduce costs to $C_2 < C_1$ after x years. But that second innovation will not take off if, at the time it is introduced, its costs are greater than those of the first technology, which is already achieving scale economies. That pure case is not so interesting, for firms can delay profits, seek quality differences, and do other things to displace the earlier innovation. But, as stressed, networking yields a strong lock-in force in transportation.

Perhaps the most costly result of lock-in is that it is unrecognized. It is assumed that pure evolutionary or competitive forces have been at play and that what we have are optimal systems. So, people put priority on optimal suboptimal designs. A quite different cost is this: some assume that lock-in is so tight that change is unthinkable. History says that is nonsense. We can recall, for example, that it was the reason why jet aircraft would never have uses other than military ones.

Limits on cognition and personal energy translate into professionals viewing the set of possible transportation systems and the set of existing systems as the same. Professionals rarely think of new ways in which transportation services might be provided or ways existing systems might be sharply altered. We find what-might-have-beens a stimulus to wider thinking and suggestive of alternatives.

Around the 1850s, there was much discussion of appropriate rail gauge, and in the late nineteenth century it was thought that dual systems of narrow gauge and wide gauge made sense (Hilton, 1990). This is one of many suggestive what-might-have-beens lost in the dust of history, so to speak.

What mechanisms are operating? The first is pure chance, for example, Bridgewater died. It just happened that road owners did not like steam vehicles. Stephenson selected Roman cart gauge for his railroad. The list is very long. But pure chance does not take us very far unless there are some strong mechanisms that lock in the results of pure chance. One mechanism that is easy to see is returns to scale.[1]

Other processes are at work to reinforce the increasing returns. Increasing returns from scale and scope economies are common in transportation, and as Marshall emphasized, things get locked in by the presence of monopolies. They also get locked in by the development of standards. So a new alternative might become an impossible choice because it does not meet the standards. For instance, today's standards call for multipurpose (trucks and autos) highways and lock-in vehicle types. Other processes yield increasing returns with time. Technology and institutional improvements are focused on the choice made. The steam engine was developed rapidly for use on trains. It was not developed (very much) for use in on-road vehicles. Learning increases efficiency.

Limits on our cognition exist. The returns that matter are in what transportation does that is worth society doing. We would never learn about returns of an alternative (unpursued) technology; they are outside of our cognition. Turning away from increasing returns, consider now changes in consumer expectations. An example may help. When the auto was first innovated, its early use was for social travel. So big cars were built. Standards were put in place for big cars and roads for them. We learned how to produce big cars efficiently. Today cars are used for all kinds of specialized things. Often, as in the journey to work, a one-passenger car would do. That is an example of the processes the change in expectations idea strives to catch. Changes in environments or situations need to be considered. Once a technology is honed and occupies the turf and limits our cognition, there is no room for an alternative.

Comment 12: *The potential for improvements as the predominant technology emerges is critical*. The steam engine was not successfully applied to wagons because, as the technology began to be deployed, it failed to improve in ways suited to that application. The main point in presenting this comment is to counter the argument that although the technology is not so good now, if we can just get it started, costs will go down and quality will go up. That is the basis of infant industry claims for subsidy.

Comment 13: *Policies may be forged to aid infant industries*. Often, however, "infant industry" is an excuse for subsidy rather than a reason. Once established, subsidies are hard to get rid of. Today, we hear it claimed for electric cars. It is taken as a principle, yet one wonders if after 80 years of trying to improve batteries and simplify car-body production there would be much improvement left to come even if electric cars enter the market.

Comment 14: Transportation development is chancy. The transportation experience is full of what-might-have-beens, such as the what-might-have-been discussed for the steam carriage. We should pay attention to these and the processes of selection and choice that affected them. Alternative paths are often enabled in unexpected ways; see box 24.2 for a discussion of spandrels.

Fulton first tried his steamboat in Paris. It steamed very well the first day, but was burned that night by bargemen concerned about their investments and their jobs. With the

BOX 24.2 Spandrels

The spandrel is the approximately triangular space between the exterior curve of an arch and the rectangular framework around it. It is not intentional, but rather a necessary result. Architects have taken advantage of the opportunity of the spandrel to provide space for decoration. Gould and Lewontin (1979) have used the term as a metaphor to describe how certain features evolve—noting that not every feature exists for a purpose when it was created. In a similar way, transportation systems produce spandrels all of the time. In the most direct analogy, the space inside a highway cloverleaf is a spandrel most often used for landscaping, but does not serve a transportation purpose. These spaces can later be exploited (e.g., as a park and ride lot or a water detention pond). Innovation can take advantage of spandrels, hooks created by the existing design to attach new services.

extensive canal system in place in France, success by Fulton might have set off technology development suited to canals. If the Duke of Bridgewater had lived to purchase and use Symington's designs, similar developments might have happened in England. Instead, the first developments were riverboats. We see many what-might-have-beens as we trace the transportation experience.

Often chance is discounted in favor of choice. Choices were made driven by the tooth and claw of competition. Best choices are assumed to have been made. Even if one accepts that the tooth and claw of competition was less than perfect, "what's done is done." Development is an irreversible process, and our concern should be with today's outcomes. We disagree.

Discussion

With transportation systems largely in place, (we have inquired, invented, and innovated), priority goes to questions about their reconfiguring, redesign, or reenergizing: how do we improve services and adjust to changing conditions? Here is some jargon bearing on structure that may help us understand what we are doing and what we might do.

Think of large technical systems (LTS) (and transportation systems in particular) as *first-order* systems recognizable because of their common characteristics and behaviors.[2] Characteristics include their unitary technologies and products. Services are produced the same way everywhere and products are the same everywhere (one size fits all). The systems are used for many purposes. Extending, let us recognize *second-order* systems. In contrast to LTS, which have homogeneous technologies and services yet serve diverse purposes, second-order systems are highly specialized and have heterogeneous technologies. They are formed by merging or combining aspects of LTS and other systems.

An example of a second-order system is the U.S. nitrogen fertilizer production and delivery system. It is built from fertilizer production technologies, as well as institutional and financing technologies. It combines or configures those with transportation and communication technologies in a very specialized and precise way. Communications and information systems play an important role. Fertilizer delivery in wet or dry form (depending largely on soil wetness, which varies from market to market and year to year) by barge, rail, and truck service combinations arrives precisely when needed for the spring plowing season.

First-order systems are made up of building blocks. With respect to transportation systems, we have referred to components (fixed facilities, equipment, and operations), and have emphasized that these involve both hard and soft ways of doing things. In the jargon proposed here, think of components as *zeroth-order* systems. We would say that the highway delivery system made up of contractors, tax collectors, state and local agencies, and so on, is a zeroth-order system. What does this notion of second-order systems do for us? Is the jargon useful? Let us consider transportation improvements.

We strive to improve transportation for many reasons. Most people target zeroth-order systems for improvement: operations (traffic flow), bridge structures, insurance arrangements, and others. Scoping to systems seen as first-order systems is rare, and second-order systems are not considered at all. Does this observation help us understand improvements achieved and not achieved? In addressing that question, instrumental and consequential are operative words. With respect to instrumental improvements—those that can change things—we must be sensitive to development and growth dynamics. Relatively mature systems are not very responsive to improvements in zeroth-order systems, and such improvements are thus not very consequential.

Even though we are surrounded by mature systems, there are some things at the first-order level that might make a difference. A list of such things to do is available from the newspapers, textbooks, and the program documents of agencies and other organizations. The list includes achieving scale economies, reducing costs, and expanding territory using networking technologies. Today, such technologies (largely soft) are needed in response to NAFTA, the integration of Europe, and the increasing globalization of industry and commerce. Boundary conditions change, such as those supported by deregulation and imposed by energy and environmental considerations. We might seek to make systems more supple by specializing services and/or introducing new technologies. One is load leveling, such as that sought by airline fare schemes, congestion pricing, and flex time. These examples of ways to reconfigure apply to all LTS.

Of these, making systems more supple seems most interesting because suppleness might be instrumental in triggering consequential second-order system development (where consequential implies improving matters by at least an order of two, for history seems to say magnitudes of that sort are needed to change things). The social uses of transportation are in second-order system activities, of course. So if we are to find consequential developments, that is where we will find them.

Is the jargon useful? Does it help us understand the following dialogue?

Technologist seeking first-order system improvement: "Expanding highway system capacity using intelligent transportation system techniques will increase consumer surplus."

Critic interested in making life better: "What is that going to do for us? Consumer surplus is the economist's fairy gold. Will the [second-order system] things that are important to me and involve transportation work better?"

By giving attention to second-order systems, one should be able to get a sense of desirable directions of development of LTS.

Clearly we like the jargon. We think:

- It provides interpretations of companion innovation and intermodal notions.
- It links communications and transportation in rich ways.
- It enriches understandings of the functions of LTS.

25

Technology

[If such drivers have no faster alternative route] Those are the people who I would encourage to change jobs or change houses. . . . The City of Edina needs to build some arterials.
—Mn/DOT Ramp Meter Chief Engineer (*Minneapolis Star Tribune,*
November 28, 1999)

The universe does not tell us when we are right, only when we are wrong.
—Karl Popper

Introduction

We define technology as a way of doing things. A technology may be hard, and embodied in physical tools, or soft, and embodied in protocols. Usually these are linked. Highways, for example, have a technology for traffic control that is embodied in signal systems, and so on, and also a set of rules for drivers. On a much broader scale, one may think of the physical makeup of a mode as a technology, with a companion set of soft technologies embodied in institutions, regulations, standards, and so on.[1] Here is an example that introduces current technology development efforts.

Ramp meters, traffic signals posted on freeway entrance ramps, seek to regulate the flow of traffic entering the freeway. They serve two main purposes: first, they limit the number of vehicles trying to merge simultaneously, smoothing traffic flow (and reducing crashes); second, they keep the total number of vehicles on the freeway trying to simultaneously use a critical bottleneck just below a threshold (capacity), so that freeway flow does not exceed capacity, thereby avoiding queueing. In and of themselves, those are both reasonable goals for managing a mature system, and most travelers readily accept traffic lights in other contexts. Yet somehow, in the Twin Cities of Minneapolis and St. Paul, Minnesota, ramp meters became *the* transportation issue of 2000.

The reasons why are clear in retrospect, but may not have been in advance. As can be seen in figure 25.1, ramp meters were slowly deployed in the 1970s and 1980s, and became much more widespread in the 1990s. As road capacity was built out, additional

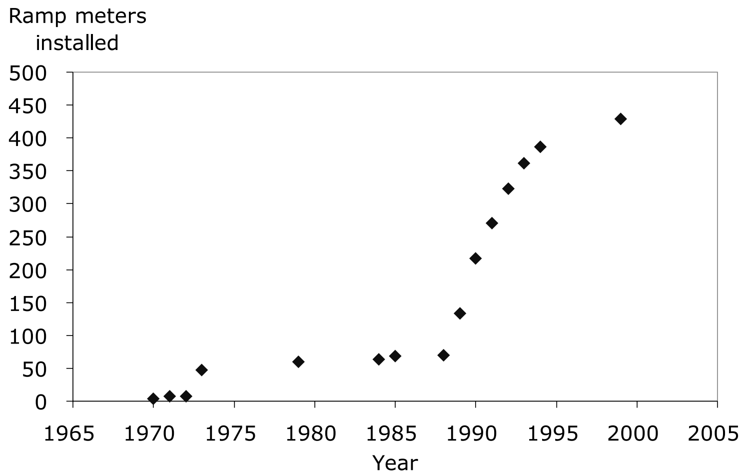


Figure 25.1. Deployment of ramp meters in the Twin Cities.

roads became more and more difficult to build, not only in monetary cost, but also in political will. The leadership of the Minnesota Department of Transportation (Mn/DOT) viewed ramp meters as a way of stretching the system slightly further, eking out a small capacity improvement and a significant speed improvement at a cost much below that of adding lanes to the freeway.

Yet the Twin Cities continued to grow, as did peak hour travel demand. The primary effect of ramp meters is to move delay from the freeway to the entrance ramp. By the late 1990s, some commuters experienced long delays at some ramps, in some cases upward of 20 minutes. In 1999 Dick Day, a State Senator from Owatonna, Minnesota, a rural community outside the (metered) metropolitan area, pushed a "Freedom to Drive" package. This package called for shutting off all of the ramp meters, allowing all cars to use HOV lanes, and establishing the left lane as a passing-only lane. (Day claims to drive 70,000 miles a year, which averages to over 3 hours a day in his car—the reader can assess whether this is reasonable or hyperbole.)

Day was able to obtain press for his initiative, and in November 1999 the *Minneapolis Star-Tribune*, the state's largest newspaper, printed a large Sunday, front-page piece on ramp meters (the opening quote of the chapter is from that article). Discussions with the engineers revealed several things. First, they were certain that metering was the right thing, and they believed that shutting off the meters would be "catastrophic." Second, they were indifferent to the fact that some drivers had long commutes so that others would have shorter commutes.[2] They did not see ramp delay as an important metric. Rather, if the freeway flows were higher with than without meters, and at higher speeds, they knew they were reducing total delay (if more total travel is using the freeway, then there is less total travel on alternative slower routes). Third, they were highly resistant to outside analysis, probably because of distrust that the outcome would be different from their own.

Nevertheless, to avoid the threatened shutdown, Mn/DOT commissioned three separate University of Minnesota studies to evaluate meters.[3] Despite these studies, in

May 2002 the Minnesota state legislature insisted on a shutdown experiment, which would last at least 4 weeks. A large consulting firm[4] was hired to conduct the study. Many of Mn/DOT's ramp meter engineers were excluded from the study process (their biases and lack of political acumen having been demonstrated), as were the university researchers (who were funded by Mn/DOT and therefore tainted by association). A lot of traffic data was collected before the shutoff period, and then the meters were to be shut off for a period of at least 4 weeks to conduct the study in October 2000. Because of the weather, the study was extended a few more weeks. Due to the lack of catastrophe, the study was extended a few more, since it was clear that Mn/DOT could not return to the old metering strategy, and no new strategy was obvious. Eventually the meters were turned on (December 2000), but running at their fastest rate, so that queues would not get too long. Over time, a new strategy was developed to cap maximum waits at the ramps at 4 minutes.

Dick Day was not entirely satisfied, and Mn/DOT staff was unhappy with the shift in their worldview, but the residents of the Twin Cities seem happier with the system now than before.

Ramp meters are but one of many new technologies collectively dubbed "intelligent transportation systems" (ITS). The new technologies vary from simple operational improvements (e.g., ramp meters, freeway service patrols [tow trucks that quickly service disabled vehicles]), to more sophisticated information systems (in-vehicle navigation systems that tell drivers the shortest path given real-time congestion information, or bus stops that tell you to the minute when the next bus will arrive), to control systems (adaptive cruise control that will follow the speed of the vehicle ahead, automated highway systems that will control all movement of vehicles). While some of these technologies have already been deployed, many have not, and won't be for 30 years. Yet already controversies emerge.

This chapter will treat the origins and status of ITS technology development and implementation efforts. It will remark on the roles of standards. ITS is receiving attention, and it provides a technology example for considerations of innovation and the generation of imaginative actions. Before talking about ITS, the question might be asked, do we see "Twin Cities" stories as we visit the modes and efforts for their improvement?

"Well, in a way," is one answer. Recalling the within-mode structure of systems, there are activities in the equipment, facilities, and operations sectors. Recalling behaviors over life cycles, marginal improvements to entrenched ways of doing things is the rule at mature stages in life cycles. Recalling that advances are made by importing new tools, it is not surprising that information and communications technologies are being introduced into transportation efforts.

But there is more on the technology shelf. There are improvements in physical and human resource management, materials, lubrication, and endless other things. So we see fly-by-wire aircraft, automated monitoring and control of ships, widespread monitoring and control in the logistics aspects of freight movements, monitoring and control of freight trains and locomotives, application of smart cards to enable electronic toll collection (ETC) and fare payments on transit, and many other activities. Improvement rather than replacement is the rule, and technology delays the onset of diminishing returns.

"Well, no," is another answer. That is partly because markets are better defined in some non-ITS situations and there are competitive pressures in some other situations, firms operating ships and aircraft, managers of competitive ports, trucking firms invest in location-finding and communication devices. The champions of technology improvement command the payoffs, the rents. That is not the case with some ITS technologies and services.

Conceiving ITS

The dream of what we now call intelligent transportation systems first gained widespread attention at the 1939 New York World's Fair. In particular, General Motors' "Highways and Horizons" exhibit, better known as "Futurama," pictured the world of a large metropolis in 1960, containing completely grade-separated freeways running some type of automated highway system. This Norman Bel Geddes (1940) vision of the future may have been too soon (obviously 1960 came and went and the interstates were barely under construction, much less an automated highway system), yet the vision remains.

There are several implicit objectives of this vision (illustrated in figures 25.2, 25.3, and 25.4). One is to promote cars and highways as the vision of the future. Clearly that much came to pass. While there are buses in the Futurama exhibit, trains and streetcars were downplayed. Another is to remove the driver from control of the vehicle. This is seen as advantageous because drivers are the cause of most crashes. Further, machines respond faster than humans, and so can follow more closely at higher speeds while still remaining safe. A third is the separation of pedestrians from vehicles. The elevated sidewalks (or skyways) are an idea borrowed from other visions of the future, and have both safety and efficiency aspects, though urban designers often see separation as problematic.

Figure 25.2. Interior view of General Motors' "Highway and Horizons" exhibit. (Source: Wood, 2004.)

Figure 25.3. Postcard view of Futurama. (Source: Yamada, 2004.)

Figure 25.4. Two 14-lane express highways cross in 1960. (Source: Life Magazine, 1939.)

Realizing Automated Highways

In August 1997, at DEMO '97 in San Diego, California, researchers of automated highway systems demonstrated a system on the reversible high-occupancy vehicle (HOV) express lanes of I-15. As shown in figure 25.5, specially equipped cars were able to follow at high speeds, without driver intervention, at a fixed 6.4 m (20 ft) following distance using advanced communication technologies (and some low-tech in-road magnets to help with lane guidance). While the demonstration was a technical success, funding for research in this area was promptly cut, and the National Automated Highway System Consortium, which sponsored the demonstration, was disbanded. That is not to suggest it was a waste, since much was learned.

First, the possibilities of deployment of such a system (which relies on intelligent highways and intervehicle communication) are much more difficult than deployment of autonomous intelligent vehicles. While autonomous intelligent vehicles are harder to engineer, they can operate in mixed traffic without upgrading both the infrastructure and all other vehicles. Where the intelligence in a network technology lies is a critical question that needs to be answered. We have seen various mixes throughout the history of transportation, from smart vehicles (cars and their drivers—we hope) and dumb links (simple roadway), to dumb vehicles (trains that do not have steering) and smart links (the tracks steer the train at junctions). However, it is clear that compatibility with existing systems is a crucial question. While you can drive a car over railroad tracks and

Figure 25.5. I-15 demo of automated highways systems.

get somewhere (though it may be a bumpy ride), it would be difficult to take a train and drive on streets (it would keep going straight until it hit something).

Second, much knowledge was gained about the specific technologies, which ones work, which do not, and which can be adapted to other technology paths, for example, intelligent vehicles.

Most participants in ITS work would probably agree with these conclusions. The interpretations we shall make now require modest to major stretches. Even so, we make them because we think they may lie behind the faltering of the ITS national program and applications such as the Twin Cities ramp metering.

It is a modest stretch to speculate that the inherently disjointed nature of the structures of the auto-highway and truck-highway systems is a major shaper of technology improvement. "You can't count on other people to do things" is the reason heard most often for compartmentalizing development efforts to drivers (navigation systems), automobiles (intelligent cruise control and vehicle braking), and highways (traffic flow sensors and ramp metering).

It is a bit more of a stretch to ask "Why can't one count on others?" The mismatch of institutional norms (which may create adversarial relations) and controls (political or market) might be a partial answer and lack of motive for joint efforts another. Glory, status, and feelgood rewards motivate only so much. The motive that counts is making the profits or capturing the rents, saving time, or what have you. "What is mine is mine" is at work. This point about who captures the rents has already been made, but it bears underlining in the institutional context.

Stretching some more, there is a clash of cultures. To illustrate, ramp metering aims to make the best use of agency resources and minimize total delay. Perhaps drivers see this as inequitable because some are stuck in traffic while others speed by. Is the agency limiting my use of common property (the road)? Some see it one way, others another.

Leaving stretching aside, this discussion will turn to planning, scoping, and standards topics that bear on technology development.

Planning Technology

The issue is not *whether* technology is incorporated in planning processes, but rather *how* it is incorporated. The urban transportation planning process (see chapter 21), which was developed for a growing mode (highways) and is now applied to mature ones (highways and transit), does not explicitly recognize technology. Rather it takes technology as a given and fails to consider change in technology. At best, some kludges to test new technology are incorporated as network elements and demand shifts, often computed with "postprocessors."

Fortunately, the urban transportation planning process is not the only one. Other planning efforts consider technology in different ways as the life cycle progresses. As the predominant technology emerges, hard and soft technologies receive much attention. They are used as building blocks for system designs. Here the issues are how widely innovators scope for building blocks and the decisions made as designs are frozen by standards. During this period the process is not ergodic. Each decision made by "historical accident" will not be smoothed out by future actions. A history-dependent path is created.

Technology is also an agent for planning as a system grows to maturity. Hard and soft technological standards constrain the planning process. They also serve as objectives, for planning seeks to put those technologies in place in some desirable way.

At maturity one issue is operations; other issues have to do with productivity declines, market channeling, repair and maintenance. Mensch (1979) uses the word "pseudo-innovations" for related technology efforts. That word recognizes that there is not much to be accomplished by tweaking a mature system. Our view is negative, but not as negative as Mensch. For one thing, we begin to see some cross-component work, such as ITS. There is also a willingness to bring in some "outside of the system" technologies, such as those being incorporated in railroad control systems.

Because of the division of labor between design and policy, planners often assume that technology considerations are being managed elsewhere. There are good reasons for division of labor. The large number of people involved in technology fields and the large literature suggests that technology is being taken care of elsewhere. We can understand the planner's assumption. However, the reader of this text will recognize that it is, of course, an unacceptable assumption for transportation.

Hard and Soft

Should hard or soft technologies be emphasized? Which aspect of technology, the hard or the soft, is instrumental in leading off change? It is important to have a clear answer to that question if we wish to use technology as a planning instrument.

Consider how the rail system came about. The steam engine, coal fuel, tramways, and so on, came together into a workable system format. That workable format called for soft operations, financial, legal, and institutional technologies. That took about 15 years, and when the hard and soft were in place the system was ready for deployment and the changes in technology that deployment required. Box 25.1 considers the idea queue (illustrated in figure 25.6), which is related to the speed at which new technologies can and should be deployed, and which relates both hard and soft aspects of technology.

Such a discussion is neat, but we do not regard it as sufficiently deep to serve our search for causality and critical instruments. The reason is that it does not deal with what was behind the first step: what caused the building blocks of the steam engine, tramways, and so on, to be melded into a system? Those building blocks were ripe for use; the technology was ready. But they were melded into a system by wise innovators, in particular situations, and for particular social and economic purposes.

That reaching for "why" says that the soft side is of interest along with the building blocks or tools. Indeed, the first question is how and why people do innovative things.

This observation changes the question. It is not a matter of emphasizing either the hard or the soft side of a technology. Interest must be on the process through which the hard and soft are born, the innovation process. That is where to start.

Standards and Orthostandards

There are two related meanings for the word "standard" that are of interest to transportation professionals. The first has to do with compatibility. The idea traces from

BOX 25.1 The Idea Queue

Queueing models describe how much delay there is in a system, by looking at when the system is entered and when it is exited. For instance, if a vehicle enters a queue at 6:00 and exits at 6:15, it experiences 15 minutes of delay. One could sum up that time for all vehicles, and estimate total delay. Everett Rogers (1962) has implicitly extended that concept to ideas or technologies themselves; they enter the queue when the knowledge is gained, they exit when the technology is deployed. Since knowledge itself faces a deployment process, this would give us an indication of the speed of take-up of a technology.

The risk remains of overadoption—the case when technologies are taken up too soon. Plank roads for instance, discussed in box 12.3, were adopted before their full life cycle was understood, and they failed prematurely. Some patience with deployment would have been warranted there. In other cases, deployment of what turn out to be successful technologies is choked off and slowed because of a lack of capital. Delay is not of itself to be minimized, but rather traded off against the costs of rushing deployments, costs that arise because not all cost-saving innovations have yet to be wrung from the system and because of the extra expenses incurred in speeding deployment (for instance, more construction workers are used for a shorter period of time, rather than training and using fewer workers over a longer period).

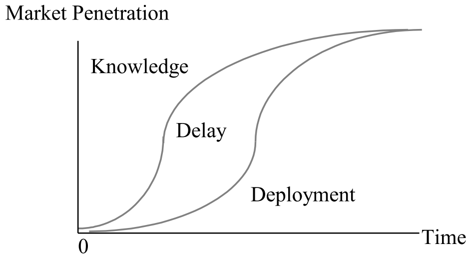


Figure 25.6. The idea queue.

interchangeable parts; we want a standard to ensure that part A from one manufacturer can fit with part B from a second manufacturer. It is contrasted with "custom." The second has to do with quality or performance, for example, achieving a level of service (LOS) standard, which we shall call "orthostandards" (meaning "correct standard") to avoid confusion. We may want to ensure that we meet the orthostandard that the road operates at LOS C or better, and shall use that orthostandard to decide how many lanes the road should have.

Both types of standards serve to ensure consistent design; though one can be thought of as hard and the other as soft, each will translate into the other. Standards are established as systems grow. Often they are simply ratifying whatever decision the first innovator made. An example is George Stephenson's use of what became the standard rail gauge, which remains after nearly two centuries.

The use of classification and standards follows the rationalist-scientific paradigm of the nineteenth and twentieth centuries. However, the extension and ubiquity of normative orthostandards, beyond what is necessary for intersystem compatibility, is more difficult to understand, and here are some thoughts:

1. One has to have orthostandards in order to classify, so orthostandards resulted from the urge to classify.
2. Experts have superior knowledge and can prescribe what is best.
3. While it is true that orthostandards do not fit every case exactly, they fit fairly well and offer great efficiencies in processes of planning and management.
4. Standards and orthostandards support articulation goals. (In the case of roads, standardized driving environments, e.g., signs, are essential.)
5. Without orthostandards, people would cheat (e.g., authority high in the delivery system hierarchy can control dishonesty at lower levels in the hierarchy).
6. Orthostandards support the common carrier, common law, public utility ethic of similar service to citizens in similar circumstances.
7. Consumer protection requires standards and orthostandards (e.g., for safety).
8. Standards and orthostandards reduce construction costs.

Conversations with U.S. DOT staff mainly involve (2), (5), (7) or (8), depending on the subject. But it is difficult to get conversations going. Most engineers and planners seem to take orthostandards as a matter of course, caring about "how" and never worrying "why?"

Transportation professionals are very committee-oriented, and there exist a number of committees to establish all sorts of transportation standards and orthostandards, from uniformity in traffic control devices to what factors to include when determining the value of highway assets. Most of these committees deal with known problems, and are simply ratifying existing procedures, and regularizing them, or choosing among competing alternatives.

However, there is one notable example of trying to put the cart before the horse, so to speak. The transportation community has spent hundreds of thousands of hours and several forests worth of trees to document the National ITS Architecture, defined by its advocates as "a common framework for planning, defining, and integrating intelligent transportation systems." They note that "It is a mature product that reflects the contributions of a broad cross-section of the ITS community (transportation practitioners, systems engineers, system developers, technology specialists, consultants, etc.) over a nine year period" (U.S. DOT/Iteris 2002).

However, there is very little to show for this effort. The few ITS applications in place developed organically (like the Twin Cities ramp metering system, local freeway service patrols, auto-makers' in-vehicle navigation systems like On-Star) rather than as a result of this process. The most successful ITS application, electronic toll collection, has produced transponders that are incompatible between regions, largely because (1) they made decisions and grew independently, (2) they felt no reason to pay more than lip service to the architecture, and (3) the cost of coordination outweighed the benefits of compatibility. However, over time, one expects that compatible transponders will be developed, so that one can use the same device to pay tolls in Maine and California. Either one of the technologies will be selected, and phased in to the other region; or the groups will get together to standardize on a next generation technology that is better, and deploy that over time. ETC transponders and "smart cards" are likely to face a convergent path, as the wireless transmission of money has applications far beyond paying tolls.

Stepping back, we discussed ITS at the beginning of the chapter. ITS was funded for several reasons, improving transportation probably being secondary to helping large defense firms convert to civilian sectors as the Cold War ended. It is no surprise that the defense industry applied their top-down systems-engineering approach that was successful in the weapons-making business to the more target-oriented transportation sector.

An alternative approach would have allowed the technologies to emerge bottom up, and then work toward compatibility and standardization among successful systems. This organic approach is more in keeping with the history of successful technologies in both transportation (there was no National Railroad Architecture, at least not until the era of rationalization, and then it was largely ignored) as well as communications, where the Internet developed without a master plan, but rather a series of decisions (politely called Requests for Comments) made when they were needed. We can consider two other aspects of standardization. Box 25.2 looks at orthostandards as economic decisions. Box 25.3 talks about the rise of professionals in engineering, imposing higher standards on the workforce.

Discussion

Professionals often believe (and it is affirmed by management consultants) that they are engaging in strategic planning when they are doing nothing of the sort. They are merely

BOX 25.2 Orthostandards as Economic Decisions

Economic analysis is applied in highly constrained circumstances. The existence of agreed-upon orthostandards constrains the analysis context. Given the standards, what does analysis say?

Consider the Interstate. Decisions were made about the product. There were a lot of layers to those decisions. They started with the free, limited access design decision, then laid out the general location of freeway links, involved the formulas for the distribution of funding among the states, and, finally, focused on the level of service to be provided. There was much economic content in each decision, but the decisions were regarded as orthostandards somehow detached from economic decisions.

The level of service decision was important. A level of service class C was to be provided on urban freeways (B on rural), and that was targeted on the 30th highest traffic hour for the design year. Although set as a design orthostandard by AASHTO, that was very much an economic decision. There were equity-economic decisions mixed in. All cities got the same service level; the value of time was set "low," and the value of time was the same for all members of the population. From discussions with AASHTO leaders, the decisions were driven by the question: how far will the available money stretch? Urban facilities are expensive to construct relative to rural ones, and that is the reason for the rural–urban difference.

The idea we wish to transmit is this. Orthostandard-setting substitutes for economic analysis. There remains room for economic decisions within the context of the orthostandards that had been set. These residual decisions were important, but small compared to the big standards-setting decisions. We find this a truism in many sectors in addition to highways and the public sector generally.

BOX 25.3 Professional Labor

Engineers are those who use ingenuity to create new technologies. The first searching questions about the social role of engineers were in the noncivil engineering fields. Most of those engineers worked for private organizations. Were the engineers responsible only to the organizations that employed them, or, as professionals, did they have responsibilities to society as a whole? This debate reemerged in the late nineteenth century when the social role of big business was at question, revisiting interests held by James Watt and other engineer-scientists of the times in social matters, interest dampened by the excesses of the French Revolution. This was the "trust busting" era. Layton (1971) reviews the social responsibility debate, which lasted into the 1940s.

The civil engineers were not much involved in that debate. Civil engineering was, even then, an old field and had not much in common with the new fields, such as electrical engineering. There were about 2,000 civil engineers in the United States during the period of canal building. The ASCE was established in 1852. The mining, electrical, and mechanical organizations were not established until the 1880s, and most other engineering professional organizations were not established until the twentieth century.

Most civil engineers worked for government, construction, and consulting organizations. Civils were not "big business" payroll employees. Finally, the civils had a sense of social role, for they were heavily involved in the emerging conservation movement at the onset of the twentieth century.

The civil engineers did no formal joining with those debating. For instance, when Carnegie gave money for a headquarters building for the engineering societies in 1903, the civil engineers elected not to join others in a unified headquarters. This was an important matter, for the societies were seeking strength through unification.

The matter of just what social responsibility meant got messy when Fredrick W. Taylor (a mechanical engineer) began to study engineering efficiency in manufacturing, for example, using time and motion studies. Frank Gilbreth (of *Cheaper by the Dozen* fame) and others rapidly implemented Taylor's notions. Why did things get messy? Taylor's notions gave engineers the tools and concepts so that they could be the "best" managers. The problem was that of reconciling the best manager role (scientific management) with democracy and obligations beyond the place of employment.

The debate continued strong into the 1930s. As late as 1933, Thorstein Veblen saw the engineers as the real social revolutionaries. But the debate began to peter out. Perhaps President Hoover's move from hero to villain in the public eye was a factor. Hoover, an engineer himself, had been a champion of the engineers' views. Perhaps the Great Depression found engineers devoid of usable ideas.

producing pseudo-innovations. Recommendations to undertake more radical technology planning fall on deaf ears; change threatens. Beyond the ways technology has been incorporated in planning, we suggest two additional strategies.

One is begin to incorporate system-changing technologies (in the building block, birthing style) as systems age. The objective would be renewal, one system rising from the ashes of another. A strong argument can be made for this strategy. We strive to create competing technologies once most of the "goodies" have been extracted from the old mode. More important, we know how to do this because the historical record is clear; we just emulate the past.

A more desirable strategy would be to smoothly create new options. This requires forging an *inquiring* style of planning that continually considers and envisions new futures and creates paths toward those futures. Society can then control its future by choosing among alternatives. This *dynamic planning* would create new hooks for the future. An object-oriented approach, to borrow some jargon from computer science, would allow one layer to be removed and replaced without worrying about others. At the micro-level, this can be as simple as ensuring that technologies are extendible. At the macro-level, this involves considering *option value* in decisions. We know that transportation consumes land in specific ways, ground transportation in long strips, sea and air transportation in large, relatively compact ports. Preserving right of way, ensuring that capacity is available, is one way of preserving future options. The problem of course is spending present dollars for future possibilities, which must be discounted.

The need to deal with strategic-technology questions and opportunities is urgent. We have mature systems, and further investment has low, if not negative, returns. The failure of transportation to improve does not bode well for economic and social development (Garrison, 1985). We should use planning to create situations in which there is wise inquiring about new, enhanced futures.

Technology improvements are not new, and advances in ITS-like things pose planning opportunities. The opportunities presented are close-to-the-heart actions by traffic engineers to improve traffic flow. Planning ways of thinking might bring these out of niche applications to networks. For instance, the automated highway idea is consistent with the highway providers' dogma: concentrate resources and achieve economies of scale.

That is soft and general, and to make it understandable the authors would be tempted to use examples of some things to be done (chapter 26 does this). There is a trap here that we have faced in many discussions: the medium (examples) are taken as the message (what to do). Yet the message is not that the technology forms used in the example are the things to do; the message is to explore likely options and let the public choose.

26

Imagination

Mature systems suffocate nascent ones.
—Hughes (1989)

Introduction

This chapter will take a proactive stance, focusing on development *pathways.* It proceeds by illustration. Each section illustrates how with a little imagination pathways might be found. The discussion is hardly exhaustive, and the reader is invited to have fun imagining.

To explain the pathways idea, recall that the urban interstates were built "on the cheap"—they were to provide capacity for some urban trips for a 20-year period. At the time they were planned, no one said "What next?" They were constructed with no room for more capacity within rights of way, and the social and economic costs of more freeways, if not already known at the time freeways were constructed, were soon apparent. We conclude that urban freeways did not open a pathway for managing urban mobility problems. More broadly, we question whether the transportation modes of the developed world provide development pathways for the less developed nations.

Concerns about scarcity of energy and land, rising costs and congestion, and worries about the environment require that we seek alternative transportation development paths. We say alternative because we cannot fully know the shape or scale of the problems. We want to be able to go this way or that (and faster or slower) depending on how situations evolve *and* depending on what we learn as we proceed along paths. An associated idea is that we want flexible paths—flexible because some paths may be found to be more socially desirable than others and it would be nice to have alternatives available. Flexibility is also desired because situations may change: new options to be taken advantage of, problems not now recognized emerge.

It goes without saying that development paths should be sought that offer returns throughout society, are consistent with the built and social environments already in place, build from resources, such as guideways, institutions, and technologies, already available, and so on. All kinds of constraints are set by the properties of the physical and biological worlds. It has been estimated (by Siemens engineers) that if the automobile had been developed as rapidly as semiconductor circuits, today's car would travel at 4,800 km/hr (3,000 mph), weigh less than 60 g (2 oz), go 480,000 km (300,000 miles) on 4.5 liters (1 gallon) of fuel, and cost less than $3.00. Accomplishing that would require breeding smaller people so that they would fit into something smaller than a matchbox. That path does not seem to be feasible. (In defense of transportation, it has also been pointed out that cars do not crash nearly as often as software.)

Our musing about achieving new pathways takes two steps. In the previous chapters, we discussed how transportation consumes energy, land, and capital, and requires human resources, communications, and technology. Here we identify a set of specific problems and suggest what can be done about it. Working toward marginal changes guarantees marginal results. We investigate radical changes with high payoffs, radical changes that are achievable because they improve transportation services. Although the changes we propose may take advantage of new or improved technologies, we do not see these as a requirement for improvements.

Our view is that the behavior of the systems is a consequence of the circumstances of their birth, of the ways the predominant technologies were defined, and the resulting structures and behaviors of the systems. The systems are now rather mature. The problems recognized are symptoms of maturity. Striving to "fix" problems without deep intervention in systems structures results in only superficial changes.

For instance, recent activities in the urban highway arena are marginal actions seeking more productivity and reduced negative externalities from a deployed, mature system. Despite the high cost of Boston's Big Dig, it too is marginal, as it only affects travel in the urban core of one city.

Can we dig deeper? Can actions be imagined, and supported by policies, that would manage perceived and deeper problems and renew the systems? Our answer to those questions is yes. But the present discussion cannot extend to a complete analysis of the systems. Rather, we proceed in two stages to illustrate how system thinking can contribute to policy work:

- First, we illustrate how some problems can be tied to system structure and behavior.
- Second, for each problem, we illustrate how considering changing system features can contribute to problem management.

Accidents

Per distance traveled, large trucks are three times more likely to be involved in fatalities than autos. Trucks take twice as long (or more) to stop as autos. They congest urban traffic. Truck stability on freeway off ramps at posted speeds is a well-documented safety problem. Operators strive to achieve the benefits from operation of longer combination vehicles (LCVs). We are unable to make the investment in road facilities needed by trucks.

The auto-truck-highway system was born and grew as a multipurpose network. The truck versus auto problem is the result. If the system had the adaptive capability of bifurcation (splitting into specialized networks), those (and others) would not be problems.

Conventional actions focus mainly on improved truck brakes and stability when braking, and are achieving modest improvements. If we really wanted to manage that problem, the action to take would be to change system structure: separate autos and trucks (see box 26.1).

Major actions have multiple effects. This same action would offer opportunities for reduced costs: some roads tailored to larger, heavier vehicles, other roads limited to cars and light trucks only. The results might be more efficient road provision and efficiencies in equipment and operations areas.

BOX 26.1 Truck Highways

> *. . . nothing seems more certain than that many special highways will be constructed for motor trucking.*
> —*Roads and Streets,* December 1928, p. 569

Trucks for rural use began to become available in the 1910s and 1920s, ranging upward in size from the Model T Ford with a simple truck bed in the back. At first, these were substituted for wagons for existing farm to market and urban pickup and delivery services.

Although trucks moved materials by road from the Midwest to East Coast ports during World War I, as late as the mid-1920s the wisdom was that only small amounts of intercity freight traffic would ever move by truck. Rail had a firm hold on that market, with air transport having long-term potential for high-priority shipments.

However, by the mid- to late 1930s the development of intercity freight movement by trucks was well under way, enough for Interstate Commerce Commission regulation to begin. The development of the state primary highway system played a major role in the growth of intercity truck services, as did improvements in truck equipment and the skills developed by trucking firms.

The intercity business grew at first in market niches—movement of household goods, agricultural livestock, and automobiles, in particular. Other services and the emergence of the common carrier, private, and owner-operator segments of trucking activities were in place prior to World War II, and they grew very rapidly afterwards.

Questions of the interrelations of equipment and roads emerged as truck axle weights began to be controlled to protect pavements. By the mid-1910s the cities had begun to control weights, their problem, at first, being solid-tire coal hauling and construction vehicles.

By that time, the rural road problem was regarded as tamed by the Federal Office of Public Roads. However, movement of trucks during World War I broke up roads badly, and a search was started for appropriate rural road designs. The Bates (Illinois) and Pittsburg (California) road tests provided information for pavement designs; longstanding bridge structure knowledge was available.

This knowledge, together with information on truck dynamics, was used in the design of state primary and secondary systems and, later, the interstate. Interstate design also drew on the findings of the AASHO road test undertaken in the late 1950s. Compared to the primary systems, the interstate was designed with wider lanes (minimum of 3.6 m [12 ft]), lower grades (3 percent maximum rather than 5), and higher overpass heights, all affecting equipment size. A design velocity of 112 km/hr (70 mph) was incorporated in the interstate. (There are design exceptions on parts of the interstate, e.g., some grades are greater than 3 percent, and many primary and secondary routes have been upgraded to interstate or near interstate standards.)

(continued)

BOX 26.1 Truck Highways—cont'd

Although the federal government working with AASHO developed construction standards for the interstate and also standards for maximum truck size and weight, the latter remained a state matter in many cases, for existing state regulations were exempted when interstate regulations were set. Another way to put the matter is thus: federal weight and size regulations said that the states must allow trucks meeting those standards on the interstate, but the states could allow larger and heavier trucks. (The 1956 Interstate Act limited width to 2.48 m [98 inches], single axle loads to 8,200 kg [18,000 lb], tandems to 14,500 kg [32,000 lb], and gross vehicle weight [GVW] to 33,300 kg [73,280 lb].) In general, the states west of the Mississippi River allowed higher gross and axle weights than those east of the Mississippi, and a north–south band of states (Illinois and southward) had lower axle weight standards than others.)

Responding to the trucking industry's desires, the Federal State Transportation Assistance Act of 1982 (STAA) coopted state control of size and weight on the interstate and on "reasonable access" routes. It raised the maximum axle weight on the interstate, although where states had higher weight limits, these continued. It increased width of equipment from 2.48 m to 2.59 m (98 to 102 inches). It permitted single trailer lengths of 14.6 m (48 ft) and double 8.7 m (28.5 ft) trailers. However, there continues to be pressure for increases in size and weight by the truck community, citing productivity and energy efficiency gains from uniform standards.

The trucking industry also points to the contribution of truck taxes to financing the road system. The DOT and the FHWA find the pressure for increased size and weight a political hot potato.

The trucking industry reports productivity increases of up to 30 percent from increased size and weight. Actions needed to obtain those productivity increases involve providing appropriate access routes to the interstate and sites for terminals. So far as we know, there has been no planning supporting systematic approaches to these actions, and to the coordination of increased truck weights, stronger pavements, and user charges. There should be because of great efficiency gains (Winfrey, 1968). There are also many market niche opportunities (Fawaz and Garrison, 1994).

The 1982 STAA asked for a study of the costs and benefits of a nationwide truck route system for longer combination vehicles (LCVs). Double 48s or triple 28s were the vehicles in mind. These LCVs would run about 33 m (110 ft) in length. Because of the number of axles, they might run 55,000 kg (120,000 lb), well above the 36,000 kg (80,000 lb) usual gross weight limit. There was much interest in the trucking community because a 50 percent gain in productivity was suggested, compared to the pre-1982 STAA situation.

The U.S. FHWA (1985) provided a rather full but inconclusive analysis of the LCVs question. It laid out what could be said about safety, fuel savings, productivity, geographic availability of services, and costs. The study examined the curving and tracking behaviors of vehicles using examples of LCVs in some western states. The cost data address mainly the geometries of interchanges and staging facilities. Costs ranged from about \$0.3 to \$0.6 billion dollars as a one-time investment (about 1/80th of annual highway expenditures).

While the FHWA study was aimed at concluding "no way," it turned out inconclusive because so many signals said "good idea." We think that there is a major opportunity here, and that well-conceived planning would define it. There is nothing new about the idea. Henry Ford was quoted in the *Washington Post* in the 1930s as supporting a regional system of truck highways, and the topic was debated in the Congress at that time.

BOX 26.1 Truck Highways—cont'd

While some designs of *ca.* 1900 for roads separated autos, trucks and wagons, and bicycles, and discussion continued in the 1920s and 1930s of the needs for truck-only highways and auto-only parkways, nothing has materialized. Might those old ideas be interesting ideas today? Samuel et al. (2003) call for such a network. We think the opportunity will remain vague and ill defined until some sort of tactical planning provides concrete ideas.

The STAA standardized and increased the size and weights of truck vehicles allowed on the interstate system, and deregulation legislation in 1980 changed the situation in ICC-regulated trucking.

The 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) recognized and went beyond the interstate by authorizing a more comprehensive National Highway System (NHS). The stated intent was to focus federal funds on roads that are most important for interstate travel and the national defense. These roads also serve as intermodal connectors and are regarded as essential to interstate commerce.

There is no question but that the NHS favors trucks. The NHS consists of the interstate and many primary highways, of which trucks already make intensive use. However, the opportunity to concentrate resources, by creating stronger pavements and bridges and, in turn, allowing heavier or larger truck vehicles, seems not to have been seized.

Benefits and Costs

Real costs are no longer decreasing. Off-system benefits have largely been captured. We observe that, by and large, the system is locked into a 1930s and earlier predominant vehicle technology and a 1930s and 1940s infrastructure technology. Diminishing returns limit what can be done.

Did the interstate in the city create and capture scale effects? That is, did it deliver a product that would work better the greater the traffic? The urban part of the interstate did achieve sharp scale economies for system providers. Even though the per-kilometer costs of urban freeways are very high, the facility cost per vehicle-kilometer of travel is very low when compared to other road facilities. That is because of the heavy traffic. Economies are not so sharply the case for most rural interstate links, where traffic is light.

The facility supplier thus gained much from deploying freeways. Costs were avoided that lower capacity facilities would have required. Did the desire to capture scale economies and avoid costs drive policy and planning?

As a general proposition, it is easy to argue that freeway suppliers did seek scale economies. Knowledge of scale economies so permeates the ambient that everyone knows about them and seeks them. Economies are found in pavements and structures; for example, it doesn't cost much at the margin to, say, double the strength of a pavement or structure. Such economies are very well known to highway providers, to the point of being so obvious (to those already in the field) that no one identifies them explicitly—thus resulting in new players being unaware of their existence.

The decision was taken to provide level of service C urban freeways compared to level of service B rural freeways. That is the reverse of what would be expected if higher quality were supplied in parallel with lower costs. With an average level of service C, congestion is common, and congestion is a diseconomy. (Freeways did, of course, offer improved quality over existing facilities, otherwise they would not be used but for their elimination and severing of older roads.)

Second, the highway supplier's product was viewed as highly desirable at the time decisions were taken. It was very inexpensive to users (compared to the cost of using an automobile) and mechanisms were in place for no-pain financing. Thus suppliers had no sharp motive to minimize costs.

The simplest explanation for the design of urban freeways may well be the one given elsewhere in this text. Long-lasting designs were desired; there was a limited system. The high-capacity freeway fit those criteria.

Can the benefit/cost proposition that makes urban highways a good investment be restored? This is unlikely, particularly with the overconsumption of roadways that underpricing generates. However, there are plenty of good, though marginal, investments that can be made to improve the operations of urban highways, using the simpler of the technologies collectively called intelligent transportation systems (ITS) (Garrison and Ward, 2000).

In current processes, we do not properly value our highways (we do not even know what they are worth). We could move from cost-to-build to damage-based costing and taxing. Transportation networks and governments are both hierarchically organized. In some states most highways are financed by state governments, while in other states similar roads are financed locally. Larger governments attain scale economies. However, they also tend to be more bureaucratic and have higher operating costs, all else being equal, due to problems such as *span of control*. After determining the appropriate organization for control (state or local government, or adjoining landowners, or private firms), across-the-board changes could occur in highway classifications, standards, and so on, along with selective upgrading and downgrading of facilities, and route abandonment. Along with restricting federal activities to roads where there is a clear national interest (and state activities similarly), we can achieve a more optimal investment pattern in the allocation of management between state and local government (Levinson and Yerra, 2002). An important caveat is that road functions change over time with changes in urban form and economic activity. The classification of the road and the level of government responsible for the road should change concomitantly. For a look at economies of scale in a new mode, see box 26.2.

Congestion

Highways suffer from congestion in large urban areas, a feature that is easy to explain if we accept the notion of "capacity." Highways, like most other transportation facilities, can be modeled as funnels. The base of the funnel represents a bottleneck (literally as well as figuratively), and if more cars are poured in at the wide top, and the speed at the bottom is not increased, queueing results, and only a fixed maximum flow can come out the narrow bottom. The problem arises when the top of the funnel is widened but the base remains constrained, or when more traffic chooses to use the freeway than alternatives. The problem is made worse because the construction of the freeway cuts off many alternative local streets.

BOX 26.2 Personal Rapid Transit: Imagination in Search of a Market

Personal Rapid Transit (PRT) systems are a hybrid between transit and the private vehicle. In a sense, they can be thought of as horizontal elevators; you enter a small car, push your destination, and the vehicle takes you there. The vehicle carries one to four individuals, typically along an elevated guideway. Unlike traditional elevators, the guideway is such that vehicles can pass each other, so that passengers can reach their destination without stops along the way. The uses for such systems vary, from within-airport transportation to urban circulators. The technology does have its promoters; for instance, Mechanical Engineering Professor Edward Anderson of the University of Minnesota, who holds patents on a number of related technologies, formed the company Taxi2000 (which used to sound more futuristic than it does presently). Taxi2000 is pushing its "Skyweb Express" system and has constructed a test facility.

Promoters claim that PRT can become an important part of the urban transportation scene. Yet despite some demonstrations of technical feasibility, no city has deployed one.

Sydney has constructed a lightweight urban monorail, which serves similar market niches, as do people movers (e.g., Detroit and Miami). However, those systems have fixed stops, and have not been widely lauded or imitated outside of airports and amusement parks.

Serious PRT development can be traced to the 1950s, when Edward Haltom developed the "Monocab," which was suspended from an overhead guideway that needed to move for switching. Its disadvantages were its height, resulting in cantilever posts that increased the cost and visual impact of the system. Under the Urban Mass Transit Administration a different PRT system was deployed at Morgantown, West Virginia, in the 1970s. It was very simple with stops at two ends, serving a college market, and though technologically successful, not the kind of large market that promoters sought. U.S. federal government funding for research in the area was withdrawn in the 1980s, as efforts focused on more conventional rail transit systems.

In France, a great deal of effort went into developing the technology called ARAMIS, a PRT that allowed vehicles to couple and decouple to gain some of the advantages of trains. The system was sufficiently complex, without enough political champions, and suffered from scope creep as the design specifications of the project were a moving target. Despite, or perhaps because of, its visionary nature, it failed before deployment (Latour, 1996).

Over the course of time, a number of other attempts at deploying these types of systems have been made (Anderson, 1996, 1997, 1999; Burke, 1979; Rydell, 2000). The latest hope is in Cardiff, Wales (APTA, 2002), where the Urban Light Transport (ULTra) began testing its system in 2002. It is claimed that the initial tests of the vehicle and the track working together under fully automatic control have been successful, and it is hoped that a revenue-producing system will be operational by 2005 (Lowson, 2002).

PRT applies imagination to envision a new mode, comprising new networks and new vehicles, and for that reason is to be praised. But maybe it reaches too far. A truly new combination of networks and vehicles has seldom been deployed in the history of transportation. One might suppose the railroad to be the best example of such a deployment. As we saw, even it drew on antecedents in mining operations, where animal-drawn carts on tracks were used to move coal. Prior to that, of course, there were already animal drawn-carts on roads. Elevators are another similar technology, where automation replaced labor (and, in general, elevators were not feasible when relying on animal or human labor, and so were rare prior to automation).

(continued)

BOX 26.2 Personal Rapid Transit: Imagination in Search of a Market—cont'd

Other technologies either used natural networks (shipping, aviation) or existing roads (automobiles). While the modes using natural networks still required new nodes, a point-based facility (port or airport) is much easier to deploy than a line. Eventually, as autos began to be widespread, old roads were upgraded and new roads constructed to accommodate them, but it can be seen as a process of coevolution: vehicles use existing network, the network is upgraded to accommodate new vehicles, the vehicles are upgraded to best fit the new network.

Proponents such as Anderson claim that government policies are preventing their technology. While government may not be helping much, we think that the problem is more fundamental. PRT, like automated highway systems, requires developing vehicles that can only use the PRT network. Because of network effects, the value of building a PRT system increases with the size of the system, and when fully blown may actually meet some of the promoters' goals. The problem is the lack of value in a small system, and any system will initially be small. Yet it will require a high fixed cost just to get going. Technologies are first proven in small market niches and then expanded, not deployed widely on promise. Thus there is no deployment path to PRT. To date, the market niche where a PRT is better than a moving sidewalk, people mover, the automobile, or conventional transit waits to be found.

Limited access highways, compared with the grid-like routes they replaced, increased average speed, but increased the variability of speed as well. Furthermore, they interrupted the existing grid system making the road network less reliable. Thus the systems were more vulnerable to failures.

Congestion is present in every transportation system. We have it in spades in urban areas facing both cars and trucks. It results from the temporal patterns of demand and the ways costs limit the capacity that can be supplied. In the 1930s we designed a "gold-plated" intercity toll system. In the 1950s and 1960s those designs were carried forward for the untolled rural interstate, which was then extended (untolled) into urban areas. That system concentrates traffic, coopts local and arterial street developments, and so on. It is a single solution to a highly diverse problem.

New electronic toll collection technologies change how revenue can be collected, and allow road managers to tie the collection of revenue to the management of roadways (charging higher tolls during peak times, thereby discouraging use, charging lower tolls during off-peak times, thereby encouraging use). But the savings in terms of reduced delay are earned by the users, while the costs of collecting tolls (which is higher than gas taxes) is borne by the highway agency. The incentives for highway agencies to implement management that would benefit a majority of users is just not there, unless they increase their revenue collected—which would be perceived by users as another tax.

As noted in chapter 12, pricing in various forms has been around a long time. Recent experiments show that varying prices by time of day (SR91 in Orange County, California), location (Singapore, Rome, and London), and level of use (I-15 HOT lane in San Diego) can successfully manage road demand.

We imagine toll roads to be a good idea, but developers should be fully aware of the difficulties. Politically, the conversion of existing "free lanes" raises a number of equity questions. On the other hand, when the basic vehicle engine is no longer gasoline powered, the existing financing system will collapse, and an alternative must be found. Moreover, while pricing may seem politically difficult, and pricing existing facilities will not really increase capacity, the technique of real-time road pricing can be used to finance new layers of transportation services. The truck highways discussed above are one alternative; for passenger demand, see box 26.3.

The Disadvantaged

The urban highway system substituted only in part for transit, and many of transit's problems result from a failure of the auto-highway system. For instance, there is an

BOX 26.3 HOT Networks

In the late 1990s, high-occupancy toll (HOT) lanes that would allow single occupant vehicles to use HOV lanes (after paying a toll which depends on the level of demand) began to be considered in many U.S. metropolitan areas. The introduction to chapter 22 discusses the history of HOV lanes. HOT lanes were introduced on I-15 in San Diego, for instance, using the same facility that had been the testbed for the Automated Highway Systems experiment described in chapter 25, and have generally been viewed as successful. The revenue generated after paying for operating the facility helps subsidize transit in the corridor.

Seeing the success of I-15, as well as a handful of other HOT lanes, Robert Poole and Ken Orski (2003) published a study calling for networks of HOT lanes (or HOT networks) in major U.S. cities. They conclude that the benefits of such a system (including congestion reduction for those not using the system) outweigh the costs.

While pricing every congested road using marginal cost pricing may increase system efficiency, providing differentiated services further enhances efficiency. We recognize that different types of freight have different priorities (overnight, two-day, and ground are choices for shipping); that same kind of differentiation applies to drivers. Different drivers have different values of time at different times of the day. Thus the ability to pay a premium and travel at a better level of service during peak times provides a service not currently available, a service enabled by bundling several ideas. The old idea is tolls themselves, whose original intent was simply to raise revenue. Electronic toll collection complements that; its original intent was simply to automate the collection of tolls at traditional tollbooths, reducing both traveler delay and agency operating costs. HOV lanes aimed at giving priority to vehicles carrying more passengers (vehicles that had a higher value of time, since two people are more than one).

The HOT networks also provide the ability to provide bus rapid transit (BRT) services in metropolitan areas, by providing the high-speed limited access routes that give transit a travel time advantage over the automobiles not paying for the HOT lanes. In many situations, buses are more cost effective than fixed rail alternatives, but the lack of a fast right of way leads people to perceive rail as inherently faster than the bus. With BRT, that perception can be made to disappear.

inability to provide high-quality personal transportation services to the poor, physically (and mentally) disabled, the elderly, or children. Moreover, this is a growing problem in the developed world, as the populations of the elderly and nonnative speakers are increasing rapidly (table 26.1).

Spanhake (2001) summarized “listening sessions” allowing transportation service providers to discuss the special issues concerning their clients. Each group has separate problems.

The elderly find giving up the flexibility of the automobile very traumatic. Rather than seek assistance or use transit (which may not go to the desired destination anyway and is perceived as dangerous), many will forgo trips and activities.

The challenge facing the disabled is not the loss of flexibility, it is its absence. The transportation system is designed for the physically able, the disabled are considered an afterthought. The trend toward community-based living compounds the problem, as many communities are poorly served by transit.

Many developmentally disabled individuals require supervision when traveling, greatly restricting options, and thus flexibility. Transfers become especially burdensome, as a single transit driver can no longer be counted on to keep an eye out for the traveler.

Poor families, especially those working poor who have multiple jobs but no vehicle, may need to work shifts during which no transit is provided. Day care services may be

Table 26.1 Size of Transportation Disadvantaged Populations

Group	Population	Share
Elderly		
65 years and over	31,241,831	(12.6%)
85 years and over	3,080,165	(1.2%)
Disabled		
Persons 16 to 64 years with a mobility or self-care limitation	7,214,762	(4.6%)
Persons 65 years and over with a mobility or self-care limitation	29,563,511	(20.1%)
The poor		
Persons below the poverty level	31,742,864	(13.1%)
Families below the poverty level	6,487,515	(10.0%)
Non-English-speaking		
Speak a language other than English	31,844,979	(7.4%)
Speak a language other than English and do not speak English very well	13,982,502	(6.1%)
Children		
Under 18 years	63,604,432	(25.6%)
Under 5 years	18,354,443	(7.4%)

Source: 1990 United States Census.

available, and provide a safe environment for poor children, but a safe means to get between the service and home is also required.

The automobile still requires both driving skills and capital. In previous eras, the transit network was sufficient to serve almost all users. However, the reduction in transit demand and the transformation of the urban landscape have worsened transit service for those who still depend on it. A negative effect of the auto is worse transit. Fixed route public transit systems cannot provide the kind of point-to-point services the transportation disadvantaged require.

If we relax a policy constraint—only fixed route public transit systems can provide transit services—we imagine many more services for specific populations of the transportation disadvantaged. A number of suggestions along these lines have been made in numerous research articles, yet the transit monopoly is reluctant (for obvious reasons) to let go (DeSoto, 1989; Klein et al, 1997; Richmond, 2001). There is a reluctance to allow taxis to be the service provider for the transportation disadvantaged. At best there are paratransit (on-demand) services. Most cities prohibit private jitney services.

Over the longer term, we imagine that truly intelligent vehicles (that can operate both on and off special facilities) might be of use. If the physical and mental abilities of the driver were no longer factors in ensuring a safe trip, travelers (or their guardians) could simply instruct the vehicle where to go. For another approach to providing infrastructure for the physically disabled, see box 26.4.

Energy

We seek fuel efficiency for a variety of reasons, geopolitical, economic, and environmental. It is a vehicle matter, but change in the fuel for automobiles is constrained by other components of the system fuel supply. This sharply limits what can be done. Disjointed decision-making, lack of incentives, and rules fashioned decades ago help prevent this from happening. For instance, the Corporate Average Fuel Economy (CAFE) standards, which have turned out to be relatively successful, and which were developed after the fuel shortfalls of the 1970s, applied to cars. Yet more than half of all “cars” are now trucks (pickups, sport utility vehicles).

To move a person 1 km requires that we move along a ton or more of tare weight (the auto), and the movement of 1 ton of freight also requires, at best, that we move a ton of equipment. That is resource-demanding. It constrains what we can expect to achieve from energy conservation efforts. It makes the services more expensive than they need to be. Just the room it takes to move tare weight is demanding of facility investment.

The system is locked in by design decisions made in earlier days. Modern vehicle equipment is descended from beefed-up wagons and buggies. It is the result of incremental change. No other kinds of changes can be easily made. The reduction in the weight of automobiles has had safety and ride quality costs, and has hardly reduced the costs of vehicles.

In a conversation with some auto manufacturers we found that they have a policy of internalizing all improvements in the vehicle. “We cannot expect the highway people to do anything.” (We were discussing vehicle guidance systems. The company will use expensive inertial devices to track location rather than off-board fixed facilities.) We find

BOX 26.4 Universal Design

> *Universal design is the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design.*
>
> —Ron Mace

The problems that transportation disadvantaged individuals face are similar to, but more severe than, the problems that the rest of the population sees on a day-to-day basis. Take for instance the simple question of which bus goes from the bus stop nearest my home to downtown. When going to the bus stop, is information provided other than the simple sign saying "Bus Stop"? Many stops do not even identify routes, much less schedules. Without a guide (either person or documentation), using the system entails taking great risks, among them the risk of winding up across town from your desired destination and being hours late. The relatively simple but seemingly revolutionary idea of providing information with the service may help. For instance, operators should make the signage clear so the bus stop can be found, make clear the route number, route end points, and the direction toward which the user needs to travel at the bus stop; make clear when the bus is coming, especially when service is infrequent; and clearly convey to the user when he or she should get off the bus (which may require more than drivers announcing the bus stops as the bus travels the route). While this may be critical for those who are unfamiliar with the location (tourists) or the language (immigrants), it is also important for those who are cognitively challenged, and would probably provide a much better travel experience for those who lack special difficulties. Some transit systems do this, especially in downtown areas. Others would rather spend money on new rail construction (seeking new, wealthier customers) than make the existing bus system (serving existing, poorer customers) work well.

To provide another example, when the Americans with Disabilities Act was passed, a major concern was retrofitting buses with elevators to accommodate wheelchairs. Buses traditionally had steps leading from the ground to the level where passengers sit. A more universal design would lower the floor of the bus (and gradually raise the level of the ground at the bus stop) so that wheelchairs could roll onto the vehicle, the way that occurs on many subway systems. Such a system would benefit many others with poor knees who can walk but find steps difficult. The lowering of the floor of buses is becoming more common, the raising of bus stops less so.

Having a universal design assists those who need the assistance while benefiting others. The principles of universal design (Center for Universal Design, 1997) are a set of values, but they are hard to disagree with:

1. *Equitable use:* The design is useful and marketable to people with diverse abilities.
2. *Flexibility in use:* The design accommodates a wide range of individual preferences and abilities.
3. *Simple and intuitive:* Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.
4. *Perceptible information:* The design communicates necessary information effectively to the user regardless of ambient conditions or the user's sensory abilities.
5. *Tolerance for error*: The design minimizes hazards and the adverse consequences of accidental or unintended actions.
6. *Low physical effort:* The design can be used efficiently and comfortably and with a minimum of fatigue.
7. *Size and space for approach and use:* Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, and mobility.

especially in the highway sector that because vehicles, vehicle trips, and highways are produced separately (unlike in railroads, where a single organization specifies vehicles, operates them, and controls the track), highly disjointed behavior restricts development options (see box 26.5).

BOX 26.5 Adapting to Very Small Cars

For some years, Garrison has explored redesign of personal highway transportation. Similar to the exploration of trucking options, the effort has been to build from existing technologies and institutions, as well as market niches. Designs have striven to specialize and optimize vehicles, roads, and operations. Neighborhood and commuter market niches have received priority. We sense that the sticky question in deployment is changing road designs, and have given such designs attention (figure 26.1).

Consider now the collection of problems involving pollution, energy use, and access to the auto system. They flow from predominant design characteristics. As a result of those characteristics, there is a lot of mass in vehicles. So let us intervene in the system to reduce mass (see box 19.1). With current technology, a passenger vehicle can be built for about one-half the cost of a compact car. It would weigh about 225 kg (500 lb), achieve 80 km/liter (200 mpg), and have high performance, say, 0 to 95 km/hr (60 mph) in 6 seconds. A lower performance vehicle would cost even less (for example, see Riley, 1994). Figure 26.2 shows a conventional electric vehicle design.

Amory and Hunter Lovins at the Snowmass Institute have developed a concept for a standard volume but low mass "hypercar" which, by using advanced materials, combustion devices, and energy storage, achieves 38 km/liter (90 mpg). They believe this automobile can be made available at a price acceptable to the market by early in the twenty-first century, and that over the long term, efficiency can be doubled (Rocky Mountain Institute, 2003). While the product technology information put forth sounds reasonable, there is an enormous assumption that somehow production for mass markets will greatly decrease production costs.

A vehicle called the Tango holds similar promise; it is small and skinny but not light, primarily because of its batteries. However, because of limited production runs, it is being sold in kits costing $85,000. It is hoped that mass production would drive down costs.

With small amounts of energy use, energy and pollution problems are sharply reduced. The small cross-section suggests more efficient road use and parking yielding major changes in congestion problems. The high-performance version could be used for commuting with salutary effects on accessibility to jobs and residential sites. The low-performance version might be used for neighborhood travel. Low cost and simple to operate, it would ease access (to the system) problems for the poor and elderly, and it would reduce insult to residential areas.

So why hasn't the market pulled small vehicle development and sales except in small market niches? We suppose that current protocols for facility design are a limiting factor (Garrison and Ward, 2000).

The general idea of specialized vehicles, roads, and operations is beginning to find markets. Disney considered it for the Celebration, New Town in Florida and others at the Research Triangle Institute in North Carolina have as well, for example. Several vehicle manufacturers have inquired, and the idea has been introduced to the Society of Automotive Engineers (SAE) community. A match exists between the idea and planning notions of new urbanist villages.

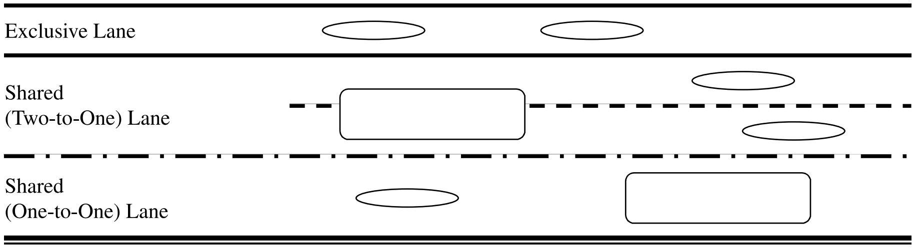


Figure 26.1. Accommodating commuter cars on existing roads.

Figure 26.2. Electric vehicle, Kyoto. (Photo by DML.)

Freight

Movement of freight within cities remains a problem. Urban goods movement planning was mandated, but not funded, as an element of the urban transportation planning process. Few metropolitan transportation agencies have given goods movement priority.

Overall, interest in urban goods movement has grown, a few professionals are interested, and sufficient work has been done to outline the magnitudes of movements, some of their consequences (especially on traffic congestion), and to identify some project-level concerns, for instance, location of terminals. Data are very much a problem, and data limitations limit the ability to identify and seek solutions to problems. (See box 14.2

for a conventional illustration—though considered innovative by most practitioners—of solving urban freight problems.) There are many paths we can take to fix freight problems (see boxes 26.6–26.8).

Discussion

The objective was not to say that certain products (separate truck highways, an Alameda Corridor) are the answer to problems. The discussion was to illustrate how system thinking offers ways to consider policy options. No discussion of how to proceed was stated. The policy question is: how do we forge policies so that system behavior manages problems? That is, we wish that transportation systems had capabilities to learn, reorganize, and renew themselves. They should be testing markets and changing the services they are able to deliver. They should be using technology as an instrument for change. They should have the capability to react to problems in full ways.

No large, complex system has those capabilities to a high degree. We do not know if transportation systems as a class are worse or better than other complex systems.

BOX 26.6 Old Paths Reinvented

The New York Air Brake Company (along with CSX) has developed an Iron Highway concept (figure 26.3), a 366 m (1,200 ft) series of flat cars with an engine at each end, linked by automatic couplers, hinged ramps in the middle of each train allowing trucks to drive on and off. The market niche envisioned may be characterized as "thin market." The train has operating characteristics permitting it to stop here and there for pickup or discharge of a few units. The Roadrailer (sponsored by competing railroad Norfolk Southern) is a competitor to the concept discussed here. The Iron Highway distributed power concept is a good one, and the train should have a good ratio of gross to tare weight. It might open a path.

BOX 26.7 Recombining the Building Blocks for Truck Collector Service

Fawaz and Garrison (1994) have explored designs and market niches building from today's roads and trucks. The market niche examined was the haulage of grain from farms to local (country) elevators and from local to large elevators. Optimizing equipment size and weight, road characteristics, and operating protocols, it was found that large trucks operating at low speeds on unsurfaced roads offered considerable efficiencies (figure 26.4 shows the truck design).

This was a very conservative approach, in the sense that it built from existing ways of doing things—equipment technology, the road system and its protocols, and the ways grain is moved. The decisions to be made if such haulage were to emerge and the distribution of costs and benefits were considered and other types of designs and market niches were imagined by the researchers.

BOX 26.8 Laying a New Path

Our Chicago to Texas piggybacks run like the wind, covering 900 miles [1,450 km] in less than 36 hours.
—Schordock (1985)

There are many paths for freight transportation that might be followed. The path discussed might evolve in different directions and it illustrates thinking about paths. The example to be used was considered seriously some years ago by a major railroad.

Imagine moving bulk freight in the vehicle illustrated in figure 26.5. It is, say, 5 m (16 ft) in width (so can fit on existing rail right of way) and has a near-square shape (which maximizes content versus structure requirements). It is not trained in coupled cars behind a locomotive (avoiding the requirements for strength and, thus, car weight imposed by training). The single car arrangement permits rolling downhill and increased recapture of potential energy from velocity or hill climbing. The body of the car sits inside the wheels for a low center of gravity. It could use steel wheel on steel plates (low rolling resistance, no flanges to rub) or run on gravel or asphalt surfaces.

If the vehicle grossed at 100 tons, a 75 kW (100 hp) diesel engine would suffice (likely less). The engine drives an alternator powering motors on each wheel. Clearly it could do much better than current practice. Low velocity, say, 16 to 32 km/hr (10 to 20 mph) avoids energy losses due to air resistance. Low velocity is acceptable. We have in mind the movement of low-value bulk commodities, and their value of time is low. It is the time from A to B that is of interest and the precision of schedule-keeping that counts. Consider the quote above by Schordock. The Union Pacific Railroad is noted for running fast trains, and it does (127 km/hr [79 mph] is common). But by our calculation 1,450 km/36 hours = 40 km/hr (25 mph), and this is for priority rather than bulk freight. What is going on: stops in yards, crew changes, waiting on sidings, and so on? We imagine cars moving at relatively slow speeds, but moving from point to point without stopping and without buffer time in yards.

The scheme is open to new technologies of many kinds: wire following and automation (no train operator needed), onboard (e.g., flywheel) or offboard energy storage (flywheel, pumped storage of water), alternative fuels, alternative propulsion devices, electrification of high-density lines, new materials, and so on. These technologies would be within a system design where they could be very effective. The design (or variations on it) might be effective in many kinds of market niches and at different market scales. For example, if high throughput is required, cars could run on very short headways. Infrequent cars on simple guideways would do for low-density routes. Put another way, the design might develop on this pathway or that depending on technology evolution, service requirements, and so on. To ensure safety, low speed avoids the need for grade separations. Velocity could be tailored to crossing situations.

The proposal uses existing guideways, is quiet, and opens a path toward reduced energy use. The shipment of merchandise (general freight) poses a more difficult problem than the shipment of bulk. Yet this bulk scheme may be a way to at least partially finesse the nonbulk shipment problem. Imagine a building design, say, in the Bay Area. Specifications are written for windows and they say when the windows are to be delivered. Rather than the designer looking up standard windows, the window designs are specific to the building (granting the designer more degrees of freedom). A local shop wins the bid. That shop (in tomorrow's world) has computer-controlled cutting and forming machinery. Rather than shipping windows from some distant factory, aluminum and glass are shipped in bulk and formed into windows on or near the construction site on an as-needed basis.

BOX 26.8 Laying a New Path—cont'd

For another example, wine is shipped in bulk and bottled locally on demand. We are suggesting that new forms of bulk shipment might combine with the computer and control revolution to produce more efficient and sustainable industry configurations.

Although striving toward sustainability may reduce coal movements, today's coal movements might provide an opening market niche. In Appalachia there are many medium-size mines that are difficult to serve because of their small output. Ideally, as is the case in the western United States, several unit trains are loaded at a mine daily. But many Appalachian mines do not produce enough coal for low-cost unit train service at the mine. Cars have to be collected, often over some distance, to yards for train makeup. At first using power cars pushing today's rail cars, a market niche might be found in Appalachia. That is blocked by high labor cost today—a minimum of two crew per train. But there are completely automated trains (e.g., in the Four Corners mining area), and automation might be feasible elsewhere. Short-line railroads serve many market niches and are not so burdened by crew costs. They might provide a place to start.

The step between starting with conventional rail equipment and creating specially configured equipment and guideway (as in figure 26.5) might be taken in a niche where vehicles are dedicated to service and not interchanges for haulage beyond the market niche. Such a niche might be at a gypsum mine, a cement plant, or where aggregate haulage is undertaken (there are already specialized aggregate haulage trains). Conventional tracks could be retained in the center of the guideway. The typical 5 m (16 ft) width of the vehicles would pose a problem in places where bridge structures and tunnels limit clearance. We see no particular institutional or fiscal problems, except for the current railroad low rate of return that limits the capital available to railroads and labor contracts. These would impose some transition friction.

Figure 26.3. The Iron Highway concept. (Image courtesy of CSX, http://www.csx.com/aboutus/company/image/csxi_trucks.shtml.)

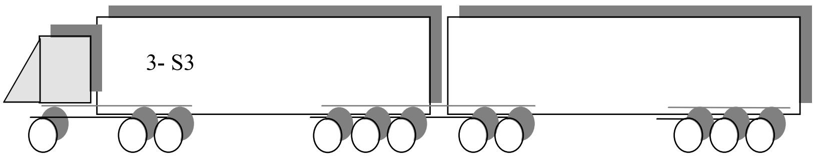


Figure 26.4. Truck for grain hauling.

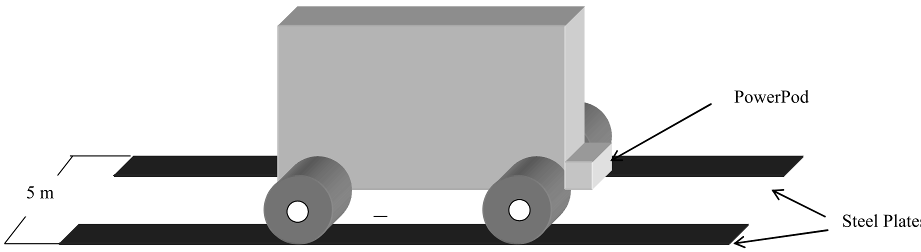


Figure 26.5. A bulk commodity vehicle and guideway.

The disjointed nature of decision making by facility suppliers and system operators (users) is one devil, as we have stressed over and over again. We think that the urban auto- and truck-highway systems are "worst case" transportation systems, closely followed by the air system. Within the urban highway system, we think that fixed facilities are the "worst case" component. They limit the options available.

What must we do? First, we need to recognize that problems are rooted in structure and behavior; second, we need to ask how structure and behavior might be changed; and third, we need policies supporting the actions needed to change structure and behavior.

The question of how structure and behavior might be changed is answered in part by consideration of actions not taken when the systems are developed. Taking some of those actions is an option. Actions should be consistent with social trends (specialize the systems) and problem management (e.g., sharp reductions in energy use, urban congestion, and environmental impacts).

What kinds of policies are needed to support change? System histories answer that question:

- Policy should support innovative individuals and institutions exploring niche-specific markets.
- Policy should give priority to new combinations. The old will enter those combinations, for instance, the extensive right of way of the highway system. Many new technologies might enter, such as developments in electronics.
- Policy should recognize resource constraints and ecological realities.
- Policy should also recognize that successful transformations will track social and economic development trends.

We think that the four general statements just made should guide policy, but are well aware that most policy makers would want something more specific. Being somewhat more specific and paying attention only to the highway system, which is the main focus of policy, one might suggest rethinking the scopes of federal, state, and local interest in the financing and provision of facilities. We think that exercise would result in a much reduced federal presence in the highway arena. However, there are other considerations. The second consideration is the federal interest in productivity increases and economic growth. That, as we see it, gives the federal government a role in efforts to improve services and the policies to support change just discussed. The third and final consideration is federal interest in health (safety, clean air). Again, we return to the policies to support change just listed.

Thomas P. Hughes (1989) has pointed out that "mature systems suffocate nascent ones" (p. 461). Might the development path we are on suffocate the concepts presented here?

As just remarked, many policy makers want specifics, and one way to generate suggestions is to think about markets. What about high-priority freight, small shipments of bulk freight, collector-distributor freight, passengers, and so on?

One may think about existing or emerging technologies that might enter as building blocks in new endeavors. There is much more than the new propulsion, information, and computer technologies so often mentioned. For example, existing tunneling and pumping (for air pressure reduction) technologies suggest vehicles in tunnels moving in a partial vacuum. Applications might be found in passenger and priority freight markets. In addition to savings in tunnel excavation costs (vehicles act less like pistons in pumps and this simplifies the need for crossover and ventilation tunnels), energy savings from reduced air resistance would reduce the cost of high-speed services.

But there are existing systems for which we have not been able to think of promising redesign schemes. For example, about the only way major energy use reductions can be achieved in petroleum pipelines is by reducing pumping pressure and/or increasing the diameters of pipes (reducing turbulence). Higher energy prices might lead to such actions, but will not open a new pathway for development.

To make a difference in transportation, one has to fiddle with system designs in market niches. All it takes is imagination. Exercising a little imagination, one can think of many system designs that build from what we have and meet social, physical, and other constraints. Applying the market niche constraint reduces that number. One might say that all that is missing is the will and energy to try some things out. But that is not the case, for one needs an overall environment that values innovation and rewards the required risks. The lack of such an environment is part of the problem. The lack of imagination is too. Because while the world abounds in imaginative people, imagining design changes in transportation requires stretching system designs.

27

Benefits

The ultimate aim of a means of communication must be to reduce not the costs of transport, but the costs of production.
—Jules Dupuit (1844)

Introduction

Transportation and communication systems serve as connecting technologies and provide for the movement of mass and information. Changes in these services have impacts on all activities, just as changes in nontransportation communications activities impact transportation and communications. From these remarks, it is apparent that we view our topic as a large one. Even so, if we were forced to pick a single word that characterizes conventional treatments of impacts, that word would be *myopic*. Fortunately, however, some rather sweeping or broad insights are available.

We may conjecture about why myopia dominates discussions of impacts.

Perhaps it is because consequential improvements in transportation are out of sight and out of mind. In today's situation, sweeping insights are not relevant. (However, understanding today's improvements in communication services is asking for sweeping insights, and perhaps some out-of-mind understandings will be rediscovered or new insights found.)

Perhaps the scales of insights mismatch the paradigms that frame worldviews—the ways in which domains of cause and effect are bounded and the means used to reason toward conclusions. That certainly applies to much of transportation engineering and economics thinking where paradigms apply to projects and a static world in which activities may be treated independently.

Perhaps the calculus that must be applied to achieve understandings involves so much perspective, time, and so on, that understandings come hard and are hard to understand. For a communications example, de Sola Pool (1990) contains an insightful discussion of the impact of the innovation of the printing press. Perhaps only now could those insights be achieved.

To squeeze our topic into a chapter of reasonable length, we first comment on traditional strands of thought. We proceed in this spirit. With respect to substance, we stress the mechanisms at work. What are the paths through which impacts are achieved?

The motive for this chapter should be obvious. We have addressed, and even advocated, improvements in transportation (lower costs and/or improved services). We need to know the benefits of such improvements. Because of the ways transportation (and communications) serve as connecting technologies, the conventional techniques measure benefits in time or dollar costs.

Conventional techniques are based on conventional wisdom, so in saying that they are inadequate we are questioning conventional wisdom. That is difficult, not only because conventional ideas are comfortable, but also because conventional ideas shape the language of, and thus steer, debate. Because language constrains reasoning, we may need to think with a new vocabulary.

The Conventional Microeconomic Paradigm

The theoretical roots of the conventional paradigm are in microeconomic theory and in engineering economics. The consumer surplus idea (dating from the 1850s) is on center stage. There are applied roots in railroad work (e.g., Wellington's work) and in the analyses undertaken by the Bureau of Reclamation (in the 1930s and 1940s, especially).

Beckmann and later Vickery and many others applied Alfred Marshall's comfortable and well-known notion of consumer surplus (following Dupuit). Figure 27.1 provides a vehicle for the discussion of types of surpluses.

Consumer surplus is the difference between what a consumer is willing to pay for some quantity of a product (as defined by the demand curve) and what he has to pay (as defined by the price that must be paid for that amount). Producer surplus is the excess of total revenue over total avoidable cost that accrues to the seller as economic profit.

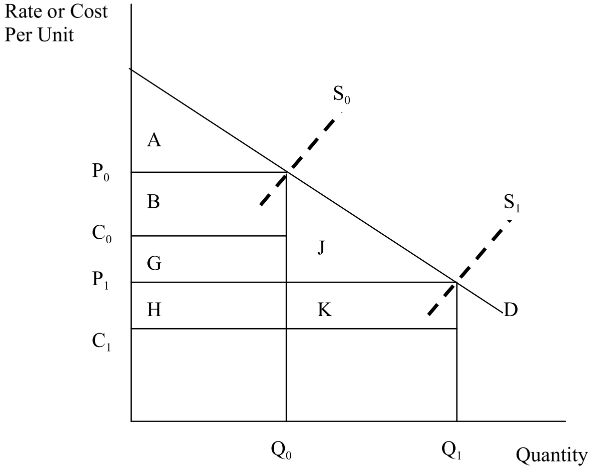


Figure 27.1. Consumers' surplus.

At market price P_0 and producer cost C_0, resulting in level of consumption Q_0, areas *A* and *B* represent consumer and producer surplus for an "as is" situation.

Areas *G*, *H*, *J*, and *K* show increases in surpluses with lowered costs (the supply curve moves outward to S_1, costs drop to C_1 and prices to P_1), leading to an increase in consumption at level Q_1. Areas *G* and *H* show costs avoided (or resources saved) over the "as is" situation. *J* is consumer surplus on new traffic, and *K* is producer surplus on new traffic.

For example, the price of coal in London fell beginning in the 1830s as rail transportation was improved. (There was a lot of seaborne coal, and railroads such as the Stockton and Darlington fed coal to coastal vessels.) The notion of surplus helps us think about the impacts of reduced prices.

Railroad and water project analyses developed and honed benefit–cost and similar techniques. With this technique, a transportation system or facility can and should be thought about in the same way one treats widget production. It is one activity in a world full of atomistic activities. There is nothing special about it. The efficient manager takes stock of the costs of inputs, examines marginal costs, and selects the optimal output. If the values of that output are to be measured, they are in the calculi of benefit–cost and consumers' surplus.

The 1956 interstate legislation called for the analysis of cost allocation, and it referred to user and nonuser benefits. The legislation set off a good bit of empirical work and debate about benefits. In response the "widget production, microeconomic view" was revisited and written in terms explicit to transportation. The products of at least ten or so authors might be noted, including Mohring, Harwitz, Meyer, Kain, Wohl, Kuhn, and others.

In the London coal case, there is the question of the incidence of surpluses—who got them. But incidence usually is ignored by the broad generalization that society is better off. So we have a conceptual scheme that lets us answer benefit questions, say "What will be the result of intelligent transportation systems (ITS) improvements in traffic flow?" ITS will create surpluses of various kinds. This is how the benefits of investment are most widely thought about—decreases in user costs are entered as benefits in benefit–cost calculations.

In addition to stress on benefits and benefit–cost analysis, attention extends to optimal pricing policy. Vickery applied these notions to urban highway congestion, and others addressed other modes. One result of this work was the deregulation of several of the modes to encourage their bringing prices charged in line with costs. There has also been an expansion of interest in congestion pricing on urban freeways and at congested airports. Time of day variation in transit fares has also resulted.

Although this conventional view can claim considerable adoption, we continue to see debate that ignores it. Not too long ago, for example, an issue of *Metro* questioned why voters in Houston turned down taxes for the construction of a rail transit system, even though the system would have 87,000 direct and indirect employees. Such employment should be counted on the cost side of the benefit–cost equation, of course.

We also see some petty things one might quarrel about, things having to do with the assumptions and limitations of microeconomic theory: distribution of costs and benefits ignored, increasing costs assumed, complete market assumed, and so on. Such challenges are easily deflected. For instance, side payments can be developed to "even out" equity, the distribution of costs and benefits.

At a larger scope, one may question how the paradigm catches the large impacts of transportation: bringing new resources into the economy, increasing the size of labor sheds, offering greater choices for jobs, shopping, recreation, and socialization, increasing market areas, and so on. The "conventional wisdom" answer to those questions is that these impacts are measured in the flow of consumers' surplus. They are the basis of the elasticity of demand.

The Conventional Macroeconomic Paradigm

The decades since World War II have seen the growth of a considerable economic development literature. Transportation enters that literature in several ways; in particular, it is conceived of as part of social overhead capital (SOC), which is a basic investment that is necessary to development—it is one of the universal input industries supporting all activities. Other such industries include production of clean water and provision of sewage treatment and electricity. Infrastructure might be another name for SOC. Additional characteristics of SOC include its tendency to be associated with large capital expenditures that have technical indivisibilities, are nonimportable, and are provided (or at least regulated) by public authorities (Hirschman, 1985).

A related idea is that of social savings, used in Robert Fogel's (1964) study of the U.S. railways as an ex-post analog to ex-ante notions used in the analysis of projects: identify costs with or without a project; compare the costs with the savings. Fogel used the idea of a counterfactual hypothesis. However, this research method has its problems (we do not have an identical United States that has evolved from 1830 without rail). While we may be able to determine the marginal contribution of additional infrastructure today (which may be small for mature systems), determining the marginal contribution 100 years ago is fraught with challenges. It is especially difficult to identify all of the indirect or external effects of the technology. It is also difficult to value qualitative differences in transportation. The questions of "How large was the social surplus from railroad development and to whom did it accrue?" remain unanswered.

Discussion of transportation in the economic development literature often introduces the concept of linkages (the often-used word "spillover" captures the same concept). Backward linkages lead to investment in input-supplying activities. For instance, investment in highway construction may require investment in cement production. Much "benefit" analysis focuses on backward linkages. However, a critic would point out that any investment, even if it only involves digging and filling holes, would have backward linkages.

Backward linkages should not be ignored, for some investments may have more socially desirable backward linkages than others. With respect to economic development, for example, investment in truck-freight activities may provide an incubator for entrepreneurship compared, say, to a pipeline.

However, the forward linkages matter more. How can we get a handle on forward linkages? One route is through the economist's production function. The neoclassical production function takes the form quantity of output (Q) = f(capital inputs (K) and labor inputs (L)) or $Q = f(K,L)$. The partial derivatives of Q with respect to K and L are the demand schedules for input factors. We may introduce transportation (T) as an input, along with capital and labor, so $Q = f(K,L,T)$.

We know that transportation investment accompanied the growth of output. In France, for example, figure 27.2 shows transportation expenditures increasing as industrialization ran its course. Observations such as these say that there is some optimal investment level. In the United States, for example, figure 27.3 illustrates that constant dollar investment in highways peaked in the 1960s. So this is viewed by some as a problem: investment is not at the level where it ought to be.

To counter the reasoning that infrastructure investment should be fixed over time, the point was made that emphases change as times change. In particular, in recent years there has been private investment (forced by government requirements for cleaner cars, factories, etc.) in response to environmental protection requirements. However, during the 1970s and 1980s it was reasoned that previous investment in infrastructure was endangered, and underfunding did not make economic sense because investment in maintenance and repair is more economical than rebuilding. That was a strong enough argument to drive some increased funding. Along with the potential for job creation, that argument has become politically salient.

Thanks to David A. Aschauer, a view of the investment shortfall crisis began to emerge in the 1990s, that it deeply matters. In a series of papers, the first appearing in 1988, Aschauer pointed out that public capital expenditures on infrastructure ought to be included in economic calculations of the inputs to production. He specified an aggregate production function that used labor, public capital expenditures, and private capital expenditures as inputs and examined how these inputs related to outputs during post-World War II years. Previously, economists had stressed private investment. Including public investment enables asking “Does public capital matter?” Aschauer deserves credit for asking the question. He points out that the ratio of nonmilitary fixed public capital stock to fixed private capital stock reached a peak of about 32 percent in the late 1960s; it has subsequently fallen to about 23.5 percent. He argues that the

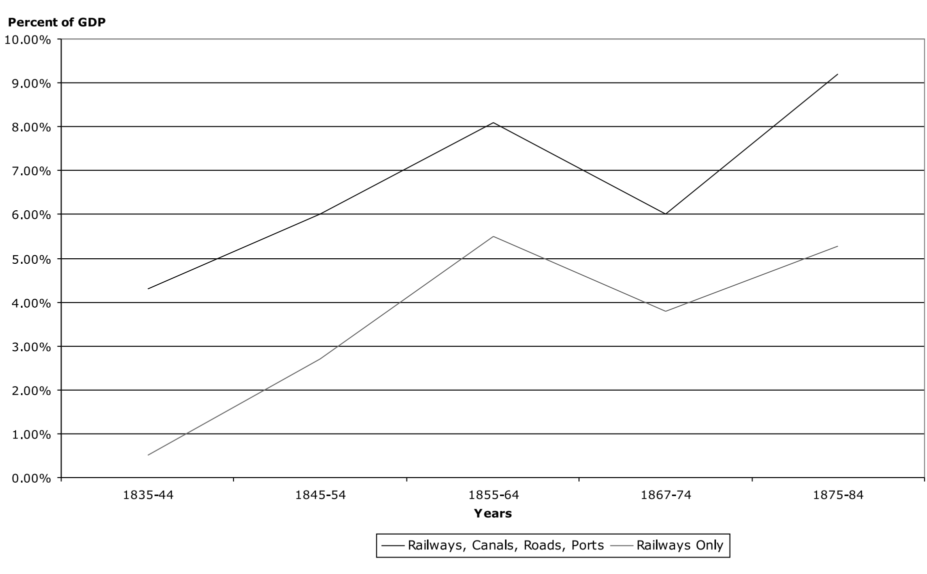


Figure 27.2. Gross public works expenditures in France as a percent of total industrial product, 1835–1884.

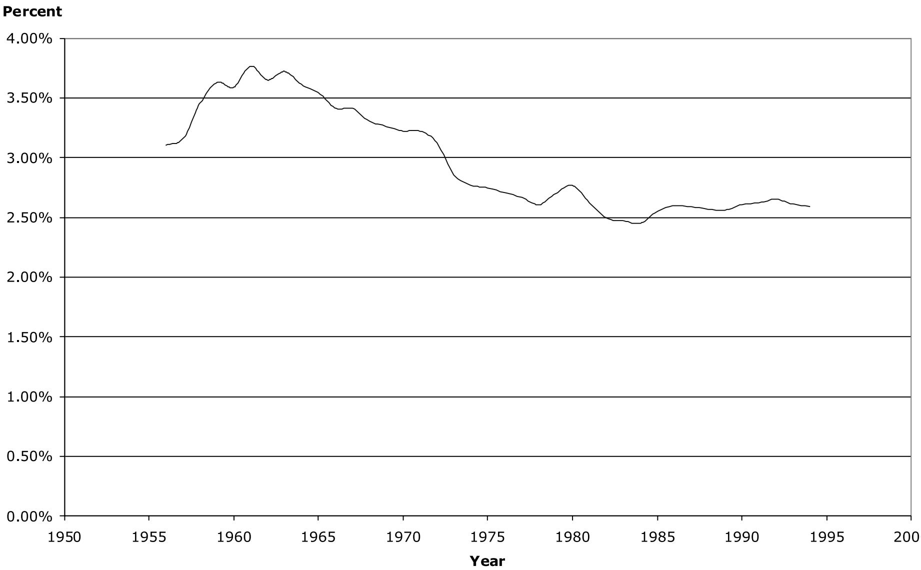


Figure 27.3. U.S. infrastructure spending as a share of GDP. (Source: *Trends in Public Infrastructure Spending*, Congressional Budget Office. Includes U.S. federal, state, and local infrastructure, capital and operating costs, for highways, mass transit, rail, aviation, water transportation, water resources, water supply, and wastewater treatment. Infrastructure spending in 1997 dollars, GDP in 1996 dollars.)

decline has adverse affects on private investment, profits, and productivity. He supports the argument with a series of time series regressions made using aggregate, national data. In addition to that finding for aggregate public capital, Aschauer (1990) identifies core infrastructure with a stress on transportation, especially highways, where public capital investment matters very much.

Swarms of naysayers and Aschauer supporters have had their say also. Aschauer's publications and findings, the findings of others, and debates about those findings are reviewed in a set of conference papers (Munnell, 1990), as well as in a U.S. Federal Highway Administration paper (1990). The question continued to be debated through the 1990s.

Productivity advances are the central issue in this literature, and productivity is improving when year after year output increases faster than inputs of capital and labor. The issue facing the United States and many other developed nations through the 1980s was the tapering of productivity advances. As Aschauer and others have pointed out, the Group of Seven industrialized nations had average productivity growth of about 4.0 percent per year during 1960 to 1968 and growth declined to 1.4 percent per year during 1973 to 1986. We add that from 1987 to 1995 U.S. productivity fell even further to about 1.2 percent. But from 1995 to 2000 it rose to 2.3 percent. There was a sharp turning point in the late 1960s and another in the mid-1990s. Decreased productivity growth was the root of the failure of real incomes to increase, and is seen as a culprit in the lack of competitiveness of the United States compared to its trading partners. Information technology may be behind the rise in the late 1990s, as new telecommunications technologies (the Internet, mobile communications) were deployed.

To get from raw comparisons and conjectures to processes, Aschauer and others have estimated the coefficients of aggregate production functions. Data and procedures differ. Some studies made international comparisons, some used aggregate U.S. data, and others were on a state basis. Results range from Aschauer's claim that a dollar of public capital investment increases output as much as does $3.30 of private capital investment to the finding of no relationship. That is, some adopt the position that stepped-up investment in infrastructure, especially transportation infrastructure, will reenergize productivity growth; others say that is wrong.

The previously cited Federal Highway Administration paper and conference report summarize and compare studies; they seem to point to a weak positive effect. The comments made by researchers are interesting. Most suggest that there must be a relationship, but that large effects are not plausible. Henry Aaron, for example, remarks that few would question that the road building of the 1950s and 1960s contributed to economic growth, but the claim that economic growth slowed because of the wind-down of road construction goes too far (Aaron, 1990; see also Slater, 1992).

Perhaps there is a simpler explanation. Let us return to the S-curve. As the interstate highway system grew and matured, the marginal benefit decreased from each additional roadway (most places were already well connected), and the marginal costs increased (the cheap roads were already built). It is natural that the economic benefits from new construction in a mature system would be smaller than the same construction in a nascent system. As the benefits of new construction decline, investment declines with it. The cause of the decline of growth is not the lack of investment; the lack of investment is the symptom of a mature system. We can explore this idea graphically in figure 27.4.

On the left, there are few roads, and travel has a significant cost in backtracking. In the middle, the number of roads is doubled, but the travel cost is less than halved. On the right, the number of roads is again doubled, but the travel cost diminishes only marginally. A similar idea occurs with transit schedules. If we have a bus running once an hour, the average schedule delay is about a half hour (the difference between actual arrival time and desired arrival time). If we double the number of buses, the schedule delay is halved, but that means it drops by 15 minutes. If we double the number of buses again, the schedule delay is again halved, but this is only a drop to 7.5 minutes. We have a clear case of diminishing returns (in terms of rate of return) to additional transportation in both space and time as a technology is deployed. Of course there is little incentive to double the number of buses (or roads) again.

It seems to us that the economist's production function, while useful to economists, is too simple a representation of reality to capture the causal relations involved in transportation impact questions. Even economists have questioned its use in productivity analysis.

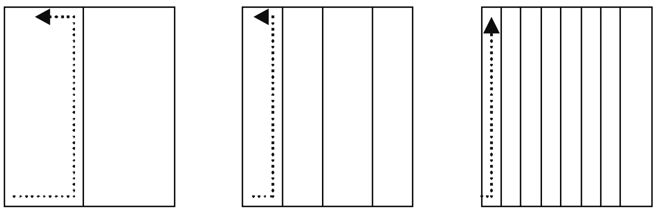


Figure 27.4. Graphical idea of diminishing returns to network deployment.

Regressions specified as neoclassical production functions and applied to time series data have low correlation coefficients. There is about an 80 percent unexplained residual, and the thought is that technical change, not captured in production function analysis, is driving increased output.

When interpreting results such as those shown by the figures above, Aschauer refers to core infrastructure, and especially to transportation. "Is a shortfall of capital expenditures on transportation facilities hurting the United States in competition with Europe and Japan?"

The following possibilities might be considered:

1. Aschauer's interpretation is correct. Congestion and other things are hurting productivity growth. That is surely the case for an organization such as Federal Express, but is the impact of congestion and the like on productivity direct, widespread, and large?
2. Underlying common causes yield the downturns in investment and productivity. A long list of causes comes to mind, ranging from federal budget problems, the high level of investment of engineering and scientific talent in defense matters, and high interest rates, to Americans' attitudes about "not in my backyard," taxes, and the environment.
3. There is an underlying relationship that is common among the compared nations. The nations differ because the relationships are driven by clocks with different settings. The United States pushed infrastructure development hard, and it has already achieved most of the productivity gains that can be obtained from present technological formats for infrastructure, for example, the technological format of the highway system. Western European nations are a little behind in timing, and they are still capturing productivity gains. Japan is yet father behind, and it is capturing healthy gains.
4. The premise is wrong; the United States is not suffering in competition with other developed countries. Although the transportation system is far from perfect, productivity growth rates of the late 1990s suggest that it is investment in the next wave of technology, not transportation, that is most important.

A good case can be made to establish the "clocks with different settings" assertion. All one has to do is look, say, at the pace of automobilization in the compared nations. Similar timing patterns appear in railroads, domestic containerization, air traffic, and elsewhere. If (3) is true, the need for increased spending on infrastructure implied by (1) makes little sense unless the increased expenditures are focused on new ventures.

Emergence of a New Paradigm

Since the 1980s, a new worldview has begun to emerge. The new paradigm partly rides on the coattails of the increasing interest in the importance of innovation and technological development in economic development. Nelson and Winter (1982) provide an example of increasing interest. They refer to progress resulting from the introduction of novelties into the system. Now there are quite a few people working with these concepts.

Nelson and Winter remark on the many neoclassical growth models, "[they have] enhanced our understanding of economic growth." But they go on to say:

> However there is a peculiarity about the success story, which we noted earlier. By the later 1950s, it had become apparent that it was impossible to explain very much of the increase in output per worker that had been experienced over the years in developed countries by

> movements along a production function resulting from increases in capital and other inputs per worker, if constant returns to scale and the other assumptions employed in traditional microeconomic theory were accepted. The "residual" was as large as that portion of total output growth explained by growth factors of production. For the growth of output per worker, the residual was almost the whole story. The researchers working within the theory found a way to resolve this problem. Earlier, Schumpeter (1934) and Hicks (1932) had proposed that innovation (technical change) could be viewed as a shift in the production function. In the late 1950s Solow's work (1957) made this notion an intellectually respectable part of neoclassical thinking about economic growth. In the empirical work, the residual was simply relabled "technical advance." Instead of reporting to the profession and the public that the theory explained virtually none of experienced productivity growth, the empirical researchers reported that their "finding" that technical change was responsible for 80 (or 85 or 75) percent of experienced productivity growth. (Nelson and Winter, 1982, p. 197)

The last sentence is the key sentence for the present discussion: real progress is made through technological change. Beyond economists, many have adopted that worldview. In the United States today, for example, there is widespread debate about technological competitiveness. The new paradigm also responds to unease about how well the conventional paradigm catches the broad impacts of transportation development.

The functions of transportation loomed large in writing about the space economy, writing that accelerated during the 1950s with the development of location theory and regional science (Garrison et al., 1958).

Let us try to be clear. The conventional paradigm, view, or wisdom is not being thrown out. It applies pretty well to a very short-run world with fixed production functions. It is a valuable guide to the optimal use of resources in such a world. Rather than being thrown out, it is being put in perspective. While valuable, it fails to help when trying to understand transportation or economic progress.

This change in priority toward ideas that are more supportive of economic progress was sharply illustrated during conversations in connection with the most recently released U.S. DOT policy study. A discussion participant remarked, "all that is available is the views of 1960s economists and engineering economists, and they are wrong. What's really important is structural change." "Wrong" isn't exactly the correct word. Economists stuck in the 1960s are not wrong in the terms of their reasoning; it is that the reasoning does not fit the situation as we now understand it.

The quote from Nelson and Winter amounts to an assertion that the conventional economics paradigm omits a lot. It does not say what is omitted, and it does not extend to our interest—how transportation improvements fit into the modern paradigm.

We observe that the social gains from improvements in transportation occurred fairly rapidly, that is, hard on the heels of system deployment. That is illustrated in figure 27.5. There is a big impact early on, and impact then tapers. Those impacts reach beyond reduced costs to consider bringing new resources into the economy, creating new options for social and economic activities, enabling enlarged labor sheds, and so on.

The winding down of impacts as systems are deployed focused our attention on how new systems are created, what happens to them once they are born, and how transportation technology works generally. The reenergizing of social impacts seems important. Also, attempts to improve existing systems late in their life cycle seem difficult to useless (Garrison, 1984).

To simplify the discussion that follows, we shall use the word "production" as metaphor—it stands for things that transportation influences, such as industrial production, availability of resources, consumption, and social opportunities.

We need some way to catch the relation between production and the status of transportation, so we offer a disequilibrium paradigm as shown in figure 27.6. No time dimension is shown; we add this in descriptive wording.

Starting at point *a*, production is in equilibrium with system status. A strong nonlinearity in the improvement of the system drives production out of equilibrium at point *b*, and equilibrium is achieved at point *c*. From that point, equilibrium may shift to the northeast or to the southeast. If the latter, there is another phase shift at point *d*. Figure 27.7 conjectures about the temporal relations between the status of a system and production.

The idea displayed in figure 27.7 suggests that, prior to 1900, the system was growing using a certain set of technologies. It began to shift to another set of technologies in

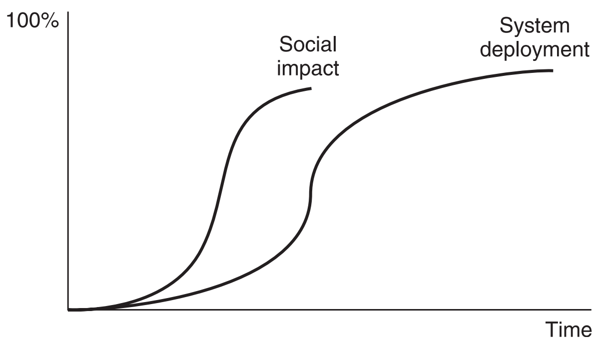


Figure 27.5. Social impact versus system deployment.

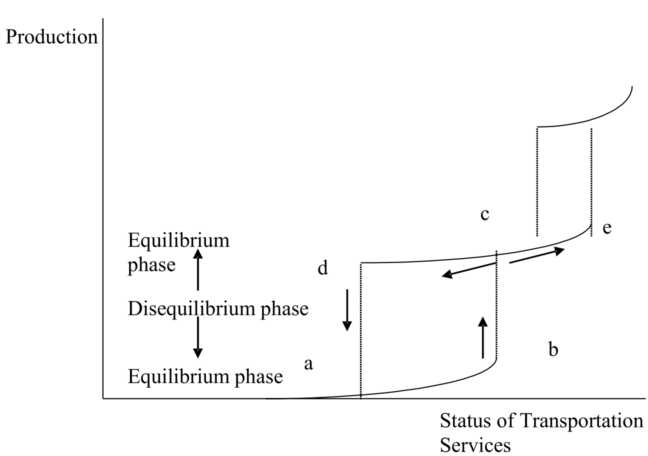


Figure 27.6. The disequilibrium paradigm.

about 1900. Associated with each set is a range of development appropriate to that set. At about that same time, Ake Andersson (1986) proposed a similar scheme.

The temporal trace of the reduced costs of service is perhaps suggestive of the relations of the curves in the figure above. The unit cost curve typically has a (reverse) J-shape, as shown in figure 27.8. Cost reductions are rapid early on, and then taper.

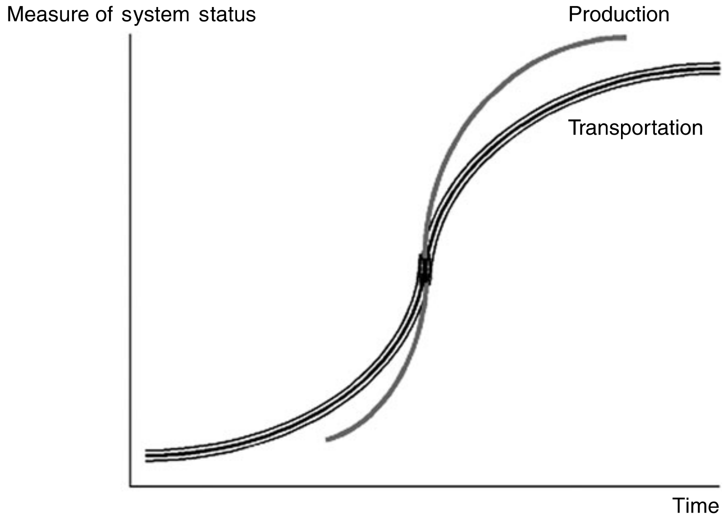


Figure 27.7. Relations between the status of transportation and the status of production.

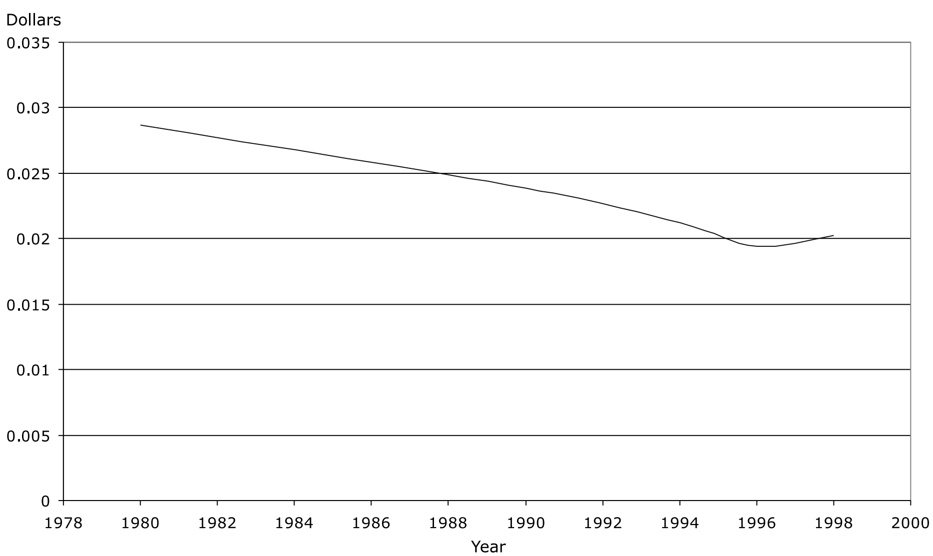


Figure 27.8. Cost per revenue ton-mile on U.S. railroads in nominal dollars (unadjusted for inflation).

The question of the mechanisms relating the status of transportation to the status of production requires a two-stage analysis. First, we know that major gains in productivity, the creation of new products, the creation of new activities, and so on, have their major proximate cause in innovation. Second, we need to ask what causes (permits) innovations. A transportation explanation works very well. As Adam Smith remarked in 1776, transportation makes new resources available to the economy, enables economies of scale and scope, enlarges market areas, and is, generally, permissive of new activities. New activities follow from innovation (Garrison and Souleyrette, 1996).

Our work on transportation technology explains the mechanisms through which transportation technology changes (or, thinking of planning, can be changed). What is the mechanism that links transportation improvements to development?

Knowing that development is mainly driven by technological advances, thinking centered on such advances. The view that emerged is this: We should view transportation (and communications) innovations as *energizing* innovation and technology development generally. One may think of *latent innovations,* that is, at any point in time there are many techniques that could bloom as usable innovations. The interactive development of transportation enables these latent innovations to be shaped for markets and to be tested in markets. Those that are successful drive a round of development. It is the burst-blooming of latent innovations that accelerates development as a new transportation system begins to be deployed. We may also think of innovations that begin to appear as transportation service spreads. These are *induced* by the availability of new services. Box 27.1 considers the spatial spread of new technologies.

Companion Innovation

There has been a lot of thinking about rounds or waves or cycles of economic development. Schumpeter proposed that they are innovation driven. As we noted in chapter 4, Mensch (1979) identifies bursts of innovations and associates these with waves. Graham and Senge (1980) have developed some ideas about the mechanisms driving innovations. The process we imagine is this:

An improvement in transportation triggers a burst of innovations. Some of these were "on hold" because previous transportation constrained their introduction to markets (latent innovations). Some are new because improved transportation permits their being imagined (induced). This creates both a constructive and a destructive situation. There is structural change, the old is replaced by the new.

The burst of innovations drives development. But once the transportation improvement is about half deployed, there is a development downturn. Graham and Senge provide one explanation for such a downturn. We would add that the slowing of productivity gains from the transportation improvement plays a role.

A pent-up market for a new system and the increasing dysfunctions of the existing one trigger new transportation services and a new wave of economic development. Garrison and Souleyrette (1996) have been able to associate some innovations with transportation development.

We do not claim, of course, that transportation steers all technological progress. There have been waves of chemical industry and electrical developments, for example, that only loosely relate to transportation.

BOX 27.1 The Value of Being at the Center of the World

The 1990s was a decade of explosion in information technologies; led by the Internet and the World Wide Web, a slew of related technologies were invented, innovated, and began to be deployed. Where they were first deployed was often the centers of high technology themselves, for instance, Silicon Valley in the San Francisco Bay Area. These areas often considered themselves at the "center of the world," and in terms of leading-edge technology, at that time they may have been. Residents there would have advantages such as broadband connections with cable modems, or in the early 2000s, wireless connections for computers to the Internet at selected "hot spots," before people elsewhere had much of a notion of what was going on. This leads us to a hypothesis: If the rate of creation of (information) technology is accelerating, the leading places will pull farther and farther ahead. If it is decelerating, the trailing places can catch up, and the relative value of being in the center steadily diminishes.

As we have noted throughout *The Transportation Experience*, most technologies follow an S-curve. During early growth, technology accelerates. It seems reasonable to suppose that some place gains the new technology first, and that place will usually be near where the technology was developed. We can call this the center. Once this may have been Detroit with the automobile. Today, in the most recent wave of technology, this would appear to be places such as the Bay Area with the Internet, Finland with wireless phones, and so on. To date, with previous technologies we have observed that during late growth and maturity phases, growth decelerates and the technology is spread around. There are a number of reasons for this, including diminishing marginal returns to innovation (at least in the short run), and the desire of capital to reap returns on investment by spending money on deployment into new markets rather than on the development of new technology.

Will the advantage of being at the "center" remain? Are there advantages that accumulate at those centers that keep them dominant? In the United States, Detroit is still the center of action for development of the automobile, but aside from a fairly good highway network, it offers little real advantage to those who wish to use one. While there are still spatial elements to the Internet, one of its great advantages is as a "destroyer of distance"; anyone connected to the network (which still may require being in the developed world) can obtain the latest software, information, or entertainment virtually instantaneously, regardless of location. But the physical infrastructure is still physical, cables must be laid, wireless hubs or towers must still be constructed, and the system cannot be assembled everywhere simultaneously.

Still, improved transportation technologies enhance services, enabling people and things to move more easily and increasing communications. Consumers benefit from more choices and more information about those choices. Consumers also gain opportunities to pursue other activities (such as recreation). Producers can replace low-grade inputs with higher-quality resources as transportation increases the size of input markets. Increases in the geographical scale of markets enable reorganization of business practices to achieve economies of scale. As Adam Smith noted in 1776, the division of labor is limited by the extent of the market. As the market expands, division of labor—specialization—increases. More market niches are created, and more specialized tools and materials for production are created.

This specialization of production enables, and even requires, innovation in the technology used to exploit these new niches. These *companion innovations* result from innovative actions spurred by transportation development.

Further, as transportation and communication technologies are deployed, ideas diffuse across the networks more and more rapidly. Ideas that once took weeks to cross the Atlantic, and years to take hold, now take seconds to cross, and days or hours to take hold.

The process generalized in figure 27.9 has been repeated numerous times through the transportation experience. The canal era, the road and wagon era, the ocean liner era, the railroad era, the automobile era, the air travel era, along with their associated communication innovations (semaphore, telegraph, telephone, television, the Internet), have led to radical changes in politics, warfare, capital accumulation, and culture, as well as changing the natural environment in which human society is embedded.

Transportation and communication advances not only enable us to do old things faster (which is adequately captured in consumers' surplus and land value measures), but also enable us to do old things in new ways, and more importantly to do new things. But this is only true of real advances, those that shrink the real and perceived distances across space.

Positive Externalities

How does the companion innovation concept enter the debate about transportation externalities? The literature on the external effects of transportation investment concentrates on negative externalities because, as Verhoef puts it in the case of highways (1994, p. 278), "we are not able to detect any significant external benefits of road transportation. . . ." The presumption seems to be that positive benefits are internalized, say, in wage rates or tariffs for service.

The companion innovation concept says that the "no significant external benefits" conclusion is incorrect. The provision of transportation services triggers new technology development and improved productivity throughout the economy. Willeke (1993) comments that the usual treatment of externalities is static in character, and that one has to consider the dynamics of change in order to imagine external benefits. We agree.

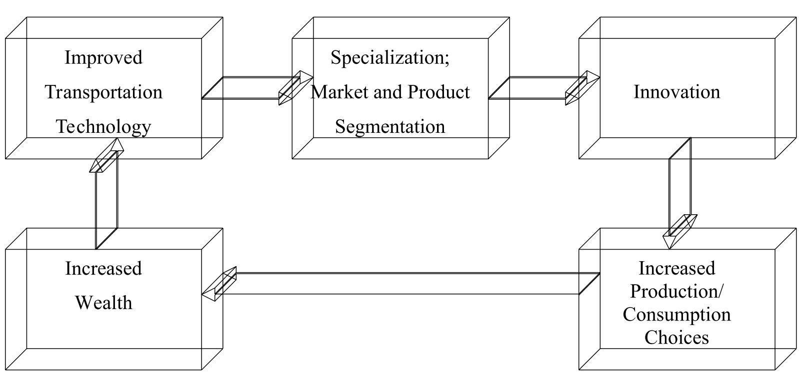


Figure 27.9. A general model of innovation and technology development in transportation.

We would also point out that innovation is an externality in same way that noise or air pollution is. No market is made for the output.

What Economists Say

Appended to this book is chapter 3 of Adam Smith's *The Wealth of Nations* (1776). Smith saw rather clearly what (improved) transportation does for society and its production and consumption activities. Transportation improvements are constructive because they support specialization of production and consumption. Efficiencies result from specialization. Transportation improvements also have a destructive side because they tear down existing arrangements, shift the holding of resources and wealth, and so on.

There are winners and losers, and that puts strain on the social contract. In theory, we might expect government action to ease that strain—side payments would be made to those who lose, so that no one is worse off. That is an equity, and not an efficiency, matter, of course. (Side payments are discussed when there are undesirable externalities. That is an efficiency matter, for actors should pay the full costs of their actions. Side payments we have seen in our discussions so far include payments to those forced to move by urban railroad or highway construction, of those harmed by airport noise. Interestingly, the need for payments was argued by social activists rather than by efficiency activists.)

The real world pattern seems to be this: As systems begin to be deployed, the voices of those who are gainers and those who expect to be gainers swamp those who lose or who will lose (but may not know it yet). It is only when most gainers have already gained and their voices are muted that the voices of losers can be heard. For example, the expansion of the railroads to the west destroyed most crop agriculture in New England. But the voices of New England farmers were swamped by the voices of gainers.

When examining the literature of the nineteenth century we have seen specialization mentioned, but not much, and it is not mentioned much at all today. Our speculation is that it does not fit the prevailing paradigms of economics. Indeed, in 1951 George Stigler looked back at Adam Smith's chapter 3 in an article that used as its title the title of that chapter. He took the title as a theorem and took the tack: if it is true, industries are characteristically monopolized; if false, Smith is wrong. Of course he found Smith incorrect. He had to; otherwise economics would have to deal with industries having spatial monopolies.

Transportation has a number of international implications. It enables nation-states to make a play for a larger sphere of influence (see box 27.2). Transportation innovations may also play out differently in advanced and less developed countries (see box 27.3)

Discussion

We can think of transportation as providing a social contract with society. When there are strains on the social contract, government policy may be forged to ease the strains. We must deal with the substance of expectations. The questions are: What does the transportation side of the contract say? What is transportation supposed to do for society?

BOX 27.2 Thrusts for World Power

How does transportation development influence nations attaining world power?

The question is posed for several reasons. For one thing, we observe that the transportation experience can be discussed rather effectively without much reference to the great social and political changes taking place as the experience unfolded. There were great social and political changes from, say, 1600 through the mid-nineteenth century, but as we examined the transportation experience during that period, the changes were more in the background than upfront in the story. The question "How did changes in the socio-political milieu affect transportation?" seemed to require no special attention; broad-brush background statements would do.

There is also the question of the reverse causality: How did transportation development affect social and political changes? Some results of transportation development were the specialization of production; increases in the tools of production, income, and wealth (and changes in the holding of wealth); conflicts among social classes and institutions and adjustments of political power; and more. While the subject is vast, we limit ourselves to a discussion of an "attaining world power" version of the question and subject.

Modelski (1984) dates the modern world from about 1500, but points out that it was prefaced by a considerable period of gestation, starting in about the year 1000. During that 500-year period, population doubled in both China and Europe, and there was much technology transfer from China to Europe. Modelski's dating is similar to that used in our discussion of the emergence of the modern world. There was growth of cities; coastal, road, and river transport; and trade in Western Europe prior to the *ca*. 1600 date we used to mark the emergence of the modern world.

Modelski's first cycle of world power begins in the fifteenth and sixteenth centuries when the Portuguese designed and built new types of ships and began to explore the Atlantic and then more widely. This was a sea development cycle, a cycle having to do with ship designs, exploration and the exploitation of native populations, church influence, and world power based on ship transportation. Both the Iberian countries of Spain and Portugal and the northern Italian city-states of Venice and Genoa made bids for world power.

The Kondratieff cycle (or K-waves) allows us to organize our understanding of history. Kondratieff proposed that there were long waves (of about 50 years) that track with the birth, growth, and maturity of clusters of major technologies, our S-curves. Historians and historiographers who analyze these things suggest K-waves dating back to the Northern Sung dynasty of China, dominated by leading sectors. Some even embed these waves within even longer cycles of about 100 years. During each long cycle there is a dominant "world power," where the world is defined initially as Eurasian. Rather than discuss subsequent cycles, a table from Modelski's paper is given below. Table 27.1 shows one interpretation of these cycles.

One would think that transportation developments would affect the capture (and loss) of world power. Transportation developments would affect the tools for capturing power and the loci where power is held. The challenge now is to say something insightful that links the information in the above table to what we know about transportation development.

One can divide transportation developments into sea development and land development. In the early days, sea transportation was the tool for world power (Portugal, Spain, North Italy). The landside consolidation of power was not so much transportation enabled. It turned on the exertion of power by the nobility, the emerging trading classes, and the church.

(continued)

BOX 27.2 Thrusts for World Power—cont'd

The importance of land transportation in securing a power base began to be important in the Netherlands (in the early seventeenth century) and in subsequent struggles for power on the Continent. An exceptional situation was Britain I (in the early eighteenth century), for at that time the internal transportation system in Britain did not amount to much compared to, say, France. With that exception, it appears that the requisite for a power base increasingly became a strong integrated economy and the transportation that goes with it. The world reach of sea power was an extension of that power base.

With respect to establishing a land power base, the land powers of Europe (Spain, France, and, later, Germany) were preoccupied with controlling the landmass of Europe. The United States and England were not so concerned with land power challenges; they were on the peripheries. They devoted their energies to the global system and on a global scale. That was the case for England beginning in the early nineteenth century; the United States was not concerned with global power until the Spanish-American War of 1898.

Challenges for power on the European landmass continued to the end of the Cold War (with some extension in the various Balkan wars of the 1990s); we also see the continued emergence of power on the peripheries, for example, Arabia and the Persian Gulf. Japan offers a partial illustration of the latter. By about 1900, Japan had emerged as a power on the periphery. It first made local-scale challenges to Russia (*ca*. 1900) and then China (in the 1930s) for power on land. Its world-scale power challenge was in the 1940s. Today, Japan's power challenge is economic rather than military.

Each successive successful world power has been larger, more powerful, wealthier, and so on, than those that went before, just as the critical global wars have increased in scope. Also, in each phase the management of world power involved more complicated strategic associations with partners and thus management relations.

BOX 27.3 Experience in the "Less Developed Countries"

We understand how an observer in a nation might compare their area with, say, Switzerland and conclude: we are less developed when the states of transportation, nutrition, education, national income, and other things are compared. Such conclusions may seem straightforward and a point of departure for discussions and analysis. Even so, we think that such comparisons and the developed/less developed language confuses the issues.

For one thing, all nations, regions, and smaller areas are developed, given their historic paths, natural resource endowments, the tools available, and other attributes, including cultural and aspirational differences. The perspective from which we make that statement is this. It is a Euro-centered judgment. All nations have been touched by developments in Europe since the year 1600 and have been developing. Four hundred years later, we say that they are all developed. They are certainly quite different from what they were in the year 1600.

Critics would be quick to point out that the current status leaves much to be desired: given the attributes of undeveloped nations, a development status could be achieved that is closer to the status of Switzerland. Therefore, such nations are less developed than they could and should be.

BOX 27.3 Experience in the "Less Developed Countries"—cont'd

Reasoning more or less like that, world-scale organizations, such as the World Bank, regional investment organizations, and individual nations have undertaken the stimulation of development. Essentially, the effort has been to provide attributes of capital, know-how, and services, such as educational and health services, that is, to provide the infrastructure for development.

Although agency records suggest that development efforts have been successful—nations identified as less developed are better off with development efforts than they would have been without those efforts—that is a value-laden and contested judgment. Hirschman (1981) uses the word *trespassing* to summarize the argument. He points out that governments have been destabilized, old ways of life changed, and so on. Demand has been stimulated more than production and balance of payments worsened. It is also pointed out that the gap between the developed and the less developed has increased. Within regions and nations, the equity impacts of development have been questioned.

We said that all places are developed given their historic paths, natural resource endowments, tools, and other attributes. Agencies promoting development take historic paths and natural resource endowments as givens; development efforts have focused on tools as instruments to build on those givens. Transportation has been considered as a tool for economic development, and it has loomed large in development assistance activities.

We have five things to say about the transportation tool:

1. The waves of transportation (and communication) development that we have examined—rail, transit, autos, air, and so on—were not just played out in the developed nations. Once the technology was standardized, they were deployed everywhere where it was feasible. Encoded in standards, institutional formats, and equipment, know-how was readily transferred. Capital was quite mobile. So, for example, the round of rapid railroad deployment beginning in about 1840 was a worldwide round. Recall that Stephenson's son, John, worked in South America for a time before joining his father's locomotive manufacturing business. Theodore Vail worked in South America building transit systems before being recalled to head AT&T.

So if we had been involved at the time development programs for the less developed countries (LDCs) were created, we might have argued that transportation should not be a centerpiece of development programs. We would have argued that transportation had already been tried. Those trials have resulted in a façade or layer of development. That is it. Not much more is to be expected.

We would not have taken that position as an absolute, for surely distortions in the delivery system left unmet needs for investment, institution building, and other items.

2. Discussing transportation and production, we would have made much of ways production opportunities unfolded with the dynamics of system deployment and development. Today's systems fit the production opportunities at places where they were born, rapidly installed, and extensively deployed. The less developed nations did not participate in that development very much because the systems did not "fit" their situations.

Suppose we have made too much of the "did not fit" reasoning; deployment was not tried hard enough or constraints now removed thwarted deployment and/or other things have changed. But even if we improved transportation in an LDC, that would not be enough to induce development. The competitive developed nations might no longer have transportation advantages, but advantages such as agglomeration economies would still be held.

(continued)

BOX 27.3 Experience in the "Less Developed Countries"—cont'd

3. If we had been critics of development, we would have objected to projects oriented to decreasing costs of providing services that worked well for the production complexes of the developed nations. Rather, we would have argued that the priority should go to finding the services that matched latent production complexes in the less developed nations. We would have been very much critics of the use of transportation to stimulate demand and therefore increase the rate of growth of GDP.
4. Recall also that there is historic path dependence working within transportation. The transportation systems we have are not the best of all possible systems. They represent designs that worked at the time they were innovated, and that were subsequently locked in by custom, economies of scale, and standards.

   The fourth thing that we would have done would be to point out that the transportation systems exported to the LDCs are foreign in both space and time. They are suited to the resources and factor prices of the LDCs only to the extent that they are similar to those of the United States and Europe. System designs reflect know-how of the times when systems were born rather than modern know-how, though modern know-how has been used to improve systems.

   Also, the systems are cursed by many dysfunctions. If one insists on further deploying those systems, they should be cleaned of dysfunctions prior to deployment.
5. Observing that the production impacts of today's transportation modes in the LDCs are bound to be limited because the system technologies do not fit the situations, we see the LDCs needing processes of both transportation and production innovation directed to their production possibilities. By production possibilities we mean possibilities defined on the resources and conditions of the LDCs.

   The powerful lure of imitation has directed attention from innovations. Excuses claiming capital shortages were offered (an excuse rather than a reason, for successful systems create the capital necessary to grow).

   Possible counterexamples to our view are the East Asian experiences since 1960. Japan, Singapore, Hong Kong, Taiwan, and South Korea are in the "developed" category now. In these cases, there has been production expansion with transportation development mainly following. (See, for instance, the discussion of high-speed rail in Japan in chapter 10.) Actually, of course, sharp changes in bulk, neobulk, and container maritime transport were quite supportive of developments in Asia. But land transportation followed rather than stimulated.

   Considering those developments, low labor factor prices helped at first. Also, the Japanese read Schumpeter; after World War II, the first two English language economics books translated into Japanese were Schumpeter's. The Japanese learned the importance of Schumpeter's (1934) "gales of creative destruction" and "carrying out of new combinations" as the edge of competitiveness and economic growth. They were also sensitive to the achievement of scale economies and economies of agglomeration.

To summarize, transportation enables thrusts for state or world power. For instance, the transcontinental railroads of the nineteenth century in the United States and French roads in the eighteenth century consolidated state power. With respect to world power, improved ships and navigation techniques enabled Iberian conquests beginning in the fifteenth century, Dutch efforts in the seventeenth century, and English accomplishments

Table 27.1 Long Waves in Social Development

Long cycles	World powers	Date	K-waves	Global leading sectors
LC1	Northern Sung	930	K1	Printing and paper
		990	K2	National market
LC2	Southern Sung	1060	K3	Fiscal framework
		1120	K4	Maritime trade expansion
LC3	(Genoa)	1190	K5	Champagne fairs
		1250	K6	Black Sea trade
LC4	(Venice)	1300	K7	Galley fleets
		1350	K8	Pepper
LC5	Portugal	1420	K9	Guinea gold
		1492	K10	Spices
LC6	Dutch Republic	1540	K11	Baltic trade
		1580	K12	Asian trade
LC7	Britain I	1640	K13	American plantations
		1680	K14	Amerasian trade
LC8	Britain II	1740	K15	Cotton, iron
		1792	K16	Railroads
LC9	United States	1850	K17	Electric power, steel
		1914	K18	Electronics, motor vehicles
LC10		1973	K19	Information industries
		2026	K20	

Source: Modelski and Thompson (1996).

beginning in the eighteenth century. Transportation makes for more efficient production in a production function context. Transportation changes the comparative advantage of places. The mechanism here is land (transportation) rent. As land rents change, spatial patterns of production and consumption change (it changes relative accessibility). Transportation brings new resources into the economy, that is, market and supply areas are increased (it increases absolute accessibility). Transportation enables specialization of production and consumption, a consequence of larger supply and market areas, which opens opportunities for innovation and productivity improvements.

To the extent that our ideas about the emerging evolutionary paradigm are correct, they directly confront conventional wisdom about transportation management. We invest in and control transportation to lower costs and/or improve services. The focus is on making existing systems work better. One cannot deny the value of making systems work better, for efficiency is always desirable. Considering the maturity of systems, however, one should not be optimistic about the gains to be achieved. What is the confrontation? It is that conventional wisdom leads us to do things that are not very important; major technological improvements are important and should be sought.

Activities resulting from conventional wisdom are costly. The opportunity cost of doing this rather than that may be great. As conventional wisdom tells us, for instance, we could improve services by introducing ramp meters and advanced traffic management systems on some highways. That would take a lot of effort; perhaps that effort would be better spent seeking new technology and services, or enacting new policies.

One might claim that conventional procedures are satisfactory. After all, concern with elasticity of demand will focus attention on new things waiting to be born.

Unfortunately, that is not true. Concern is with what can be seen and measured. Conventional procedures tend to favor the old and block the new.

There are many other implications. Of special interest is the problem of developing regions or nations. They have invested in conventional systems to “catch up.” That has merit, for it allows those areas to participate in the current round of development. Even so, that strategy can be questioned, for those areas that developed earlier have the lead in development. The developing world must run faster and faster just to keep up. Perhaps it would be better to pursue an alternative path than copying the well-worn path of the developed world. That might provide an opportunity to surpass rather than merely catch the developed world.

Part VI

Conclusion

This page intentionally left blank

28

Speculations

Things have never been more like they are today in history.
—Dwight Eisenhower[1]

Introduction

This chapter aims to place a capstone atop our explorations of the transportation experience. However, perhaps capstone claims too much; speculations might be a better word. A simple statement of our objective is "Learn to do better." That is quite a charge, for it bears on the abilities of organized societies to improve and adjust to changing conditions.

What policies are needed to steer systems in more appropriate ways, that is, do better? In chapter 4 we described the "magic bullet": demand creates *economies of scale* that either improve *quality* or reduce *cost*, thereby increasing *demand*. This is true at a macroscopic scale, and describes how technologies are successfully deployed. But moving from within the life cycle of a technology to the next technology's life cycle is harder. There are many kinds of systems and all are complex, so there is no "silver bullet" for that technology-shifting problem. No single action fits all cases.

What sets transportation and communications systems apart from others are their connecting—enabling roles and the ways they pervade so much of life. They are universal input industries (part of social infrastructure). These features, we think, give special importance to our task, for doing better with these systems enables social and economic development. At the same time, the everywhere-available character of these systems coupled with lack of recent development places many aspects of their problems and opportunities out of sight and out of mind.

We said "learn" because one must learn the rules in order to use, bend, circumvent, finesse, or break them, as well as to have a sense about which ways to go. There is said to be a Chinese adage, "Imagination without learning is wings with no feet."

Policy Debates Matter

We have explored policy and policy making as it has been sifted, sorted, and judged by political scientists and by transportation policy experts, such as James Q. Wilson, John Hazard, David Jones, and Alan Altshuler. This exploration told us that transportation policy is a game that, with a little effort, anyone can play.

The professional should understand issues and varied concerns, and work effectively in contexts where issues are debated and decisions made, so this learning about sizing up and participation seems, *ipso facto*, valuable. But we must also recognize that many if not most debates are about marginalia or miss the point because of poor process specification. Does one's effectiveness in such debates have merit? Yes is the answer to that question when one takes the view that much progress takes place in small steps, and even though the debate may be somewhat off the mark, it is about moving in the right direction.

Consider this example of such a debate. The local mercantilism policy theme often gets simplified to job creation. Cost per job, the incidence of costs, and equity issues are debated. Those matters are important if, say, the debate is about tax reduction and other inducements for the location of a firm in an area. If the action being debated is transportation enhancement, a similar debate may occur about the jobs created to build and operate something, say an airport. This misses the point. It may be overlooked that such jobs represent a cost rather than a benefit to the economy.

But one could argue that jobs created for facility operations have some positive correlation to the effectiveness of the facility; if a new airport creates jobs (above what jobs there would have been without the new airport), it implies that the airport has increased activities in its service area and something good must be going on.

Yet that argument is quite fuzzy. For one thing, decreased efficiency may require an increased number of jobs, or increased airport efficiency may disconnect airport jobs from job creation in the service area. Other things may be said, but we have made our point. The example debate suffers from poor process specification, and argument about airport jobs is argument at the margin of the development process.

To reconsider the question "Does one's effectiveness in debates such as that just illustrated have merit?" We said yes before, but could have said no or "it depends on how the subject at debate is framed." We shall strengthen our speculation by observing that there are opportunity costs when policies are debated and actions taken.

Pick Consequential Battles

Debating and taking actions on low-priority or misspecified issues may sap energy and attention from more fruitful endeavors. Perhaps one can tar with the opportunity cost brush most of the debates responding to transportation energy and pollution problems and also debates focusing on transportation system management.

The Transportation Experience attends to the structures that characterize transportation (and similar public facility) systems, to their growth dynamics, and to the nature of decision making within systems and between them and the rest of the world. We know that consequential changes in what systems do are rather rare, and are rarely a part of personal experiences.

We have learned that a consequential change in the capabilities of a system involves a change in system format. We know that a change in system format may occur in several ways. One way that format change occurs, for example, is when innovators put building blocks together into a new format (e.g., container shipping); another is when a change in a component forces change in other components (as jet aircraft did).

We know that a system format has a technological as well as an institutional aspect, and that the institutional aspect usually falls in place to match the technological format. (That is why we emphasize technology as the instrument for change.) That is not to say that there are no generic ways to understand institutions. After all, institutions result from learning, and they have behavioral characteristics.

We have learned that once the system format is established, decision making is more and more component and subcomponent constrained, and the likelihood that a change in a component will force system format change becomes less and less. As the scope of available decisions becomes more and more locked in, the priority for kinds of decisions changes. Near the end of the growth cycle we shift from deployment decisions to operations decisions.

This explains why system structure and behavior in transportation provides a context unlike the contexts in which many experienced technology managers and innovators have accumulated their deep understandings, and why mapping from their experiences to transportation is difficult.

That learning can help us place perspective on day-to-day experiences. It explains, for example, why many departments of transportation privilege technologies for system operations. It also explains the authors' opinions that the priority is not likely to lead to anything very consequential, even though there are lots of exciting and interesting technologies to be played with and used as building blocks.

Policy and planning ought to be inquiring, exploring activities, ever opening new options for social and economic choices. They should open pathways rather than exploit existing ones. The word "consequential" implies that actions should offer improvements by a factor of two or more in the human condition. Resources for analysis and implementation are small; apply them to things that will make a difference.

To strive to understand questions of how and why, we have invested in seeking what the literature says. There are literatures on the history of science and technology, on the economics of invention and innovation, and on program- or event-specific things, for instance, the Panama Canal.

The literature does have a lot to say about what, how, and why, but the information is limited to parts of systems or to the economist's atomistic system. When we ask that something be consequential in the context of large system behavior, the relevance of the literature is sharply limited. The literature rarely analyzes large systems, such as transportation, as a whole.

People do analyze things of consequence *to* large systems; for example, we know the Ford Model T story very well. What is missing is the connection of the analysis to system behavior, constraints, payoffs, and so on.

Where does that leave us? It requires that we add to what the literature and our own personal experiences say. We urge the reader to make a liar of Georg Hegel, "What history teaches us is that men have never learned anything from it."

Consequential action, as we have defined it, demands much thinking about the nature of transportation and its functions. In turn, that thinking suggests interesting work. We cannot resist the comment that *conventional action* hardly takes any thinking at all. Box 28.1 contrasts conventional wisdom and consequential action.

BOX 28.1 Conventional Wisdom versus Consequential Action

Over the years, Garrison has spent many hours and days in meetings with "experts." Here are some examples: Not long ago, he met with a group of about twenty, including some policy analysts from the White House, to work out what, if anything, should be done at this time to begin to substitute methanol for gasoline. About the same time he met with a group of about forty, mostly scientists, to recommend "breakthrough technology" opportunities for energy conservation. He has been in lots of meetings recently to talk about technologies for highway traffic operations.

Experiences such as these have accumulated into the hundreds over the years; topics have ranged from bus design through regional economic development to earth resources sensors.

What do these experiences teach that might be useful to planning? In particular, is there anything that suggests more consequential planning concepts and methods as opposed to methods that help us do more than deploy a given system marginally better?

The answer to the question is "not much," although the experiences do provide a point of departure from which we have tried to craft ways of thinking.

Each experience is different, of course. Even so, they tend to be at two extremes. In the first are situations where there is unquestioning consensus, and the meeting achieves smooth conformity. An example is an experience several years ago dealing with how to incorporate energy conservation experiences into transportation system management (TSM) protocols. The consensus was that TSM is a good thing to do; protocols already adopted were just right; fine-tuning was the problem. Dullsville.

It is true that if something consequential is going on, then conforming and doing better is worthwhile. But we desire to learn how to shift development paths and achieve more consequential outcomes, and cannot learn that from conforming behavior.

Here, Garrison's past ideas conflict with his present ideas. Suppose we had been asked in the late 1940s whether the idea of needs studies was a good one. The answer would have been, sure—all the states ought to do such studies because it will make the highway program much better. Needs studies were viewed as a consequential thing to do. In the long run, of course, needs studies locked in ways of thinking and highway development.

In a situation like that today, we would want to do consequential things, but not in a style that locks in inquiring planning.

Garrison's experiences on the National Academy of Engineering Committee on Transportation (NAECOT) advisory committee to the U.S. DOT were at another extreme. The committee did not conform to conventional wisdom at all. Nothing was taken for granted. The DOT advisory committee comprised individuals who had been very successful in technology innovation and management situations. Members came mainly from private-sector, high-tech environments. Each person could speak from personal experience, and previous successes gave authority to what they had to say.

Suggestions made by committee members were far from conventional ones. Compared to conventional suggestions, they had an out-of-left-field flavor. At the same time, suggestions obviously had a lot of insight and knowledge backing them up.

The committee's work was not very effective for two reasons:

- There was a misfit between the successful (and exciting) experiences brought to the table and the inherent nature of the transportation system. There was a lot of talent at the table, evidenced by the major accomplishments of the actors, but the talent just did not fit transportation.

BOX 28.1 Conventional Wisdom versus Consequential Action—cont'd

- The reason successful experiences and rich insights could not be transferred to transportation was because while committee members had good intuition on what might be done, they did not have systematic ideas about how and why things might be done; they had rich insights that could not be transferred. It takes knowledge of how and why to transfer insights from one field to another.

Other experiences cluster toward either the TSM–energy planning or DOT advisory committee extremes. By definition, most people's thinking conforms to conventional wisdom (often reflecting government programs; if DOT says it, therefore it is important).

Similar experiences are formed when general technology, policy, planning, or other topics are the subject. Such conversations are often impression-based and, in contrast to talking with experts, tend not to be deep. "I think" dominates, with little authority experience to back up the "I think." Often even the insights and hunches are not very good.

As a result of these experiences, we conclude:

- That conventional, conforming behavior is wrong-headed.
- That unless "experts" have a track record backing up their insights (as was the case on the DOT advisory committee), most "I think" statements are to be disregarded.
- Where the speakers' record says that one should pay attention to insights, they can't be used very well without good understanding of why and how questions.

Interest Groups Are Socially Constructed (Where You Stand Depends on Where You Sit)

We have also undertaken the daring and little attempted task of looking beyond what some sages say. We examined the full modern transportation experience. We asked what the railroad experience says about the logic of policy, and then saw that logic working in other modes.

Why did we explore in this fashion? We have already said that one has to learn the rules, and exploration of the full experience fleshes out the rules. It ought to be apparent that there is much more to the rules than what is found in the current literature and topical debates. Perhaps Friedrich Nietzsche's remark is appropriate, "The surest way to corrupt our youth is to teach them to hold in higher esteem those who think alike than those who think differently," and we have sought to interest the student in thinking differently and questioning those who think alike.

Those who think alike may be thought of as holding conventional wisdom; those who think differently are not so taken by conventional wisdom. To illustrate this point, consider the rather large literature on decision making relative to policy. That literature emphasizes interest groups and the structures within which interest groups seek their ends. It is rich in the sense that tradeoffs, side payments, and other such interactive and behavioral dimensions are introduced.

Without denying the usefulness of the literature, we would raise the point that interest groups are not God-given. Their roots have to do with what we have called the national political ethic, transportation systems structures, particular development paths, and other things. We think that understanding the evolution and shaping of interest groups is rich from a causal point of view for that says how and why the die is cast. How interest groups behave does not reach so much to the heart of the matter. That is not conventional wisdom. Interest groups are socially constructed, and how and why are first questions.

To illustrate that speculation, consider the difference between inland water policy debates and highway policy debates. The stage (the die, to reuse the word) tells us that the U.S. Army Corps of Engineers is very much a player on waterways matters at the national level, while the highway establishment is relatively a lesser player at that level and more of a player at state and local levels. The explanations for the differences involve the French engineering/statist style of the Corps, and many other things.

No Decision Is "Truth" (Many Roads Lead to Rome)

Another speculation is conveyed by the expression "there are many roads to Rome." We saw the difference between English, French, and U.S. policy styles and one can imagine how styles in other nations relate to those differences. Each style has its advantages and dysfunctions and these may be debated. However, the bottom line is that many things turn out more or less the same regardless of the road taken. Many roads lead to Rome. There is no single correct way to proceed, conventional wisdom notwithstanding.

Linear Reasoning Yields Conventional Wisdom

Up to this point we have discussed conventional wisdom at a very broad level. Conventional wisdom assumes a mythic level. A first-glance interpretation of why this is true might go this way:

- First, something seems obvious, therefore it is true. (When we ride a bus, there are more riders on a bus than in a car; therefore a bus is more energy efficient than a car.)
- Second, we are lazy, and do not bother to go beyond the obvious. (What about the times when there aren't so many riders on the bus? Because only a few people are acting as observers, it follows that low ridership is less likely to be observed than high ridership. What about dead-heading, thin collector/distributor service, and so on?)
- One can add the underscoring of the obvious by advocates and the inherent difficulty of rebutting the obvious by those opposed to an issue.

While this line of thinking may apply to cases, we think it oversimplifies the situation and is pessimistic about the ability of individuals to think about things. Ordinary life experiences say "you can fool some of the people only some of the time."

The calculus of reasoning yields conventional wisdom. We reason, using symbols, metonymy, and metaphor to turn complex situations into common sense. This obviousness leads to "ends justifies means" programs and to incarnations of moral imperatives. 'Good versus evil' is easy to see. That is how automobiles and highways became peccable; mass transit became good and worth achieving, no matter what.

What is the bottom line? Metaphors are useful, but they can trap us. For instance, the system life cycle is useful, but we should be wary of the inference that maturity is inevitable and that maturity halts development.

Policy and Design Would Be Improved by Bridging the Soft and Hard

It is not news that there is a considerable chasm between thinking in the social sciences and allied fields and thinking in the physical and biological sciences and allied fields. It is also not news that the policy world divides into what for shorthand we shall call hard and soft. Energy, aerospace, defense, and health policies are largely framed by hard thinking; welfare, education, trade, international relations, antitrust, and some other policies by soft thinking.

The chasm is illustrated by energy policy. By and large, it is dominated by hard thinking, and the creation of more efficient technologies is the objective of policy. Soft policy mainly addresses constraints on demand.

Bridging or merging the soft and the hard would vastly improve policy and policy-making processes. That point is somewhat obvious, and it fleshes out very well when we remember that progress is achieved by design and through design. That is just saying what we have said elsewhere using expressions such as "putting old things together in new ways." It is true that most of our discussion has used hard language to describe creating the new. That is an easy way to transmit images. At the same time, we have striven to include the soft sides of designs.

It needs to be emphasized that the "progress by design" notion is not just a notion held by players in hard arenas. Zuckermann et al. (1992) make the point that administrative and policy innovations follow from the "assemblage of old stuff in new ways." These are words very similar to those we use. Zuckermann et al. go on to say that the sequence Aim–Fire–Ready is the one that works, and we see this observation as close to our emphasis on trying things out.

What about achieving bridges between the hard and soft worlds? Many would say that economics permeates policy in both worlds and that is the bridge that needs to be strengthened. That is true, yet we have some problems with the economics emphasis. For one thing, that connection has been present for a long time and the hard and soft are still worlds apart, so to speak. (Indeed, both benefit–cost and consumer surplus ideas evolved in transportation contexts.) Economics can be said to serve a "checklist" role for testing the economic feasibility of hard proposals. That is a limited role, and there is no counterpart—a checklist for the hard implications of soft thinking. The creation of designs would provide venues for merging hard and soft thinking.

Transportation Ideas Are Light Baggage

Overall, transportation ideas are light baggage. Chicago Area Transportation Study-rooted urban transportation planning methods were adopted worldwide in about a decade. Private-sector-like arrangements for government activities are spreading. Tolls in Singapore are emulated in Rome and London. The technology for the manufacture of gunpowder seems to have migrated to Europe before Marco Polo's travels. The list is long.

But there is the problem of counterexamples. Ideas about road technology and road programs did not seem to migrate from France to England very well, though canal technology did. The English read the fate of canals and toll roads versus railroads very quickly, but that reading did not seem to migrate to the United States very rapidly.

So the notion that ideas are light baggage needs some tightening and interpretation. Can we interpret the notion by examining the carryover to later times of ideas from the English prerailroad experience?

The equity issues associated with toll road development and use were mentioned in our discussion. Were those issues light baggage? In a short time frame they certainly were. The evolution of railroad commodity pricing and Parliamentary trains responded to those issues. In a long time frame, however, those ideas have not proved light baggage.

We did not mention environmental and property rights issues very much in our discussion. To augment the discussion, we note that the first Act enabling road relocation carefully specified that no gardens, lawns, or structures should be taken for road use. Parnell (1833) was concerned about such trespassing.

Our conclusions about environmental and property issues are similar to the equity–toll issues. In the short run, ideas are light baggage; in the long run they are lost. Experience of earlier debates seems to be forgotten. Few anticipated the vigor of environmental debates, and no one seems to remember how previous debates were resolved.

Transportation Provides a Mother Logic for Society

We said that the railroads provided a mother logic for modern transportation systems. The transportation experience provides a mother logic useful beyond the transportation context, a logic useful when interpreting political attitudes, institutions, and many other things about societies. A simple reason for this is that transportation systems are large, touch on all of life, and are omnipresent. Caveats are needed. We said "a" mother logic, rather than "the." Also, we should think of the realizations of systems as a result of interactions between systems and society. As systems were developed, they were a venue for learning, shaping, and framing.

The Pennsylvania Railroad as a model for the modern decentralized corporation was mentioned. For the rail mode and other modes, a long list of other such models may be identified—use of job descriptions, provision of healthcare for workers, retirement schemes, rule establishment and rule following, the union movement, designated inspectors, standards-setting institutions, and so on.

Our discussions made much of local entrepreneurship in the interest of local competitiveness and the evolution of constrained capitalism. Are there other themes at this broad level?

Alexis de Tocqueville (1831) stressed the tension between the individual and community in American life, and transportation was certainly a stage for the play of those themes because local mercantilism required a community base and community actions were needed, for example, for the provision of road systems. For this reason, one might suppose that community was shaped by transportation.

Yet transportation (and communications) decreased the tyranny of space and the sense of place as a base for action. As Webber (1963) puts it, we now live in a "no place" world. The sets of interactions of individuals and institutions span long distances, and transportation and communications have yielded placeless community. It has weakened traditional community based on place. At the same time, it may have strengthened community based on common interests. The transportation–communications–community relation has changed over time.

Transportation Regulatory Agencies Provided a Mother Logic for Regulatory Government

Recall that while government planned and financed transportation improvements in the nineteenth century, the experience was unsatisfactory because of misuse of funds, shoddy work, and other ills. This experience translated into a suspicion of big business and played a role in the move to constrain capitalism.

It seems to have been widely understood at the time that the fault was partly with government. Governments were small, consisted of many elected persons with few skills beyond politics, were tainted by bribery, and had other characteristics limiting abilities to understand, monitor, and control private organizations.

Among other things, this situation and the transportation experience laid the basis for the progressive movement that swelled in the early twentieth century. (It also swelled because of the increasing interest in "scientific" management.) Governments were to have expert bureaucrats on board equipped to run government in an efficient and equitable way. Government procurement rules, civil service laws, personnel programs, and so on, followed. The implementation of progressive government was speeded by expanding road programs (and public health programs) where the meaning of expertise was clear and diffused costs and benefits demanded equity. Transportation problems and programs seeded and nurtured government by professional bureaucrats (a point made earlier about government's learning about regulation).

How did the transportation experience steer today's intergovernmental relations? We speculate that there was a lot of steering, even though the relation often seems fuzzy. Consider the growth of federal power. The up-the-hierarchy movement of government power in transportation began with the nation setting port charges (favoring U.S. ships in the coastal trades) in the early nineteenth century, Army Corps of Engineers programs in the mid-nineteenth century, and the creation of the Interstate Commerce Commission in the 1880s. Power moved up the hierarchy in other programs subsequently. Did the transportation experience influence those programs? We can find cases where the answer seems to be yes, such as the use of federal grants to steer local programs. But the link seems weak in other cases.

Along with power moving upward, there has been an increase in the size of the federal establishment. Today, the U.S. DOT has some 63,577 employees.[2] There is also the state and local government partnership character of programs. Developing early, the transportation experience, especially the highway experience, must have affected partnerships that came along later, but "how" poses a larger question. The answer to the how question is fuzzy in part because the transportation experience was a very diverse one; for example, the Corps of Engineers' program development experience was very different from the highway program experience.

Transportation Opportunities Enable Innovation in the Economy

For completeness we need to include the companion innovation speculation. Transportation improvements open opportunities for innovation. The pursuit of those opportunities steers development generally.

Transportation Is Bound by a Social Contract

We have said that government policy formation and implementation has, in part, a "default" character, and we noted government actions in instances where the embedded policies of the railroads could not meet the needs of the properties or manage their problems. We argued that government actions are also taken when system services fall short of social expectations, that is, when the social contract is broken.

To deal with transportation's relations with society, it is useful to think of a social contract. Society is one party to the contract. Members of the population and social and economic institutions hear about and/or experience and learn what transportation can do; expectations develop. Service providers test the market, and they gain a sense of what is expected of them. In a sense a kind of contract emerges, a social contract, and problems arise when the parties to the contract no longer honor it.

For an example of a contract in trouble, today's highway establishment is upset because the public is no longer providing the money to continue with "business as usual." The public is unhappy too—facility providers are no longer providing a better road system. The social contract has been violated.

Speaking especially to highways, David Jones[3] put the matter this way:

> Transportation development is a contractual phenomenon. At its core is a negotiated agreement about what to build and how to pay for it. This agreement has the character of a social contract. Transportation development can proceed when there is agreement on what to build and who shall pay. It falters when such agreement erodes.
>
> Transportation development is also a technological phenomenon. Progress is made as improvements in technology are introduced, perfected, and built up into systems. The introduction of successive technological improvements—developmental progress—hinges on successful adjustment of prevailing agreements on what to build and how to pay for it. In turn, sustained development hinges on renewing that agreement in successive rounds of investment. Each round of investment reopens the question: What to build next and how to pay for the next increment to be added. Without renegotiation, consensus erodes, and development falters.

And Jones sees political actors as negotiating successive rounds of development investments. We like Jones's discussion, but would not want to restrict the notion of social contract to instances where the contract is formally negotiated or those where there are successive rounds of investment. We think of a contract's existing if what is being done is acceptable to both parties. Things are copasetic if the "if it ain't broke, don't fix it" rule is holding.

The Life Cycle Dynamic of Systems Strains Social Contracts

For example, as long as a system is in a deployment phase, service improves and expectations increase. Growth by deployment results in access to ever increasing markets and social opportunities. But once deployment is complete, service providers cannot deliver expected improvements: growth slows; profits return to normal; all customers are served. At this point, companion innovation slows down until the next technology comes along.

The social contract implies that society will serve the needs of its members. With respect to the physical facilities used by the public, needs are recognized by observing how users behave. The physical dimensions of needs are then defined through analysis.

Geared to efficiency, safety, and other goals, the effort is made to provide for needs in desirable ways.

We see cars consuming numerous gallons of gasoline per day, we count the traffic on a highway route, or we observe how travelers check in at an airport. The professional regards such behaviors as needs, and strives to define then in physical terms. The latter, the definition in physical terms, is often stated as the need: we need an M meter wide pavement of P centimeter thick Portland cement concrete on route R; at time T, we need N open ticket counters for flight XXX. Highway planners today are observing the growth of the suburbs. Tomorrow's needs are for suburban facilities.

While the definition of physical facility needs is less than perfect, there is no doubt that there has been steady progress in responding to needs defined this way. Compared to other wealthy nations, the United States does a pretty good job of meeting needs.

Unlike needs, the notion of wants has not been well operationalized. Wants is a vague idea. While needs may be limited, wants are practically insatiable.

In the mythical, purely atomistic world of the economist, there is market clearing. The goods or services that consumers want get turned into needs (things purchased) through a calculus that balances preferences, disposable income, supply and demand relations in aggregate markets, and prices.

How well do wants get translated to needs? That depends on many things, with the level of disposable income being critical. The rich can get what they want; the poor do not do as well.

Taking one step back from a static market situation, how well do the goods and services supplied track on changing wants? In the atomistic world there are innovators developing new products to replace the old. There is a constant exploring of ways to meet old and new wants. Successful in the market, new products or services displace the old. The new, responded to in the market as a need, matches wants better than the old. Something needed before is no longer needed. The market tells me there is little or no need for buggy whips. Now, there is a need for GPS-based in-vehicle navigation systems. At least, that is the way it is supposed to work in the private sector.

In the public sector the lack of fit between the ever changing wants of publics and needs as defined by suppliers gets treated through political markets. That process works to some extent. It has some distortions, of course. Publics with intense interest in some want can get that turned into a general need. For instance, there are those who intensely want American jobs and bottoms in coastal trade. Therefore, the nation needs Jones Act protection.

The private-sector-style innovator exploring new ways to meet wants is generally absent in the public sector. When an activity is identified, interest is mainly in more efficient ways to meet wants. It is not in new products or services that displace the old in the fashion that we imagine in the private sector.

The planning style suggested is aimed at stimulating innovation in the public sector—transportation in particular. The innovation of concern is market- or wants-exploring.

We have suggested that the private sector provides a model for that kind of innovation, but that is arguable. The private sector is less than perfect. Some private sector managers have little use for thinking about new things; others (like the reasonable man in the Shaw quote at the head of chapter 24) accept the world as it is and concentrate on playing the cards they hold. And some let others innovate, assuming that they can produce a lookalike that is better. Let others take the risk; after all, the pioneer is the one with the arrow in his back.

In the early days of the life cycle of systems, two questions are explored. The first concerns supply: "What technology designs are feasible?" The second relates to demand: "What do publics want?" New systems meet wants rather than needs, as real needs have already been satisfied by older systems. The social contract says when satisfying new "wants," don't unsatisfy old "needs." This is in line with the notion of undertaking only Pareto improvements, those that makes some people better off without making anyone else worse off. The problem arises when "ensuring steadily improving conditions" or "ensuring that everyone achieves proportionate gains" appear as needs rather than wants.

Transportation Tomorrow Will Resemble Today

We have mainly been *looking back*. We have seen how the policy, planning, deployment, and management tasks changed as modes ran out their life cycle dynamics. We also looked back at ideas. We have also seen how techniques have evolved. Looking back has an element of looking around, for we look back using today's perspectives—we interpret what used to be using today's perspective.

Looking around we see that much has been accomplished. Almost everywhere, systems are safer, more reliable and accessible, cleaner, and so on. That is in spite of the growth in demand and the many who predicted disasters just around the corner because of shortfalls of capacity.

Looking around says a good bit about *looking ahead*, for tomorrow we shall be reacting to today's ideas and problem statements, institutions and policies, and social and economic trends, as well as the running out of the life cycle dynamics of systems. Assuming that progress similar to that we are making today continues, tomorrow will be a polished today (assuming away the possibilities for war, depression, violent social conflicts, disease, and sudden ecological disasters).

A major reason why tomorrow will be much like today is that the turf is occupied by *legacy systems*. There are the physical systems—highways, transit, airports, and so on. Institutional and financial arrangements are there too—metropolitan planning organizations, congestion management agencies, fuel taxes, state agencies, and so on. And there is an endless list of things ranging from legal arrangements to protocols for construction contracts and the job descriptions of transportation planners and workers. Legacy systems change slowly.

Institutional inertia bears on the continued life of legacy systems. But we think that *social contracts* are the strong glue that says that legacy systems will continue into the future. It is decided to do something a certain way, and that is the contract. Consider the surface transportation bill every five years or so as a social contract. It will stick in ways, regardless of what Congress does. First there is the cost of contracting—getting the legislation. It takes years, much effort, and lots of horse-trading (side contracts). The bill occupies the intellectual turf as the solution, and other solutions have to find a place to spawn, before pushing aside the current wisdom. Although it may not be so great in the case of a single pork-barrel-laden surface transportation bill, most contracts have ethical implications if they are broken—people get hurt.

The social contract is often described in terms such as those applying to jobs, rights to education and welfare, and security. It really is much broader than that for it shapes the accepted views of problems and solutions; it sets the stage for things.

We are observing that actions are constrained by contracts. However, a naysayer might comment that contracts do get broken (e.g., as corporations downsize) and that the Congress is engaged in massive contract breaking (downsizing and devolution)—welfare, education, environment, and so on. That is true, and it underscores the cost of contract breaking, as well as the role of imperatives when contracts are broken. Competition is the imperative in the marketplace and the national debt is the culprit in the government case.

We wonder if the use of a highly metaphoric language in transportation is a *dysfunction*. We speak of arterials, bypasses, transportation–housing balance, and many other things using metaphors. Does this limit the scope of planning actions and affect the ways tasks for planning are identified?

The disjointed character of systems is another dysfunction. It constrains the way systems are conceptualized and thus constrains the ideas for improving planning. The situation is worse, however, because turf is occupied by ideas of limited effectiveness. They translate to techniques that are similar to hammers. If that is what one has, everything looks like a nail. In this kind of world, "research is involved in a positive feedback spiral where increasingly inefficient research becomes the training ground for each new generation of research workers" (Forrester, 1975, p. 87).

Finally, life-cycle-based processes play a large role in defining the stage and thus how ideas are shaped and techniques used. With respect to the life cycle, one presumption is that things will go along as they are: maturity and stasis continue. Emphasis on transportation management is one result. Among other things, there is fine-detail exploitation of opportunities, such as opportunities to develop HOV lanes or park and ride lots. Another feature of maturity is that institutions are very conservative and risk averse, as well as being very process oriented.

At the same time, achieving scale economies in actions is critical. That is partly to reduce risk. It is also a requirement for being competitive. Facilities such as the new Denver airport, the Channel tunnel, and high-speed intercity trains are very risky and a critical question is "Will they achieve necessary scale?" Within urban areas, people movers and rail transit investment have faced the scale question.

There is the option of breaking the tyranny of the existing life cycle. That could happen as the result of inventors and innovators creating new technologies that break the dependence on old systems. An alternative would be to implement planning and policy to break the tyranny.

What is surprising is the number of project starts made even when it was already clear that a superior system was replacing the system being planned. This was the case for many canal projects in the United States. Investments were made even though there were ample hints of the potential of railroad competition. The competition dynamic says that plans ought to consider what the competition will do, as well as considering strategies for decline in the face of competition. The inability to break away from legacy systems places a curse on posterity.

All Nations Are Both Developed and Undeveloped Concerning Transportation

Although there are gradations between the two, it is useful to speak of three types of nations: developed, developing, and undeveloped (following the maturity, growth, and birth stages). From a transportation perspective all nations are developed nations. That seems to run counter to ordinary experience in undeveloped and developing nations where service is not of high quality or everywhere available. In what sense could this be true?

The modern transportation systems were born in the "developed" world environment, energized development through companion innovation processes, and were deployed as development pushed and pulled deployment. At that time, they were deployed in the undeveloped world. They were pushed and pulled by the same processes. For example, there were early railroads in Africa and South America where development opportunities called for them. The difference between the developed and the underdeveloped nations is that the undeveloped nations experienced Western-style development at the fringe, so to speak. The companion innovations that bloomed as modern transportation was created and deployed fit the Western situation very well. They took hold only in limited ways in other places.

The economic development programs that emphasize deployment of the systems successful in the developed nations in the undeveloped nations do not much make sense. Wilfred Owen (1987) argues for equity as a basis for subsidized deployment. It is not fair and just for the undeveloped nations not to have good highway and other services. That argument has merit. After all, their deployment has already been tried with limited success. What is needed is the development of services suited to the situations in the undeveloped nations.

On the other hand, one could rightly view all nations as undeveloped in a transportation sense. That follows from observing that modern systems are not so modern. They were developed using once-modern tools to fit once-current circumstances, and they are obsolete today.

Policy Should Create Environments for Innovators to Improve Service

In the first paragraph of this chapter, it was said that our objective is to do better. Toward doing better, the discussion above sought to dig deeper. For example, it was said that we ought to go beyond how interest groups behave and be concerned about their structures and origins. It was said that the use of metaphors has an upside and a downside. Running through *The Transportation Experience* there was an effort to understand policy in a generic fashion.

Also, we sought to scope widely; for example, we considered both mode-embedded and government policies, and we recognized logic copying, learning from experiences, and so on. We scoped to considerations of national points of view about the roles of government. Growing out of the examination of life cycles and the mature status of today's systems, there was effort to scope to the energizing, redesigning, or rebirth of systems.

The development of more efficacious policies surely will be aided by our digging deeper and scoping widely. Scoping to energizing adds a dimension to policy, and our *final speculation* is that policy should create environments within which organizational and individual innovators can search for system-scoped service improvements. All the speculations bear on this task. For example, an environment ought to encourage the merging of hard and soft ideas, it ought to provide for rich problem and opportunity statements. We shall not discuss the environment for innovation further because that topic goes beyond our policy speculations.

Turning now to dysfunctions, recall that a large part of the improvements in the financial health and productivity of the railroads has been achieved by treating dysfunctions accumulated during the era of regulation. A similar sort of thing might be imagined for urban transportation. For instance, the railroads constrained their common carrier responsibilities, changed pricing to a modified Ramsey (inverse elasticity) scheme, and rationalized network and institutional structures. Urban transportation systems might adopt similar changes.

Some obvious dysfunctions in transportation service reside at interfaces: interfaces between local and regional roads, interfaces between transit lines, interfaces between airports and rail stations and local transportation services. There are failures to balance costs and prices, leading to overconsumption and underproduction of transportation services. There are also negative externalities such as air pollution and noise. A long list could be made of such dysfunctions. Such dysfunctions are targets for plans and actions.

Planning for changes of this sort would represent an expansion of existing activities. A sticky aspect is that some social contracts might have to be modified. However, there is one policy question that should be mentioned. There is renewed interest in proactive policy (as opposed to what might be called enabling policy). Tools include subsidy, tax advantages, regulations, investment in demonstrations and R&D, and the use of government procurement to create markets. How proactive should policy be?

Considering national policy, our bias is very much toward emphasizing *enabling* more than *enacting* policy. Our view is that there are lots of latent ideas that would bloom if allowed. Something that has to be pulled, say, by subsidy is probably not a very good idea. Also, national level programs suffer from one size fits all, emphasize big programs, and other ills.

Let us put this another way. There are lots of enthusiasms out there. The niche market venues for trying out lots of things would seem to be at the local level where local mercantilism is a motivating force. That suggests proactive local policies, and that is fine because risks, payoffs, measures of progress, objectives, and so on, would be under close scrutiny. This close coupling is not present at the national level.

One may object to the authors' position by claiming that some things, such as research and development and massing large amounts of capital, might be most efficiently done at the national level. And one might add the notion that the national government could best recognize and utilize creative talent. As we have said, however, progress has come from new arrangements of old things in unsatisfied market niches. Research and development to improve systems and finding capital for their deployment become salient only after something worth doing is found.

A second objection follows from the "more than one road may lead to Rome" observation—a national proactive stance is another road. That could be true. But it seems risky at this point in time because national government activities in transportation have not nurtured the development of the traditions, insights, and talents that a national proactive program would require. One could say that they are not present at the local level either, so the issue becomes that of where learning best takes place: in local laboratories or by national direction. Experience will show the way.

Afterword: The Transportation Professional and Transportation Policy (The Design of a Life)

The Real Question is not to explain our sorry reality, but to improve it.
— August Lösch

August Lösch's *The Location of Economic Activity* is one of the great books of the twentieth century. It is essential reading for anyone interested in planning, location economics, transportation, or geography. Written during the 1930s and 1940s in Germany by an outsider to National Socialism and the university community, the words "sorry reality" run deep.

These afterwords will address a most difficult question: What is the reader to do with the understandings of policy absorbed from *The Transportation Experience,* and how should those understandings affect the reader's work? Because each reader differs and there are many paths through life, there is a limit on how far we can work the question. We can address how understandings might be used, with how they are used depending on the student and the opportunities that unfold.

Toward the end of these words, we comment on the author's (Garrison's) interactions in policy affairs and about the world as he would like it—a world where options are explored and new paths taken.

The Sorry Reality

One sorry reality is that transportation systems are not controllable in important ways. They get started; they grow and develop; and then sail in the sunset of obsolete stasis. Subject to responding to markets, systems are self-organizing and self-steering, and embedded policies play a dominant role in shaping the ways they are organized and the performance they achieve.

At fine detail, society can ease barriers to deployment (and subvent deployment via subsidy), control the behavior of system actors when they blatantly violate social norms, force fixes on externalities, and fine-tune deployment decisions to places and local circumstances. These are tuning policies rather than controlling policies.

It seems to us that understanding the problem of control is a major contribution of *The Transportation Experience*. Control is a nontrivial matter. It deserves our attention as a transportation question. And we see the transportation question as one of a larger set of questions about the social control of technology. The question of social control is usually phrased in more limited and less deep ways, and understanding the transportation situation gives us some general, nontrivial insights.

A second aspect of our sorry reality is the maturity of systems. There are two aspects. One is that systems are not yielding on- and off-system improvements in the way that we have known them in the past. Transportation's external benefits and reorganizational changes have been exploited. Indeed, in some cases service improvements are negative.

The other aspect of maturity is the limited options available to managers and to policy makers. The options are a sorry lot because they are tinkering or tuning ones. Managers can seek to improve product quality and differentiate standardized services to minor variations in markets. With the objective of lowering costs, they strive to get the scale of production just right; they search for lower factor prices, for example by using nonunion labor. Fine-tuning pricing policy, market channeling, and product differentiation become priorities.

The maturity of transportation systems deserves our attention as such, and also because of similarities among transportation systems and other maturing activities. Understanding the transportation situation yields some general, nontrivial knowledge.

A third aspect of sorry reality emerges from considering what we found when we examined how policy is studied, debated, made, and implemented. We saw iron triangles, policy being made from "pure" technology considerations, exercise of many-against-the-few and few-against-the-many power, and actions where ends justify means.

Focusing on these aspects of reality, Darling (1980) sees policy as "witchcraft." We would not go that far. Given the options available and the circumstances in which policy is made, actors impose their rationalities on systems. If that leads to gross subsidies for coal transport over Crows Pass, we, unlike Darling, judge those subsidies as rational. If policy makers in Los Angeles compare streetcars to buses and opt for streetcars, we judge that decision as rational.

But to Improve It

To assist the discussion of the improvement of our sorry reality, shorthand expressions will be useful; three words will be used: control, maturity, and rationality. Control has to do with intervening in the apparent inevitability and irreversibility of the life cycle. Maturity describes the present state of affairs. And rationality has to do with ways we make judgments and decisions.

Taking life cycle and control matters first, the usual prescription is to live with the tyranny of the life cycle. Dahl and Lindblom's (1953) incrementalism, muddling-through prescription is that. There is the body of concepts in microeconomics. The situation is taken as is, production functions are fixed. Optimization is at issue.

We accept the need for incrementalism, but point out that incremental actions consistent with embedded policies and the movement of a system along its life cycle are one thing and incremental actions yielding consequential improvements are another. Fulton, Stephenson and Pease, McLean, and the unnamed people who created auto, air, transit, and other systems worked incrementally. In the transportation situation, muddling through yields only squabbling over marginal things.

Ayres (1984) offers another prescription. He would have us track progress for activities and implement control when activities are in the adolescent stage of the cycle. The instrument of control would be innovation, and at adolescence the manager-planner would make investments in R&D so as to make the maturing product obsolete. In this scheme, systems avoid maturity. New products are put in the pipeline to make old products obsolete just when old products begin to mature. There is action of this type in the private sector. Ayres terms this strategy, policy, or activity "indicative" planning. In his world, intellectual or innovation resources would be deployed here and there as needed to renew/replace activities before they mature.

Elsewhere, Ayres and Steger (1985) argue that new technologies are changing the name of the game, offering the possibility for small-scale production. Thus the standardization and production on a large scale that locks in mature activities is no longer needed.

We like Ayres's insights, but have problems with his indicative planning. It is demanding of knowledge and insights, and it suggests the centralized allocation of resources for innovation. The latter is a risky thing for democratic societies.

Some policy experts and business types talk about industrial planning, using Japan's MITI as a model. That debate lacks Ayres's insights. Its essence is how to live with mature activities, and a close examination of MITI's activities gives only lessons on how to gain comparative advantage in mature activities.

Up to this point we have spoken to the life cycle and maturity as we see it in history; it is irreversible and inevitable. History says more, for new products do come along and make the old obsolete. All we have to do is wait, and something will happen.

We give this strategy little credit. As we have seen, there is a lot of chance in what happens. There is no reason to believe that what will happen will have desirable properties compared to the universe of all things that might happen. Furthermore, while this strategy may work reasonably well in an atomistic world, in today's locked-in big-system world it may be a long time before anything comes along.

In years to come, the reader will be hearing a good deal about long waves (on the order of 50- to 80-year cycles) in the economy—recession, depression, recovery, recession, and so on. Observers have called attention to these waves for about 50 years, but lacking a theory and a convincing empirical base, most (such as Samuelson) have called them "science fiction."

But improved data and some articulate causal arguments have emerged. Understandings of the relations among investment, productivity, and innovation are at the core of the causal argument (Marchetti, 1980). Innovation waves are stimulated by depressions. The depressions reflect adjustments, as investments are made obsolete. That is not a pretty picture. We are not happy that life rides on waves beyond our control. We are not attracted to a "wait until things change and something comes along" strategy.

Kant's perception of ethical behavior is one that we find useful. It takes a book to state it, but it boils down to never using others to serve one's purposes. Another version is to avoid imposing one's calculus of values and rationality on others.

Kant's perception is often violated in transportation affairs and in life generally. For example, we often hear transportation planners saying, "We have got to get land use under control in order to make transportation work." We hear that in the light rail debate: it will work just fine if we control land uses. That is bothersome. A transportation person is trying to get people to do things they would not otherwise do to make transportation work. It is pushing our collective failure to develop the right kinds of transportation on someone else.

Another case involves opportunity costs. We implement lots of policies that attempt improvements by throwing money at problems—save the cities with transit, smart cars and highways will manage congestion, solve the air pollution problem by degrading combustion efficiency, and so on. We suspect that those are not very good ways to go, but in the spirit of Kant, we limit ourselves to saying that and do not interfere when others proceed in that direction. But that puts us in a bind because opportunity costs are so high; we could be using resources of attention, energy, and money in better ways.

Finally, there are ethical-equity dimensions. There is the here and now question of vertical and horizontal equity. In our minds, however, the now and tomorrow equity question overrides. Are we doing things that are inequitable to future generations? We hear some urbanists say we ought to invest in heavy rail. True, it will not work very well now, but think of how wonderful it will be for future generations. That is a mind-bending way of thinking.

Design of a Life

What is the reader to do? Does deep knowledge of our sorry reality immobilize us? Are problems so tough that nothing can be done?

Garrison, who has been involved in many things and claims to have done no harm, says, "I manage by wearing two hats. I wear one hat when judging whether or not to enter ongoing affairs. I wear a second hat when debating goals, programs, opportunities, the allocation of intellectual resources, and such."

There are thousands of policy debates ongoing at any time. For reasons of where one happens to be or whom one happens to know, the professional has the choice of entering the debate or sitting it out. The question boils down to when to enter and when to sit out, subject, of course, to limits on energy, attention, and time. The answer to the question has to be tempered by judgments of the probability of something happening.

One question to ask of an opportunity is the extent to which it addresses making a mature system work better. We know, for example, that anything that better matches a mature product to markets is an improvement. We can be alert to whether the opportunity is concerned with on-system or off-system payoffs. Will there be a direct confrontation with an embedded policy with a low likelihood of changing? What magnitudes of payoffs are involved?

Armed with understandings from *The Transportation Experience*, the reader ought to be able to work with efficiency and taste.

There are ethical questions that bear on the enter/sit out decision. As already remarked, we hesitate to impose our values on others, so we sit out when decision makers choose differently than we would. But at the same time, we are quick to speak out when we see those in power using others for their purposes. We have found "That is immoral because . . ." statements effective in many circumstances.

The "What to do about the state of systems?" question is central. Aware of the systems problem, we have some ideas about desirable systems attributes and how change might be achieved. Indeed, we have some ideas about specific designs that might be desirable.

But is not wanting to impose our will on others, we talk and write using a widely scoped view of our circumstances. We emphasize process rather than products, verbs rather than nouns. As a result, we hope readers better understand their circumstances, and that those who are in the right place at the right time try out some designs that might be system-changing. We hope scarce resources are not dissipated on unfruitful efforts.

The fact of the matter is that strategy has not worked very well. People want specific, what-to-do guides—build this, build that.

That is what we want too. But we want specifics to be found in a world where people holding rich understandings of transportation and using integrative ideas are identifying a large number of options. That is a lot more than just the few things we can imagine. In such a world, society could choose from a menu of options that open rather than close opportunities for future generations.

We would like a learning, self-organizing world in place of an accepting, reacting world.

These last remarks are drawn from the designs of our respective lives as transportationists. With them, we leave the design of a life as a transportation consumer or professional as an exercise for the reader.

Appendix

Adam Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations*

Chapter 3, "That the Division of Labour Is Limited by the Extent of the Market"

As it is the power of exchanging that gives occasion to the division of labour, so the extent of this division must always be limited by the extent of that power, or, in other words, by the extent of the market. When the market is very small, no person can have any encouragement to dedicate himself entirely to one employment, for want of the power to exchange all that surplus part of the produce of his own labour, which is over and above his own consumption, for such parts of the produce of other men's labour as he has occasion for.

There are some sorts of industry, even of the lowest kind, which can be carried on nowhere but in a great town. A porter, for example, can find employment and subsistence in no other place. A village is by much too narrow a sphere for him; even an ordinary market town is scarce large enough to afford him constant occupation. In the lone houses and very small villages which are scattered about in so desert a country as the Highlands of Scotland, every farmer must be butcher, baker and brewer for his own family. In such situations we can scarce expect to find even a smith, a carpenter, or a mason, within less than twenty miles of another of the same trade. The scattered families that live at eight or ten miles distance from the nearest of them must learn to perform themselves a great number of little pieces of work, for which, in more populous countries, they would call in the assistance of those workmen. Country workmen are almost everywhere obliged to apply themselves to all the different branches of industry that have so much affinity to one another as to be employed about the same sort of materials. A country carpenter deals in every sort of work that is made of wood: a country smith in every sort of work that is made of iron. The former is not only a carpenter, but a joiner, a cabinet-maker, and even a carver in wood, as well as a wheel-wright, a plough-wright, a cart and waggon maker. The employments of the latter are still more various. It is impossible there should be such a trade as even that of a nailer in the remote and inland parts of the Highlands of Scotland. Such a workman at the rate of a thousand nails a day, and three hundred working days in the year, will make three hundred thousand nails in the year. But in such a situation it would be impossible to dispose of one thousand, that is, of one day's work in the year.

As by means of water-carriage a more extensive market is opened to every sort of industry than what land-carriage alone can afford it, so it is upon the sea-coast, and along the banks of navigable rivers, that industry of every kind naturally begins to subdivide and improve itself, and it is frequently not till a long time after that those improvements extend themselves to the inland parts of the country. A broad-wheeled waggon, attended by two men, and drawn by eight horses, in about six weeks' time carries and brings back between London and Edinburgh near four ton weight of goods. In about the same time a ship navigated by six or eight men, and sailing between the ports of London and Leith, frequently carries and brings back two hundred ton weight of goods. Six or eight men, therefore, by the help of water-carriage, can carry and bring back in the same time the same quantity of goods between London and Edinburgh, as fifty broad-wheeled waggons, attended by a hundred men, and drawn by four hundred horses. Upon two hundred tons of goods, therefore, carried by the cheapest land-carriage from London to Edinburgh, there must be charged the maintenance of a hundred men for three weeks, and both the maintenance, and, what is nearly equal to the maintenance, the wear and tear of four hundred horses as well as of fifty great waggons. Whereas, upon the same quantity of goods carried by water, there is to be charged only the maintenance of six or eight men, and the wear and tear of a ship of two hundred tons burden, together with the value of the superior risk, or the difference of the insurance between land and water-carriage. Were there no other communication between those two places, therefore, but by land-carriage, as no goods could be transported from the one to the other, except such whose price was very considerable in proportion to their weight, they could carry on but a small part of that commerce which at present subsists between them, and consequently could give but a small part of that encouragement which they at present mutually afford to each other's industry. There could be little or no commerce of any kind between the distant parts of the world. What goods could bear the expense of land-carriage between London and Calcutta? Or if there were any so precious as to be able to support this expense, with what safety could they be transported through the territories of so many barbarous nations? Those two cities, however, at present carry on a very considerable commerce with each other, and by mutually affording a market, give a good deal of encouragement to each other's industry.

Since such, therefore, are the advantages of water-carriage, it is natural that the first improvements of art and industry should be made where this conveniency opens the whole world for a market to the produce of every sort of labour, and that they should always be much later in extending themselves into the inland parts of the country. The inland parts of the country can for a long time have no other market for the greater part of their goods, but the country which lies round about them, and separates them from the sea-coast, and the great navigable rivers. The extent of their market, therefore, must for a long time be in proportion to the riches and populousness of that country, and consequently their improvement must always be posterior to the improvement of that country. In our North American colonies the plantations have constantly followed either the seacoast or the banks of the navigable rivers, and have scarce anywhere extended themselves to any considerable distance from both.

The nations that, according to the best authenticated history, appear to have been first civilised, were those that dwelt round the coast of the Mediterranean Sea. That sea, by far the greatest inlet that is known in the world, having no tides, nor consequently any waves except such as are caused by the wind only, was, by the smoothness of its surface, as well as by the multitude of its islands, and the proximity of its neighbouring shores, extremely favourable to the infant navigation of the world; when, from their ignorance of the compass, men were afraid to quit the view of the coast, and from the imperfection of the art of shipbuilding, to abandon themselves to the boisterous waves of the ocean. To pass beyond the pillars of Hercules, that is, to sail out of the Straits of Gibraltar, was, in the ancient world, long considered as a most wonderful and dangerous exploit of navigation. It was late before even the Phoenicians and Carthaginians, the most skilful navigators and ship-builders of those old times, attempted it, and they were for a long time the only nations that did attempt it.

Of all the countries on the coast of the Mediterranean Sea, Egypt seems to have been the first in which either agriculture or manufactures were cultivated and improved to any considerable degree. Upper Egypt extends itself nowhere above a few miles from the Nile, and in Lower Egypt that great river breaks itself into many different canals, which, with the assistance of a little art, seem to have afforded a communication by water-carriage, not only between all the great towns, but between all the considerable villages, and even to many farmhouses in the country; nearly in the same manner as the Rhine and the Maas do in Holland at present. The extent and easiness of this inland navigation was probably one of the principal causes of the early improvement of Egypt.

The improvements in agriculture and manufactures seem likewise to have been of very great antiquity in the provinces of Bengal, in the East Indies, and in some of the eastern provinces of China; though the great extent of this antiquity is not authenticated by any histories of whose authority we, in this part of the world, are well assured. In Bengal the Ganges and several other great rivers form a great number of navigable canals in the same manner as the Nile does in Egypt. In the Eastern provinces of China too, several great rivers form, by their different branches, a multitude of canals, and by communicating with one another afford an inland navigation much more extensive than that either of the Nile or the Ganges, or perhaps than both of them put together. It is remarkable that neither the ancient Egyptians, nor the Indians, nor the Chinese, encouraged foreign commerce, but seem all to have derived their great opulence from this inland navigation.

All the inland parts of Africa, and all that part of Asia which lies any considerable way north of the Euxine and Caspian seas, the ancient Scythia, the modern Tartary and Siberia, seem in all ages of the world to have been in the same barbarous and uncivilised state in which we find them at present. The Sea of Tartary is the frozen ocean which admits of no navigation, and though some of the greatest rivers in the world run through that country, they are at too great a distance from one another to carry commerce and communication through the greater part of it. There are in Africa none of those great inlets, such as the Baltic and Adriatic seas in Europe, the Mediterranean and Euxine seas in both Europe and Asia, and the gulfs of Arabia, Persia, India, Bengal, and Siam, in Asia, to carry maritime commerce into the interior parts of that great continent: and the great rivers of Africa are at too great a distance from one another to give occasion to any considerable inland navigation. The commerce besides which any nation can carry on by means of a river which does not break itself into any great number of branches or canals, and which runs into another territory before it reaches the sea, can never be very considerable; because it is always in the power of the nations who possess that other territory to obstruct the communication between the upper country and the sea. The navigation of the Danube is of very little use to the different states of Bavaria, Austria and Hungary, in comparison of what it would be if any of them possessed the whole of its course till it falls into the Black Sea.

This page intentionally left blank

Notes

Chapter 1

1. The web page http://www.segway.com/segway/save_time.html (accessed January 8, 2005) compares travel time by foot with the Segway for any address in the United States.

Chapter 3

1. There is also the issue of central or social planning, determining centrally the outcome of society, which evidence has shown does not work particularly well. That is planning overreach. Just because one cannot plan a society, does not mean that one cannot plan a canal, a road, or a subway. Of course, just because one can plan a thing does not necessarily mean one should, as the plan says nothing of tradeoffs, opportunities forgone by applying resources in a particular way.
2. City engineering organizations are interesting. Good insight can be obtained from Phelps (1978), which details the 100-year history of the Seattle Department.
3. Here is an example. Several years ago, Garrison participated in work for the National Council on Public Works Improvement. From the way the turf has been divided in the past, one would have expected civil engineering-dominated analysis. That was not the case. Why was it not the case? Why have others encroached on the traditional turf of public works engineers?
4. Lewis held important positions. In addition to his textbook, he published widely and wrote with much force. He headed planning organizations. Because of his influence, the American Society of Civil Engineers established a city planning division in 1923, after establishing power, sanitary, irrigation, and highway divisions the previous year.
5. The urban planning student ought to examine an early edition of Nelson P. Lewis's textbook. The debt that current concepts of city planning owe to Lewis shows clearly when one examines his book.
6. It would seem (*ca*. 2003) on the west coast of the United States that "geek" is a compliment for an intelligent, technically proficient individual with social skills and "nerd" an insult (indicating a lack of social skills), the mirror of what is found on the east coast. http://www.geekvsnerd.com, http://www.mills.edu/ACAD_INFO/MCS/SPERTUS/Geek/ (accessed January 8, 2005).

Chapter 7

1. Examples of this kind of behavior proliferate throughout the modes. For instance, truckers buy high-pressure, radial tires and ignore pavement damage questions. Sometimes this component

suboptimization begs remedial policy, as was the case when drivers started to use snow tires with metal studs. Often, policy is faulty because it fails to consider the system environment. In rail, there is policy about the condition of track and speed limits that pays no attention, as it should, to the type of equipment ordered.

2. Most state departments of transportation have no global highway transportation goals. They seek to maintain the roads in the fashion their values say they should be maintained, given the priorities of their road classification and subject to the monies and other resources available.

Chapter 8

1. The Crown privatized exploration and settlement. It did not create a NASA-like organization to explore and then build stations in space.
2. The German situation was quite different from that in France. The kingdoms and states authorized private railroad development, with the only early state railroad being in Bavaria. As a result there were about 50 rail companies by 1850. Rail development was market-driven, and standards varied according to what markets warranted and could pay for. Several railroad centers emerged in addition to Berlin.

Chapter 9

1. To this day railroads question the need for nationalization and its results; it is a sore point with them that the public might have thought that they were not doing their job. A later USRA (the United States Railroad *Association*) acquired bankrupt railroads in the 1970s, and was eventually sold to Conrail.
2. See NTPSC (1979).
3. An interesting thing about network revamping is its contingent character. A certain pattern of route ownership was in place at the start of the game. (Think of this, say, as the situation in about 1950 when there about 50 major railroads.) The run of the game (think of this as plays involving mergers, acquisitions, and abandonment) yielded a system of five or six large firms by the end of the twentieth century (depending on how you count). This is not the same end-state as would have been achieved with a different starting arrangement. Considering all possible starts, we do not know if the realized end of the game compares well or poorly with possible ends. Also the plays might have been sequenced in many different ways. Some attempted plays were thwarted by regulatory actions, and the outcomes of some plays were tempered by railroad requirements, such as allowing running rights on trackage. The value of the plays available at any time depended on what had gone before.

   An example: Suppose there are two routes between A and B; route 1 is longer than route 2, all other features are the same. Suppose that, as the "game is played," route 1 gets lots of traffic because of a merger. Economies of traffic density give it lower costs than route 2. The potentially superior (shorter) route 2 is abandoned because of its relatively high costs. It just had bad luck and was not included in a merger that increased its traffic. Actually, this example applies to only a few cases.

Chapter 10

1. SNCF, the French rail agency, also after many years of planning starting in 1966 opened the TGV in 1981 (nearly 20 years after Japan). The opening ceremonies were a significant event, being reported internationally, but not associated with a major showpiece event such as a World's Fair or Olympics.
2. Market segmentation in Japan has principally focused on the business travel market. The French have focused on business travelers. Pleasure travel is a secondary market, though many of the French extensions connect with vacation beaches on the Atlantic and Mediterranean. In fact, Friday evenings are the peak time for the TGV (Metzler, 1992). The system has lowered prices on long-distance travel to better compete with air service, and have even turned cities now within an hour of Paris (by TGV) into commuter bedroom communities, increasing its own market while restructuring land use.

3. Other cited complaints against the air and highway modes are their externalities: pollution, noise, accidents, and so on. While it cannot be argued that either air or highway modes have internalized their externalities, it also cannot be argued that from a systems perspective high-speed rail does not create problems of its own. Vibration is one issue (Krylow, 2001). Access to rail generally requires vehicle trips. These vehicle trips generate pollution of their own; for instance, the most severe pollution comes from the so-called "cold start," or running a car before it is warmed up. It is difficult to establish how much of the potential demand on high-speed rail is diverted from other modes and how much is induced travel. While induced travel may expand the economy, it certainly does not mitigate externalities.

Chapter 11

1. The indicted companies were: National City Lines, Inc., American City Lines, Inc., Pacific City Lines, Inc., Standard Oil Company of California, Federal Engineering Corporation, Phillips Petroleum Company, General Motors Corporation, Firestone Tire & Rubber Company, and Mack Manufacturing Corporation. The individuals indicted were: E. Roy Fitzgerald and Foster G. Beamsley of NCL; H. C. Grossman, GM; Henry C. Judd, Standard Oil of California; L. R. Jackson, Firestone Tire & Rubber; Frank B. Stradley and A. M. Hughes, Phillips Petroleum.
2. We have heard some Marxist say that suburbanization and automobilization artificially propped up the economy, postponing the collapse of capitalism.
3. The Yago interpretation of the NCL conspiracy is widely known and taken to be true. Indeed, we know of "urban experts" who take Yago's book to be the definitive work on urban transportation.
4. Snell says that the conversion of the New York system in 1936, then the world's largest streetcar system, was due to GM. In this case the agent was the Omnibus Corporation. GM's involvement with Omnibus was later than 1936, however. There are other problems of fact in Snell's writing.
5. For GM's "sweetness and light" side of the matter, see General Motors Corporation (1974). Other writings critical of the conspiracy theory include Adler (1991), Bianco (1998), and Slater (1997).
6.

Cost of Alternative Technologies (1893, 1894)

Mode	Average cost ($) per car per km	Average cost ($) per car per mile
Horse	0.0638	0.102
Cable	0.0525	0.084
Electric	0.0625	0.10

Cable and horse data for 1894 from Philip G. Hubert Jr, "The Cable Street-Railway," *Scribner's Magazine* 15, no. 3 (1894). http://www.cable-car-guy.com/html/ccscrib.html (accessed March 2004). Electric data for 1893 from "St. Charles Avenue Streetcar Line, 1835," National Historic Mechanical Engineering Landmark brochure, American Society of Mechanical Engineers and Regional Transit Authority. http://www.asme.org/history/brochures/h101.pdf (accessed March 2004).

7. PCC-type cars provided service in Moscow and other East European cities after World War II. The cars imported for use in San Diego were second-generation PCC cars.
8. Bion J. Arnold was another leader; his *Report on the Improvement and Development of the Transportation Facilities of San Francisco* (1913) is most interesting and illustrates the points we have made (Arnold underestimated the impact of the automobile on transit). The Kelker, De Leuw & Co. *Report and Recommendations on a Comprehensive Rapid Transit Plan for the City and County of Los Angeles* (1925) is another product typical of the times.

9. The federal government took action requiring the electric utilities to divest their holdings in transit companies. The action was intended to encourage the competitive pricing of electricity. The action also responded to the feelings of many that the utilities were thwarting the conversion from electric rail to buses.
10. Knowledgeable about transit, especially from contacts with George Krambles of the Chicago Transit Authority, Garrison followed early UMTA developments quite closely. Because UMTA was established at about the same time that the DOT was established and it was feared that the organizational problems of DOT would interfere with the takeoff of UMTA programs, and people wanted to keep UMTA away from "transportation think," UMTA was housed in the Department of Housing and Urban Development (HUD) during its first year. Garrison participated in the study team that arranged the transfer to DOT and the conditions imposed on that transfer. During the first ten years of so of UMTAs life, he served on a variety of other advisory-study committees. These early UMTA days are not regarded as ones in which Garrison did constructive things.
11. But perhaps not so many as one finds in local governments. At the time, it was felt that special skill and knowledge was needed to operate transit properties.
12. We knew a few who managed to be "quick studies," but most didn't. We think this was because the agency did not have a core who could give it appropriate instant agency culture.
13. The first demonstration grant made by UMTA went to Selma, Alabama, hardly a big city bail-out.
14. As Garrison did in Denver some years ago and Levinson has done in Minneapolis.
15. We hear that we tried new technology programs in the early days of UMTA and they were a failure. So new solutions do not exist. This turns the discussion to why UMTA technology programs failed—a discussion that is not helpful when policy is under discussion in an urban area.
16. There are some devil theories that run the other way; see Hamer (1976).
17. The Keeler–Webber data are old data; we use it because it is well known to many critics.

Chapter 12

1. The Corps compares in some ways with the U.S. Bureau of Public Roads and its engineers (Seely, 1987).
2. Macadam pavements were adopted in the early 1800s, and road development continued until about 1860 when intercity rail began to coopt traffic. Between then and the development of the automobile, work continued on local and feeder roads.
3. Among these routes were "Kuga-no-michi" (Northland Road), "Umitsu-michi" (East Sea Road), and "Nishi-no-michi" (West Road), linking the Yamato region (present-day Nara prefecture), with Chikushi (present Fukuoka prefecture), which later became the San-yodo "Higashi-no-yamamichi" (East Mountain Road).
4. Although it was a rail and not a highway application, Alexandria, Virginia, for instance, blocked the Baltimore and Ohio railroad from making connections through the Shenandoah Valley in Virginia, in favor of their own rail connections.

Chapter 13

1. As of this writing (summer 2004) www.asphaltisbetter.com and www.concreteisbest.com both remain available.
2. There have also been some special regional planning endeavors, such as the Appalachian Regional Commission and U.S. Forest Service planning activities.
3. Impacts are not well documented, but for examples of the social impact of the automobile in rural areas, see Berger (1979).
4. Three state surveys illustrate the Bureau's early work: Bureau of Public Roads, U.S. Department of Agriculture and the New Hampshire State Highway Department, *Report of a Survey of Transportation on the State Highways of New Hampshire* (Washington, D.C., 1927); Bureau of Public Roads, U.S. Department of Agriculture and the Ohio Department of Highways and Public Works, *Report of a Survey on the State Highway System of Ohio*

(Washington, D.C., 1927); Bureau of Public Roads, U.S. Department of Agriculture and the Vermont State Highway Department, *Report of a Survey of Transportation on the State Highways of Vermont* (Washington, D.C., 1927).

5. Weiner's text has been published in several places: as a commercial book and as articles. It is a very useful collection of information, but has two faults. In the main, it views transportation planning as something innovated after World War II. Also, it is Washington centered in the extreme. The text says that brilliant Washington bureaucrats had flashes of insight about rules and regulations. That is nonsense, at best.
6. The Bureau of Public Roads *Manual of Procedures for Home Interview Traffic Studies* (1944) treated interviews at dwelling units and at the roadside.
7. Here is how the needs are calculated: The condition today is known. With the traffic growth projected into the future (particularly truck traffic), the pavement deteriorates to lower and lower PSRs. The decrease in the PSR is projected using information from the AASHO road test. If we know the number of projected 18 kip (kilo-pound—talk about schizophrenia) equivalent standard axle loads (ESALs) on a pavement of a particular type, then we can estimate how its PSR will change. Needs may then be estimated. The pavement may need rebuilding or repair, and so on.
8. Garrison served on the advisory panel for the federal study triggered by the Interstate Act, and there have been subsequent federal studies. Congress asked the study to consider benefit-based financing—pay according to benefits received—but it ended as an incremental study. There were views of benefits received that could not be reconciled.

Chapter 14

1. Central Artery/Tunnel Project Official Page: http://www.bigdig.com; see also http://www.boston.com/beyond_bigdig/. Also see the following link, which gives the details of Scheme Z in the history of the CA/T: http://libraries.mit.edu/rotch/artery/schemez_chron.htm. For information regarding the open space created by the submerged central artery, see http://enews.tufts.edu/stories/070102BigDigBonus.htm. (All websites accessed January 8, 2005.)

Chapter 15

1. There was also the Caledonian Canal (Commission established in 1803) across Scotland.
2. For instance, as a boy, Garrison learned the head of navigation on the streams in Middle Tennessee from people who lived in the area. He did not set out to do that. It was part of regional conversation and lore.
3. Despite the lack of war affecting policy much, the Department of Defense has a longstanding concern about insufficient strategic sealift and insufficient construction capability.

Chapter 16

1. No obvious technical reason existed for concluding that the 7 ft gauge was superior, given the fixing of wheels to axles and the problems of curving. Hilton (1990) discusses the work of the Commission and the evolution of various gauges.
2. We think of such a standard as an interface standard. Later, we shall stress the critical importance of interface standards or policies. The British selected clearance standards tighter than those used on the Continent and elsewhere. This has limited the attainability of economies of scale and created interface problems with the Continent.
3. Total cubic contents in "tons" of 100 cubic feet.
4. Liner coal consumption was not very efficient. At the time, seawater was used in the boilers, and it was thought that low pressure (*ca.* 0.2 MPa [30 psi]) should be used to reduce scaling in boiler tubes. As a rough approximation and for a given velocity, the power required to move a ship increases with the square of ship length; capacity increases with the cube of length. A large ship, carrying a lot of coal, was needed to evolve steady steaming.
5. dwts = dead weight tons, the tons a ship can lift. The dwts a ship can lift are the tons that will depress a ship from its unloaded to its loaded water marks. Dwts are usually long tons of 2240 lb.

6. Twenty-foot container equivalent units—8 ft × 8 ft × 20 ft.
7. Pursuant to Section 902 of the Merchant Marine Act, 1936.
8. The register ton seems to have first been used in the Baltic trades, where 100 cubic feet = one ton of Russian wheat and the ship was full and down. Conventions for construction changed, and by 1800 a ship in the Atlantic trades was down when its load was about 1.5 times register tonnage. A 400 ton ship in the Atlantic trades might have a cargo of 600 tons. If wheat, that load could be moved in six modern rail hopper cars. In the fifteenth century in Spain and Portugal, tons were measured in another way: two large kegs equaled one ton. By 1900, steel ships in the Atlantic trades were running 20,000 tons. 1 metric ton equals 0.9842 imperial tons, so the difference is small.

Chapter 17

1. On April 1, 2003, Air Canada declared bankruptcy. The day before, American Airlines announced an agreement with its unions to renegotiate labor contracts to reduce costs. U.S. Airways emerged from bankruptcy that day as well, while America's second largest airline, United, remained in bankruptcy, having failed to come to terms with its unions.

Chapter 18

1. The discussion of U.S. telegraph messengers is based on Downey (2002).
2. Compared to many transportation systems, the capital and operating cost requirements were small. The current investment in the phone system is about $290 per capita, and the annual per capita operating cost is about $33. (Those numbers seem low, but that is what we calculate.) By comparison, the annual per capita operating costs for freight transportation are about $1,150.
3. Did the FCC decision permit that service? The decision was written by Bernie Strassburg, Chief of the FCC's Common Carrier Bureau. We have never reviewed it. It is said to be very dense and complex and to appear to permit many-to-many services. On close reading, the FCC's position was that the decision did permit that service, although that was not the intention of the decision. The fact is that the FX decision was one that received little attention at the time. FCC had bigger fish to fry in debates about TV and the radio spectra. FX was a minor thing in the stagnant telephone field; the Commissioners approved FX on staff recommendation and without discussion.

Chapter 21

1. Garrison was involved in this study.

Chapter 22

1. Though a time savings of 6.3 seconds per vehicle sounds small, it still adds up to 175 person-hours a day (or 7.3 person-days/day) on a busy road with 100,000 cars per day. The lives of 7.3 persons per day, at a value of life of about $3 million, suggests that the speed hike is saving in economic terms $21,875,000. Alternatively, at a $10 per hour value of time, the speed increase saves $1,750 per day, or $638,750 per year, or $19,157,100 over 30 years with 0 percent interest rates. Those numbers might be worth talking about, but whether small values of time are additive in such a fashion is a controversial question in transportation economics, though most practice does add them. In brief, since time is likely the dominant benefit, if the project to save 6.3 seconds per vehicle costs much less than $19 million, it is probably worthwhile; but if it costs much more, it probably isn't. Ezra Hauer (1994) has an interesting paper comparing value of time and value of life, "Can one estimate the value or life or is it better to be dead than stuck in traffic?"

Chapter 23

1. The southwestern spur of the ICC (connecting to I-270 south of the City of Rockville), dubbed the "Rockville Facility," would cross Rock Creek Park and the Northwest Branch. The planning

agency and state government had acquired much of the land in this Master Plan alignment to preserve the right of way. Government ownership of land does have its drawbacks, and in 1987 Maryland State Senator Idamae Garrot was able to pass a state law creating Matthew Henson State Park in part of the road's right of way, and prohibiting the state from building the highway. The county still seeks to build the western segment of the road (now the Montrose Parkway) in a suburban area without such significant environmental impacts.

2. Quotes from http://www.iccyes.org/ See also http://www.iccfacts.org for the opponents' point of view.
3. For example, as a boy Garrison lived about one-quarter of a mile from the Natchez Trace, a walking way from Natchez, Mississippi, to the Nashville Basin and places to the north for traders who carried farm products on flatboats down the Mississippi and its tributaries to New Orleans. Now improved for much of the way as a parkway by the federal government, it bears no functional or design resemblance to the historic Natchez Trace. Levinson grew up near Columbia Pike (a one-time turnpike emanating from the District of Columbia), in Columbia, Maryland. Columbia Pike is now part of U.S. 29. He went to college at Georgia Tech on North Avenue (U.S. 29) in Atlanta, and returned to Maryland to work on Colesville Road (U.S. 29) in Silver Spring. The road, which runs from Ellicott City, Maryland, to Pensacola, Florida, is sometimes a two-lane rural route, sometimes an urban street, and elsewhere a freeway. With a little searching, almost any reader could also tell a "growing up near" story.
4. For example, Voith (1991) found that the accessibility value of commuter rail stations in Philadelphia was capitalized in home values. Pollakowski and Wachter (1990) have examined land value and transportation in Montgomery County, Maryland, and found that distance from downtown Washington, D.C., was negatively associated with a housing price index, as was distance to employment.

Chapter 24

1. To give a neat example, suppose the choice is between systems, A and B, and returns from the choice are as shown in the following table:

Total Returns from Choice A and Choice B

Year	A	B
1	5.0	10.0
2	5.5	10.1
3	6.0	10.2
4	7.0	10.3
n	20.0	11.1

The choice would be B. But an analyst might say that if $n \leq 20$, then analysis might say that A is the best choice. In addition to the question of the size of n, we can ask when A becomes a choice. Suppose A was not available until year n. Then A would indeed be a poor choice.

2. In addition to transportation systems, large technical systems include electrical and other energy systems, sewage, and communications. They are infrastructures that are ubiquitous, have homogeneous technologies, require special technical knowledge, and have other features in common (see Summerton, 1994).

Chapter 25

1. We have been in many situations where the mood is "Technology is not the problem. The problem has to do with institutions, protocols, and things like that." We think that such views misread the situation, for the focus is on soft technology. In addition, the problem may be misread.

Sometimes the problem is one of the mismatch between hard and soft technologies. Sometimes the hard technology seems to be the problem, and adjustments to soft technology have little to do with that problem.

2. The discussions revealed that many of the traffic engineers lived outside the metered area, and so could enter a free-flowing freeway and drive relatively unencumbered by traffic, which was sitting at freeway on-ramps.
3. The three university studies were by Levinson et al. (2001), Hourdakis and Michalopoulos (2002), and Kwon et al. (2001). One might suggest that these studies were a holding strategy, essentially telling the state legislature, “See, we *are* studying this—please go away.” However, those studies did not involve shutting down the ramp meter operations; rather they would conduct computer simulations to examine operations with and without meters, compare metering approaches from a number of cities, and examine empirical data.
4. From outside the state (and therefore seemingly incorruptible by future Mn/DOT consulting contracts) (Cambridge Systematics).

Chapter 28

1. That rather murky sentence appeared on p. 683 of Dennis W. Carlton and Jeffrey M. Perloff’s *Modern Industrial Organization* (New York: HarperCollins, 1990).
2. However, of the 63,000 non-Coast Guard employees (according to the Office of Personnel Management 2001 Fact Book, http://www.opm.gov/feddata/factbook/index.htm) (this number also predates the creation of the Transportation Security Administration), about 16,000 are in air traffic control and 15,000 are involved in airways facility jobs, so about 32,000 bureaucrats run the shop. That seems to be lots of people (though down over the past ten years). W. Stull Holt’s study of the Bureau of Public Roads in the 1920s said that about 24 employees managed the federal–state relation very well. (It might also be noted that the Department of Transportation, with a 79 percent white workforce, is the whitest federal department.)
3. The source for this quote is class notes distributed *ca*. 1985.

References

Aaron, Henry J. 1990. Discussion of "Why Is Infrastructure Important?, " in Alicia Munnell (ed.), *Is There a Shortfall in Public Capital Investment?* Boston: Federal Reserve Bank of Boston, 51–63.

Abernathy, William J. 1978. *The Productivity Dilemma*. Baltimore, Md.: Johns Hopkins University Press.

Adler, Moshe. 1985. "Street Parking: The Case for Community Property." *The Logistics and Transportation Review* 21(4):375–387.

Adler, Sy. 1991. "The Transformation of the Pacific Electric Railway: Bradford Snell, Roger Rabbit, and the Politics of Transportation in Los Angeles." *Urban Affairs Quarterly* 27 (September): 51–86.

Albert, William. 1972. *The Turnpike Road System in England, 1663–1840*. Cambridge: Cambridge University Press.

Aldcroft, D. H., and M. J. Freeman (eds.). 1983. *Transport in the Industrial Revolution*. Manchester: Manchester University Press.

Altshuler, Alan A. 1965. *The City Planning Process: A Political Analysis*. Ithaca, N.Y.: Cornell University Press.

Altshuler, Alan A. 1979. *The Urban Transportation System: Politics and Policy Innovation*. Cambridge, Mass.: MIT Press.

Altshuler, Alan A., and D. Luberoff. 2003. *Mega-Projects: The Changing Politics of Urban Public Investment*. Washington, D.C.: Brookings Institution Press.

American Association of Port Authorities (AAPA). 2004. "Public Port Facts." *Industrial Information*. http://www.aapa-ports.org/industryinfo/portfact.htm, accessed March 2004.

American Electric Railway Association (AERA). 1933. *The Urban Transportation Problem*. New York: AERA.

American Public Transport Association (APTA). 2002. "Personal Rapid Transit Being Tested in Cardiff, Wales." http://www.apta.com/services/intnatl/intfocus/cardiff.cfm, accessed January 9, 2005.

American Trucking Association (ATA). 1999. "ATA's Statement on the Passage of Legislation for the New Federal Motor Carrier Safety Administration." *Inside ATA*. November 19. Alexandria, Va.: ATA. http://www.truckline.com/insideata/press/111999_wbm_passage_of_bill.html, accessed November 2003.

Anas, Alex, and Regina Armstrong. 1993. *Land Values and Transit Access: Modeling the Relationship in the New York Metropolitan Area, An Implementation Handbook*. Washington, D.C.: Federal Transit Administration.

Anderson, J. Edward. 1996. *Some Lessons from the History of PRT*. Website of Innovative Transportation Technologies, 4 August. http://faculty.washington.edu/~jbs/itrans/history.htm, accessed January 15, 2005.

Anderson, J. Edward. 1997. *Why, After Decades, Has Personal Rapid Transit Not Yet Been Widely Accepted?* Innovative Transportation Technologies. 19 April. http://faculty.washington.edu/jbs/itrans/why.htm, accessed January 15, 2005.

Anderson, J. Edward. 1999. "A Review of the State of the Art of Personal Rapid Transit." *Journal of Advanced Transportation* 34(1):3–29.

Andersson, Åke E. 1986. "Presidential Address: 'The Four Logistical Revolutions.' " *Papers of the Regional Science Association* 59:1–12.

Annual Energy Review. 2000. *Energy in the United States: 1635-2000, Annual Energy Review 2000.* http://www.eia.doe.gov/emeu/aer/eh/intro.html, accessed January 15, 2005.

Armstrong, Ellis, Michael C. Robinson, and Suellen M. Hoy. 1976. *A History of Public Works in the United States, 1776–1976*. Chicago: Public Works Historical Society.

Arnold, Bion J. 1913. *Report on the Improvement and Development of the Transportation Facilities of San Francisco: Submitted to the Mayor and the Board of Supervisors, City of San Francisco*. City of San Francisco.

Arthur, Brian. 1990. "Positive Feedbacks in the Economy." *Scientific American* 262 (February): 92–99.

Aschauer, David A. 1990. "Highway Capacity and Economic Growth." *Economic Perspectives* 14(5):4–24.

Ayres, Robert U. 1984. *The Next Industrial Revolution: Reviving Industry through Innovation.* Cambridge, Mass.: Ballinger.

Ayres, Robert U., and Wilbur Steger.1985. "Rejuvenating the Life Cycle Concept—and Possibly the Economy." *Journal of Business Strategy* 6(1):66–76.

Banister, David, and Laurie Pickup. 1989. *Urban Transportation and Planning: A Bibliography with Abstracts.* London: Mansell Publishing.

Barker, Theodore C., and Doria Gerhold. 1993. *The Rise and Rise of Road Transport, 1700–1990.* New York: Cambridge University Press.

Barnes, G., and G. Davis. 1999. *Understanding Urban Travel Demand: Problems, Solutions, and the Role of Forecasting.* Report No. 2 in the Series: Transportation and Regional Growth Study, CTS 99-02. Minneapolis, Minn.: Center for Transportation Studies, University of Minnesota.

Barrett, Paul A. 1983. *The Automobile and Urban Transit: The Formation of Public Policy in Chicago, 1900–1930*. Philadelphia: Temple University Press.

Barrett, Paul A. 1987. "Cities and their Airports, Policy Formation." *Journal of Urban History* 14:112–137.

Bartholomew, Ann. 1989. *Delaware and Lehigh Canals.* Easton, Pa.: Center for Canal History and Technology.

Basalla, George. 1988. *The Evolution of Technology*. New York: Cambridge University Press.

Batten, David, and B. Johannsson. 1985. "Industrial Dynamics of the Building Sector: Substitution and Trade Specialization." *Economic Faces of the Building Sector*. Stockholm: Swedish Council for Building Research.

Beasley, David R. 1988. *The Suppression of the Automobile: Skullduggery at the Crossroads.* New York: Greenwood Press.

Becker, Gary. 1965. "A Theory of the Allocation of Time." *Economic Journal* 75(299):493–517.

Beckmann, M., C. B. McGuire, and C. B. Winston. 1956. *Studies in the Economics of Transportation*. New Haven, Conn.: Yale University Press.

Berger, Michael L. 1979. *The Devil in God's Country: The Automobile and Social Change in Rural America, 1893–1929*. Hamden, Conn.: Archon Books.

Berners-Lee, Tim, with Fischetti, Mark. 2000. *Weaving the Web: The Original Design and Ultimate Destiny of the World Wide Web by its Inventor*. New York: HarperCollins.

Bianco, Martha Kennedy. 1998. *60 Minutes, and Roger Rabbit: Understanding Conspiracy-Theory Explanations of the Decline of Urban Mass Transit*. Discussion Paper 98-11. Portland, Oreg.: Center for Urban and Public Affairs, Portland State University.

Blaise, Clark. 2001. *Time Lord: Sir Sandford Fleming and the Creation of Standard Time*. New York: Pantheon Books.

Blanchard, Arthur. 1919. *Highway Engineering Handbook*. New York: John Wiley.

Bouladon, G. 1967. "The Transport Gaps." *Science Journal* (April) 41–46; also published in *Ekistics* 25:6–10 (1968).

Boyce, David E. 2002. "Is the Sequential Travel Forecasting Paradigm Counterproductive." *ASCE Journal of Urban Planning and Development* 128(4):169–183.
Branson, Richard. 1999. "Pilot of the Jet Age Juan Trippe." *Time Magazine*. http://www.time.com/time/time100/builder/profile/trippe.html, accessed April 22, 2003.
Brinkman, P. Anthony. 2003. "The Ethical Challenges and Professional Responses of Travel Demand Forecasters." Ph.D. dissertation, University of California at Berkeley, Department of City and Regional Planning.
Brundtland, Gro Harlem. 1987. *Our Common Future: Report of the World Commission on Environment and Development.* Oxford: Oxford University Press.
Bruno, L. C. 1993. *On the Move: A Chronicle of Advances in Transportation*. Detroit: Gale Research Inc.
Buchanan, James M., and Gordon Tullock. 1962. *The Calculus of Consent: Logical Foundations of Constitutional Democracy*. Ann Arbor: University of Michigan Press.
Buechner, William. n.d. *History of the Gasoline Tax.* http://www.artba.org/economics_research/reports/gas_tax_history.htm, accessed March 2004.
Bureau of Public Roads. 1939. *Toll Roads and Free Roads.* Washington, D.C.: U.S. Department of Commerce.
Bureau of Public Roads. 1955. *General Location of the National System of Interstate Highways* (also known as the *Yellow Book*). Washington, D.C.: U.S. Department of Commerce.
Bureau of Transportation Statistics (BTS). 1999. *Transportation Revenues and Revenue Raising Instruments by Mode: FY 1999*. Government Financial Statistics.
Bureau of Transportation Statistics (BTS). 2000a. *Table 3-15b, Average Passenger Fares (Chained 1996 Dollar)*. National Transportation Statistics.
Bureau of Transportation Statistics (BTS). 2000b. *Table 1-2, Number of Air Carriers, Railroads, Interstate Motor Carriers, Marine Vessel Operators, and Pipeline Operators*. National Transportation Statistics.
Bureau of Transportation Statistics (BTS). 2000c. *Table 3-7, Passenger and Freight Transportation Expenditures*. National Transportation Statistics.
Bureau of Transportation Statistics (BTS). 2001. *Federal Expenditures for Water Transportation by Agency and Program from Own Funds: FY 1985–2001*. Government Transportation Financial Statistics.
Bureau of Transportation Statistics (BTS). 2002. *2002 Federal Transportation Budget Source*. Government Transportation Statistics.
Burgess, Edgar. 1925. "The Growth of the City," in R. Park, E. Burgess, and R. McKenzie (eds.), *The City.* Chicago: University of Chicago Press, 37–44.
Burke, Catherine G. 1979. *Innovation and Public Policy: The Case of Personal Rapid Transit*. Lexington, Mass.: Lexington Books.
Burnham, Daniel (assisted by Willis Polk and Henry Gutterson). 1905. *A Plan for San Francisco*. San Francisco: Sunset Press.
Burnham, John Chynoweth. 1961. "The Gasoline Tax and the Automobile Revolution." *Mississippi Valley Historical Review* 48:435–459.
Burns, James D. 1998. *Railroad Mergers and the Language of Unification*. New York: Quorum Books.
Burt, William D. 1998. "Was the Conrail Monopoly Necessary?" *Journal of Transportation Law, Logistics and Policy* 66 (Fall): 19–53.
Burton, Anthony. 1992. *The Railway Builders*. London: Trafalgar Square Books.
Carlson, E. H. 1884. *Photo of Ron Nixon's Northern Pacific Locomotives.* http://www.montana.edu/wwwmor/photoarc/nixon/nixon-loco/npl-6.html, accessed February 22, 2004.
Carlson, S. P., and F. W. Schneider III. 1980. *PCC: The Car that Fought Back.* Glendale, Calif.: Interurban Press.
Caro, Robert. 1975. *The Power Broker.* New York: Random House.
Census Bureau. 2002. "Selected Pacific Gateways: Percent Imports from Asia in 20-ft Container Equivalents." *Journal of Commerce's Port Import Export Reporting Service* (deatbase).
Center for Universal Design, North Carolina State University. 1997. *What is Universal Design: Principles of Universal Design.* http://www.design.ncsu.edu/cud/univ_design/princ_overview.htm, accessed November 11, 2003.

Chandler, Alfred D. 1979. *The Railroads: Pioneers in Modern Management*. New York: Arno Press.

Christaller, W. 1966. *Central Places in Southern Germany* (trans. Carlisle W. Baskin). Englewood Cliffs, N.J.: Prentice-Hall.

Chumak, A. and J. P. Braaksma. 1981. "Implications of the Travel Time Budget for Urban Transportation Modeling in Canada." *Transportation Research Record* 794:19–27.

Churchman, Charles West. 1979. *The Systems Approach and its Enemies*. New York: Basic Books.

Cipolla, Carlo. 1973. "A Century of Change." *Fontana Economic History of Europe* IV(2):770.

Clark, Helen, Elaine Finnie, Nick Holmes, Susan Jeffrey, and Sandra Marwick. 1991. *The People's Story.* Edinburgh: Department of Recreation, City of Edinburgh District Council.

Coke, James G. 1968. "Antecedents of Local Planning," in William I. Goodman and Eric C. Freund (eds.), *Principles and Practices of Urban Planning*. Washington, D.C.: International City Managers' Association.

Cramer, Harold. 2004. *1796 Map of Lancaster Turnpike*. Historical Maps of Pennsylvania. http://www.mapsofpa.com/roadthumb/1796roadmapcu.jpg, accessed March 4, 2004.

Crandall, Robert W., and Leonard Waverman. 2000. *Who Pays for Universal Service? When Telephone Subsidies Become Transparent*. Washington, D.C.: Brookings Institution Press.

Creighton, R. L. 1970. *Urban Transportation Planning*. Urbana: University of Illinois Press.

Crow, Arthur. 1881. *Highways and Byeways in Japan*. London: Sampson, Low.

Csele, Mark. 2003. *The Newcomen Steam Engine (1712).* http://technology.niagarac.on.ca/people/mcsele/newcomen.htm, accessed March 2003.

Cupper, Dan. 1990. "The Road to the Future." *American Heritage* (May/June) 103–111.

Dahl, Robert Alan, and Charles E. Lindblom. 1953. *Politics, Economics, and Welfare: Planning and Politico-economic Systems Resolved into Basic Social Processes*. New York: Harper.

Dahlgren, Joy. 1998. "High Occupancy Vehicle Lanes: Not Always More Effective than General Purpose." *Transportation Research* 32A: 99–114.

Darling, Howard. 1980. *The Politics of Freight Rates: The Railway Freight Rate Issue in Canada.* Toronto: McClelland & Stewart.

Darlington Railway Centre and Museum. 2003. *Route of the Stockton and Darlington Railway 1825*. http://www.drcm.org.uk/Frames/RHed.htm, accessed January 15, 2005.

Darlington Railway Centre and Museum. 2004. *Locomotion No. 1 photo.* Locomotion webpage, http://www.drcm.org.uk, accessed February 2004.

Dartford Grammar School. 2003. *Levy of Tolls Using the Dartford to Northfleet Turnpike Road, 1760*. http://www.dartfordarchive.org.uk/early_modern/magnified/toll_levy.htm, accessed September 2003.

Davis, Stacy C. 2001. "Table 2.11: Energy Intensities of Highway Passenger Modes, 1970–99." *Transportation Energy Data Book: Edition 21.* Oak Ridge, Tenn.: Center for Transportation Analysis, Energy Division, Oct.

de Grazia, Sebastian. 1962. *Of Time, Work, and Leisure.* New York: Vintage Books (1990 ed.).

DeLoche, Jean. 1993. *Transport and Communications in India Prior to Steam Locomotion* (English translation). Oxford: Oxford University Press.

de Sola Pool, Ithiel 1990. In Eli Noam (ed.), *Technologies Without Boundaries: On Telecommunications in a Global Age.* Cambridge, Mass.: Harvard University Press.

DeSoto, Hernando. 1989. *The Other Path: The Invisible Revolution in the Third World.* New York: HarperCollins.

de Tocqueville, Alexis. 1831. *Democracy in America*. http://xroads.virginia.edu/~HYPER/DETOC/toc_indx.html, accessed March 2004.

Dickerson, Oliver M. 1951.*The Navigation Acts and the American Revolution.* New York: A.S. Barnes (reprinted 1974).

Downey, Gregory. 2002. *Telegraph Messenger Boys: Labor, Technology, and Geography, 1850–1950.* New York: Routledge.

Downs, Anthony. 1992. *Stuck in Traffic: Coping with Peak-Hour Traffic Congestion.* Washington, D.C.: Brookings Institution Press/Lincoln Institute of Land Policy.

Due, John F. 1979. "State Rail Plans and Programs." *Quarterly Review of Economics and Business* 19:109–130.

Due, John F., and Susan Leever. 1993. "Post 1981 Experience with New Small and Regional Railroads." *Transportation* 33:40–52.

Dunn, Jacob Piatt. 1919. *Indiana and Indianans: A History of Aboriginal and Territorial Indiana and the Century of Statehood,* Vols. I–III. Chicago and New York: American Historical Society.

Dupuit, Jules. 1844. "On the Measurement of the Utility of Public Works" (trans. R. H. Barback). Reprinted in *International Economic Papers* 2:63–110. London: Macmillan, 1952.

Dupuit, Jules. 1849. "On Tolls and Transport Charges" (trans. Elizabeth Henderson from the *Annales des Ponts et Chausées*). *International Economic Papers*, Vol. 11. London: Macmillan, 1962.

East Asia in the World. 2004. "Chapter 21: Expansion, Reform, and Communication in the Agrarian Empires of Asia." *Empires of Asia.* http://www.mit.edu/afs/athena/course/21/21h.504/OldFiles/www/perdue_21.htm, accessed April 2004.

Elliott, Ward. 1975. "The Los Angeles Affliction: Suggestions for a Cure." *The Public Interest* (Winter).

Engineering News-Record. 1996. "Light Traffic Chills Dulles Debut." 236(1) (January 8):18.

Eno, William Phelps. 1939. *The Story of Highway Traffic Control*. Saugatuck, Conn.: Eno Foundation for Highway Traffic Control.

Faigin, Daniel. n.d. *California Highways*. California Highway Website 1996–2003, Pacific Net. http://www.cahighways.org, accessed January 9, 2005.

Fawaz, Youssef M., and William Garrison. 1994. "Truck and Highway Combinations for Increasing Trucking Productivity in Market Niches." *Transportation Research Record* No. 1430, 10–18. Washington, D.C.: Transportation Research Board.

Fellmeth, R. 1970. *The Interstate Commerce Omission: The Public Interest and the ICC.* New York: Grossman.

Ferejohn, John A. 1974. *Pork Barrel Politics: Rivers and Harbors Legislation, 1947–68*. Stanford: Stanford University Press.

Fielding, Gordon J., and Daniel B. Klein. 1993. "How to Franchise Highways." *Journal of Transport Economics and Policy* 27(2):113–130.

Fletcher, M. E. 1958. "The Suez Canal and World Shipping, 1869–1914." *Journal of Economic History* 18:556–573.

Flyvbjerg, B., Nils Bruzelius, and W. Rothengatter. 2003. *Megaprojects and Risk: An Anatomy of Ambition*. Cambridge: Cambridge University Press.

Fogel, Robert W. 1964. *Railroads and American Economic History*. Baltimore, Md.: Johns Hopkins University Press.

Foley, Michael. 1990. *Modern American Government and the Appeal of Newtonian Mechanics*. London: Routledge.

Ford, George B. 1911. "The Relation of City Planning to the Municipal Budget." *American City* 4:66–71.

Forrester, Jay W. 1975. *The Collected Papers of Jay W. Forrester.* Cambridge, Mass.: Wright-Allen Press.

Foster, Mark S. 1981. *From Streetcars to Superhighway: American City Planners and Urban Transportation, 1900–1940*. Philadelphia: Temple University Press.

Friedlaender, Ann F. 1965. *The Interstate Highway System*. Amsterdam: North Holland.

Friedlaender, Ann F., and Richard H. Spady. 1980. *Freight Transport Regulation: Equity, Efficiency and Competition in the Rail and Trucking Industries.* Cambridge, Mass.: MIT Press.

Garrison, William L. 1974. "Social, Economic, and Planning Impacts of a Rapid Excavation and Tunneling Technology," in *Proceedings of a Conference on Rapid Excavation and Tunneling.* New York: American Society of Civil Engineers, 313–324.

Garrison, William L. 1984. "Transportation Technology." *Transportation Research* 18A: 267–276.

Garrison, William L. 1985. "Technology and the Infrastructure Problem." *Rebuilding America: Infrastructure Rehabilitation.* Reston, Va.: ASCE.

Garrison, William L. 1989. "Using Technology to Improve Transportation Services," in David F. Batten and Roland Thord (eds.), *Transportation for the Future.* Berlin: Springer-Verlag, 87–119.

Garrison, William L., and Elizabeth Deakin. 1992. "Land Use," in George E. Gray and Lester A. Hoel (eds.), *Public Transportation.* Englewood Cliffs, N.J.: Prentice-Hall, 527–550.

Garrison, William L., and Duane F. Marble. 1965. "A Prolegomenon to the Forecasting of Transportation Development." *United States Army Aviation Material Labs Technical Report.* Washington, .D.C.: Office of Technical Services, U.S. Department of Commerce.

Garrison, William L., and Reginald R. Souleyrette. 1996. "Transportation, Innovation, and Development: The Companion Innovation Hypothesis." *Logistics and Transportation Review* 32:5–38.

Garrison William L., and Jerry D. Ward. 2000. *Tomorrow's Transportation: Changing Cities, Economies, and Lives*. Boston: Artech House.

Garrison, William L., B. Berry, D. Marble, R. Morrill, and J. Nystuen. 1958. *Highway Development and Geographic Change*. Seattle: University of Washington Press.

Geddes, Norman Bel. 1940. *Magic Motorways*. New York: Random House.

General Motors Corporation. 1974. *The Truth about "American Ground Transport."* Submitted to the Subcommittee on Antitrust and Monopoly of the Committee on the Judiciary, U.S. Senate, April. Washington, D.C.: U.S. Government Printing Office.

Gerondeau, Christian. 1997. *Transport in Europe*. Boston and London: Artech House.

Gifford, Jonathan. 1984. "The Innovation of the Interstate Highway System." *Transportation Research* 18A:319–332.

Gifford, Jonathan, and William L. Garrison. 1993. "Airports and the Air Transportation System: Functional Refinements and Functional Discovery." *Technological Forecasting and Social Change* 43:103–123.

Glaskowsky, N. A. 1986. *Effects of Deregulation on Motor Carriers.* Washington, D.C.: Eno Foundation.

Gofman, Steven. "My Own Private Idaho: Staking Claims to the Public Streets." *Journal of Transportation Law, Logistics, and Policy* 64(2):495–504.

Goodrich, Carter. 1962. *Canals and American Economic Development*. New York: Columbia University Press.

Goodwin, Arthur. 2002. "Alameda Corridor: A Project of National Significance." http://gulliver,trb.org/publications/mb/2002Ports/06Goodwin.pdf, accessed June 25, 2002.

Gordon, John Steele. 2002. *A Thread Across the Ocean*. New York: Perennial.

Gould, Stephen Jay, and Richard C. Lewontin. 1979. "The Spandrels of San Marco and the Panglossian Paradigm: A Critique of the Adaptationist Programme." *Proc. Roy. Soc. London B* 205:581–598.

Graham, A.K., and P.M. Senge. 1980. "A Long Wave Hypothesis of Innovation." *Technological Forecasting and Social Change* 17:283–311.

Grübler, Arnulf. 1990. *The Rise and Fall of Infrastructures: Dynamics of Evolution and Technological Change in Transport.* Heidelberg: Physica-Verlag.

Grübler, Arnulf. 1998. *Data Appendix, Technology and Global Change*. Cambridge: Cambridge University Press.

Hafner, Katie, and Matthew Lyon. 1996. *Where Wizards Stay up Late: The Origins of the Internet*. New York: Simon & Schuster.

Hall, Peter Geoffrey. 1980. *Great Planning Disasters.* London: Weidenfeld & Nicolson.

Hamer, Andrew N. 1976. *The Selling of Rail Rapid Transit.* Lexington, Mass.: Lexington Books.

Hamer, Mick. 1987. *Wheels Within Wheels: A Study of the Road Lobby.* London: Friends of the Earth/Routledge & Kegan Paul.

Hankla, James C. 2001. "The Alameda Corridor Project: Its Successes and Challenges." Hearing Before the Subcommittee on Government Efficiency, Financial Management, and Intergovernmental Relations of the Committee on Government Reform, 107th Congress, House Hearings. Washington, D.C.: U.S. Government Printing Office.

Harris, Chaucey, and Edward Ullman. 1945. "The Nature of Cities." *Annals of the American Academy of Political and Social Science* 242:7–17.

Hauer, Ezra. 1994. "Can One Estimate the Value of Life or is it Better to be Dead than Stuck in Traffic?" *Transportation Research* 28A(2):109–118.

Hay, Peter. 1985. *Brunel: Engineering Giant*. London: B.T. Batsford.

Hayek, Friedrich A. von. 1989. *The Fatal Conceit: The Errors of Socialism* (ed. W. W. Bentley). Chicago: University of Chicago Press.

Hegemann, Werner, and Elbert Peets. 1922. *The American Vitruvius: An Architect's Handbook of Civic Art.* New York; reissued by Princeton Architectural Press, 1989.

Heitmann, Thierry. 2004. *Photo of Transportation in the Zorn River Valley, Saverne: City of the Roses, Town of Art and History*. http://www.chez.com/theitmann/english/canal3.htm, accessed February 22, 2004.

Henard, Eugene, and Jean-Louis Cohen. 1905. "Etudes sur les Transformations de Paris." *L'Architecture*; reprinted Paris: L'Equerre, 1982.

Heppenheimer, T. A. 1995. *Turbulent Skies: The History of Commercial Aviation.* New York: John Wiley.

Hillman, James. 1979. *Psychological Fantasies in Transportation Problems*. Irvine: University of Texas.

Hillman, Jordan Jay. 1968. *Competition and Railroad Price Discrimination.* Evanston, Ill.: Northwestern University Transportation Center.

Hilton, George W. 1982. *The Cable Car in America*. La Jolla, Calif.: Howell-North Books.

Hilton, George W. 1990. *American Narrow Gauge Railroads.* Stanford: Stanford University Press.

Hippel, Eric von. 1988. *The Sources of Innovation*. New York: Oxford University Press.

Hirschman, Albert. 1981. *Essays in Trespassing: Economics to Politics and Beyo*nd. Cambridge: Cambridge University Press.

Hirschman, Albert. 1985. *The Strategy of Economic Development.* Cambridge, Mass.: Harvard University Press.

Hollander, Jack. 2003. *The Real Environmental Crisis: Why Poverty not Affluence is the Environmental Number One Enemy*. Berkeley: University of California Press.

Holmes, E. H., and J. T. Lynch. 1957. "Highway Planning, Past, Present and Future." *Journal of the Highway Division*, *Proceedings of the ASCE* 83(HW3):1298-1–1298-13.

Holt, W. Stull. 1923. *The Bureau of Public Roads, its History, Activities, and Organization.* Baltimore, Md.: Johns Hopkins University Press.

Horwood, E. M., and R. R. Boyce. 1959. *Studies of the Central Business District and Urban Freeway Development*. Seattle: University of Washington Press.

Hourdakis, J., and P. Michalopoulos. 2002. "Evaluation of Ramp-control Effectiveness in Two Twin Cities Freeways." *Transportation Research Record* 1811:21–29.

Hoyt, Homer. 1939. *The Structure of Growth of Residential Neighborhoods in American Cities.* Washington, D.C.: U.S. Government Printing Office.

Hughes, Thomas P. 1989. *American Genesis: A Century of Invention and Technological Enthusiasm, 1870–1970*. New York: Viking.

Hughes, Thomas P. 2000. *Rescuing Prometheus.* New York: Vintage Books.

Hugill, P. J. 1993. *World Trade since 1431: Geography, Technology, and Capitalism.* Baltimore, Md.: Johns Hopkins University Press.

Hyman, L. S., R. C. Toole, and R. M. Avellis. 1987. *The New Telecommunications Industry: Evolution and Organization,* Vol. 1. Arlington, Va.: Public Utilities Reports, Inc.

Interregional Highway Committee. 1941. *Interregional Highways.* Published by the Committee.

Internet Systems Consortium (ISC), Inc. 2004. *ISC Domain Survey Host Count.* http://www.isc.org, accessed January 8, 2005.

Isard, Walter. 1942. "A Neglected Cycle: The Transport Building Cycle." *Review of Economics and Statistics* 24:149–158.

Jackson, Gordon. 1983. *The History and Archaeology of Ports*. Tadworth, U.K.: World's Work Ltd.

Jacobs, Jane. 1961. *The Death and Life of Great American Cities.* New York: Random House.

James, E. W. 1916. "Distribution of Traffic on a Rectangular System." *Engineering News Record* 24:439–440.

Japanese Automobile Inspection and Registration Association. 1991. "Number of Registered Motor Vehicles." *Automobile Inspection Association Statistics,* March 18.

Japanese Railway Engineering (JRE). 1994. No. 131, Special Issue: *30 Years of Progress in the Shinkansen.* Tokyo: Japan Railway Engineer's Association.

Jeans, J. S. 1875. *Jubilee Memorial of the Railway System: A History of the Stockton and Darlington and a Record of its Results*. London: Longmans, Green.

Jevons, William S. 1866. *The Coal Question; an Enquiry Concerning the Progress of the Nation, and the Probable Exhaustion of our Coal-mines.* London: Macmillan.

Jewish Tribal Review. 2003. *A Closer Look at Poland and Eastern Europe*. http://www.jewishtribalreview.org/07poland.htm, accessed January 15, 2005.

Johnson, Larry R., D. M. Rote, J. R. Hull, H. T. Coffey, J. G. Daley, and R. F. Griese. 1989. *MAGLEV Vehicles and Superconductor Technology: Integration of High-Speed Ground Transportation into the Air Transportation System.* ANL/CNSV-67. Argonne, Ill.: Argonne National Laboratory.

Jones, Daniel P. 1990. "Commercial Progress versus Local Rights: Turnpike Building in Northwest Rhode Island in the 1790s." *Rhode Island History* 48 (February): 21–32.

Jones, David W. 1985. *Urban Transit Policy: An Economic and Political History.* Englewood Cliffs, N.J.: Prentice-Hall.

Kawamura, Kazuya. 2000. *Perceived Value of Time for Truck Operators*. Washington, D.C.: Transportation Research Board.

Keeler, Theodore E. 1983. *Railroads, Freight, and Public Policy.* Washington, D.C.: Brookings Institution.

Kelker, De Leuw & Co. 1925. *Report and Recommendations on a Comprehensive Rapid Transit Plan for the City and County of Los Angeles*.

Klein, Daniel, Binyam Reja, and Adrian Moore. 1997. *Curb Rights: A Foundation for Free Enterprise in Urban Transit.* Washington, D.C.: Brookings Institution.

Knight, Robert, and Lisa Trygg. 1978. "Urban Mass Transit and Land Use Impacts," *Transportation* 5:12–24.

Kolko, Gabriel. 1976. *Railroads and Regulation 1877–1916.* Westport, Conn.: Greenwood Press.

Kondratieff, Nikolai D. 1935. "The Long Waves in Economic Life." *Review of Economic Statistics* 17(6).

Konvitz, Josef W. 1978. *Cities and the Sea: Port Planning in Early Modern Europe*. Baltimore, Md.: Johns Hopkins University Press.

Konvitz, Josef W. 1985. *The Urban Millennium: The City Building Process from the Early Middle Ages to the Present.* Carbondale, Ill.: Southern Illinois University Press.

Kozel, Scott. 1997. "Dulles Transportation Corridor." http://www.roadstothefuture.com/Dulles_Trans_Corridor.html, accessed January 15, 2004.

Kristula, David. 1996–2002. *The History of the Internet, Davesite.com, Webstation, Net History, 1996–2002.* http://www.davesite.com/webstation/net-history5.shtml, accessed March 2004.

Krumm, Brian Kingsley. 1994. "High Speed Ground Transportation Systems: A Future Component of America's Intermodal Network?" *Transportation Law Journal* 22(2): 309–326.

Krylow, Victor (ed.) 2001. *Noise and Vibration from High-Speed Trains.* London: Thomas Telford.

Kuhn, Thomas S. 1957. *The Copernican Revolution.* Cambridge, Mass.: Harvard University Press.

Kwon, E., S. V. Nanduri, R. Lau, and J. Aswegan. 2001. *Comparative Analysis of Operational Algorithms for Coordinated Ramp Metering*. Washington, D.C.: Transportation Research Board.

Latour, Bruno. 1996. *ARAMIS or the Love of Technology.* Cambridge, Mass.: Harvard University Press.

Lay, Maxwell G. 1992. *Ways of the World: A History of the World's Roads and of the Vehicles that Used Them.* New Brunswick, N.J.: Rutgers University Press.

Layton, Edward T. 1971. *The Revolt of the Engineers*. Cleveland, Ohio: Case Western Reserve Press.

Lee, Douglas B., Jr. 1973. "Requiem for Large Scale Models." *Journal of the American Institute of Planners* 39:163–178 (based on *Models and Techniques for Urban Planning*, Cornell Aeronautical Lab, 1968, VY 2474-G-1).

Levinson, David. 1998. "Accessibility and the Journey-to-Work." *Journal of Transport Geography* 6(1):11–21.

Levinson, David. 2002. *Financing Transportation Networks.* Northampton, Mass: Edward Elgar.

Levinson, David, and Ajay Kumar. 1994. "The Rational Locator: Why Travel Times Have Remained Stable." *Journal of the American Planning Association* 60(3):319–332.

Levinson, David, and Ajay Kumar. 1995a. "Activity, Travel, and the Allocation of Time." *Journal of the American Planning Association* 61(4):458–469.

Levinson, David, and Ajay Kumar. 1995b. "Temporal Variations on the Allocation of Time." *Transportation Research Record* 1493:118–127.

Levinson, David, and Ajay Kumar. 1995c. "A Multi-modal Trip Distribution Model." *Transportation Research Record* 1466:124–131.

Levinson, David, and Ramachandra Karamalaputi. 2003. "Induced Supply: A Model of Highway Network Expansion at the Microscopic Level." *Journal of Transport Economics and Policy* 37(3):297–318.

Levinson, David, and Yao Wu. 2005. "The Rational Locator Re-examined: Are Travel Times Still Stable?" *Transportation* 32(2):187–202.

Levinson, David, and Bhanu Yerra. 2002. "Highway Costs and the Efficient Mix of State and Local Funds." *Transportation Research Record: Journal of the Transportation Research Board* 1812: 27–36.

Levinson, David, Lei Zhang, Shantanu Das, and Atif Sheikh. 2001. "Ramp Meters on Trial: Evidence from the Twin Cities Metering Holiday." Presented at the Transportation Research Board Conference, Washington, D.C., January.

Levinson, David, Kathleen Harder, John Bloomfield, and Kasia Winiarczyk. 2003. "Weighting Waiting." Presented at the International Association of Travel Behavior Research Conference, Lucerne, Switzerland.

Lewis, Nelson P. 1916. *The Planning of the Modern City: A Review of the Principles Governing City Planning*. New York: John Wiley.

Life Magazine. 1939. GM Exhibit, Futurama, New York World's Fair 1939, "Two 14-Lane Express Highways Cross in 1960." *Life Goes to the Futurama* (June 5): 90.

Lind, William E. 1965. "Thomas H. MacDonald: A Study of the Career of an Engineer Administrator and his Influence on Public Roads in the United States, 1919–1953." Unpublished Master's thesis, American University, Washington, D.C.

Linn, Bjorn. 1979. "Learning from Experience: The Use of Building and Planning History," in *Growth and Transformation of the Modern City* (conference report). Stockholm: Swedish Council for Building Research, 277–278.

Lösch, A. 1967. *The Economics of Location* (translation of 1943 German edition by W. H. Wolgom and W. F. Stopler). New Haven, Conn.: Yale University Press.

Lowson, Martin. 2002. "Sustainable Personal Transport." *Proceedings of the Institution of Civil Engineers,* 5(1):73–82.

Lyovic, Joseph. 2000. *Train Resistance, Load Modeling, AC Traction System Modeling.* University of Newcastle, Australia. http://murray.newcastle.edu.au/users/students/2000/c9036897/loadmodel.htm, accessed January 15, 2005.

Mainichi Newspapers Co. 2002. "Eliminating the Political Bias against Cities." *Mainichi Daily News,* October 8. http://mdn.mainichi.co.jp/news/archive/200210/08/20021008p2a00m0oa033000c.html, accessed March 2004.

MacDonald, Thomas H. 1937. "Looking Toward the Highway Future." *American Highways* 16(1):4–7.

Marchetti, Cesare. 1980. "Society as a Learning System: Discovery, Invention, and Innovation Cycles Revisited." *Technological Forecasting and Social Change* 18:267–282.

Marchetti, Cesare. 1994. "Anthropological Invariants in Travel Behavior." *Technological Forecasting and Social Change* 47:75–88.

Margary, Ivan D. 1993. *Roman Roads in Britain*. London: John Baker.

Marsh, George Perkins. 1898. *The Earth as Modified by Human Action: A Last Revision of "Man and Nature"*. New York: C. Scribner's Sons.

McClintock, Miller. 1926. *Metropolitan Street Traffic Survey*. Chicago: Chicago Association of Commerce.

McCullough, Robert, and Walter Leuba. 1973. *The Pennsylvania Main Line Canal*. York, Pa.: American Canal and Transportation Center.

Meehan, Sean. 2002. "Dulles Greenway Single-day Traffic Exceeds 60,000." http://dullesgreenway.com/cgi-bin/dgpress26.cfm?home=, accessed 20 June 2002.

Mensch, Gerhard. 1979. *Stalemate in Technology: Innovations Overcome the Depression.* Cambridge, Mass.: Ballinger (English language edition).

Metropolitan Transportation Commission (MTC). 2003. *Regional Growth Trends.* MTC Library, St. Paul, Minn., September 16.

Metzler, Jean-Marie. 1992. "A Decade of Commercial Policy," in *A Decade of TGV Operation. Revue Générale des Chemins de Fer.* Paris: Gauthier-Villers.

Meyer, John R., Merton J. Peck, John R. Stenason, and Charles Zwick. 1959. *The Economics of Competition in the Transportation Industries.* Cambridge, Mass.: Harvard University Press.

Miller, Eric, and Fan Kai-Sheng. 1992. "Travel Demand Behaviour: Survey of Intercity Mode-Split Models in Canada and Elsewhere." *Directions: The Final Report of the Royal Commission on National Passenger Transportation*, Vol. 4. Ottawa, Canada: Ministry of Supply and Services.

Miller, George H. 1971. *The Railroads and the Granger Laws.* Madison: University of Wisconsin Press.

Ministry of Land, Infrastructure, and Transport (MLIT), Road Bureau. 2003. *Condition of Roads in Japan in the 1950s.* http://www.mlit.go.jp/road/road_e/index_e.html, accessed September 2003.

Mishra, Lakshmidhar. 2000. *Child Labour in India.* New Delhi: Oxford University Press.

Modelski, George. 1984. "A Sequence of Long Cycles in the Succession of Lead Powers in the Modern World System." *Man, Environment, Space and Time* 4:55–77.

Modelski, George, and W. Thompson. 1996. *Leading Sectors and World Powers: The Coevolution of Global Economics and Politics.* Columbia: University of South Carolina Press.

Mohring, Herbert D. 1993. "Land Rents and Transport Improvements: Some Urban Parables." *Transportation* 20:267–283.

Mohring, Herbert D., and Mitchell Harwitz. 1962. *Highway Benefits: An Analytic Framework.* Evanston, Ill.: Northwestern University Press.

Mokhtarian, Patricia L., and Cynthia Chen. 2003. "TTB or Not TTB, That is the Question: A Review and Analysis of the Empirical Literature on Travel Time (and Money) Budgets." Presented at the Transportation Research Board Conference, January.

Moynihan, Daniel P. 1975. *Coping: On the Practice of Government*. New York: Vintage Books.

Munnell, Alicia (ed.) 1990. *Is There a Shortfall in Public Capital Investment?* Boston: Federal Reserve Bank.

Munro, John H. 2000. *The Economic History of Modern Europe to 1914: Course Notes for Economics 303Y1.* http://www.economics.utoronto.edu/munro5/eco303Yweb.htm, accessed January 15, 2005.

Nader, Ralph. 1972. *Unsafe at Any Speed: The Designed-in Dangers of the American Automobile*. New York: Grossman.

Nakicenovic, Nebojsa. 1988. "Dynamics and Replacement of U.S. Transport Infrastructures," in J. H. Ausubel and R. Herman (eds.), *Cities and Their Vital Systems: Infrastructure, Past, Present and Future.* Washington, DC.: National Academy Press, 175–221.

National Research Council. 1975. *A Review of Short Haul Passenger Transportation*. Washington, D.C.: Committee on Transportation Report.

National Transportation Policy Study Commission (NTPSC). 1978. *Special Report No. 1: Current Transportation Issues in the United States.* Washington, D.C.: The Commission.

National Transportation Policy Study Commission (NTPSC). 1979. *National Transportation Policy Through the Year 2000.* Washington, D.C.: The Commission.

Nehashi, Akira. 1998. "New Urban Transit Systems Reconsidered: A Better Transport Environment for the Next Century." *Japan Railway and Transport Review* 16:4–14.

Nelson, Richard, and Sidney Winter. 1982: *An Evolutionary Theory of Economic Change.* Cambridge, Mass.: Harvard University Press.

Nelson, Y. 1997. *Results of the Delphi IX Survey of Oil Price Forecasts.* Sacramento: California Energy Commission.

Newbery, David M., and Georgina Santos. 1999. *Road Taxes, Road User Charges and Earmarking.* Department of Applied Economics, University of Cambridge, March 30.

Newman, Peter, and Jeffrey Kenworthy. 1989. "Gasoline Consumption and Cities: A Comparison of U.S. Cities with a Global Survey." *Journal of the American Planning Association* 55(1):24–37.

Nickel Plate Historical Society. 2004. *Nickel Plate Road System Map.* http://www.nkphts.org/history.html#main, accessed February 22, 2004.

Northern Echo Newspaper. 2004. *The History of the Stockton and Darlington Railway from its 175th Anniversary*. http://www.thisisthenortheast.co.uk/railway/history/, accessed February 2004.

Nova. 1998. "Supersonic Spies." *PBS Airdate*. http://www.pbs.org/wgbh/nova/transcripts/2503supersonic.html, accessed January 27, 1998.

Odlyzko, Andrew. 1997. "The Slow Evolution of Electronic Publishing," in A. J. Meadows and F. Rowland (eds.), *Electronic Publishing '97: New Models and Opportunities.* Washington, D.C.: ICCC Press, 4–18.

Office of Technology Assessment 1983. *U.S. Passenger Rail Technologies*. OTA-STI-222. Washington, D.C., December.

Olmsted, Frederick. 1910. "The Basic Principles of City Planning." *American City* 3:67–72.

Oregon Department of Transportation. 2003. *Volume I: Final Report 2003 Oregon Highway Cost Allocation Study Prepared for Oregon Department of Administrative Services.* Salem, Oreg.: ODOT Transportation Development Division Policy Section and ECONorthwest. http://www.oea.das.state.or.us/highwaycost/hwaycost.htm, accessed May 2003.

Owen, Wilfred. 1987. *Transportation and World Development.* Baltimore, Md.: Johns Hopkins University Press.

Pacey, Arnold. 1974. *The Maze of Ingenuity: Ideas and Idealism in the Development of Technology.* London: Allen Lane.

Parnell, Sir Henry. 1833. *A Treatise on Roads*. London: Longmans, Green.

Pawson, E. 1977. *Transport and Economy: The Turnpike Roads of Eighteenth Century Britain.* New York: Academic Press.

Phelps, Myra L. 1978. *Public Works in Seattle: A Narrative History. The Engineering Department, 1875–1975.* Seattle: Seattle Engineering Department.

Pickrell, D. 1992. "A Desire Named Streetcar: Fantasy and Fact in Rail Transit Planning." *Journal of the American Planning Association* 58:158–176.

Pollakowski, Henry O., and Susan M. Wachter. 1990. "The Effects of Land Use Constraints on Housing Prices." *Land Economics* 66(3):315–324.

Pollard, Sidney. 1980. "A New Estimate of British Coal Production, 1750–1850." *Economic History Review*, 2nd ser. 33:212–235.

Poole, Robert W., Jr., and C. Kenneth Orski. 2003. "HOT Networks: A Better Way to Attack Urban Highway Congestion." *Regulation* 23(1):15–20.

PR Newswire. 1999. "Dulles Greenway Obtains Triple-A Bond Rating in $350 Million Refinancing Project." April 29.

Pratt, Jon D. 2003. *An Idea into a Business: Center for Entrepreneurship and Information Technology at Louisiana Tech.* http://cenit.latech.edu/cenit/misc/Making%20an%20Idea%20into%20a%20Business.ppt, accessed June 9, 2003.

Prendergast, L.S., and R.D. Williams. 1981. "Individual Travel Time Budgets." *Transportation Research* 15A:39–46.

Preston, Howard L. 1991. *Dirt Roads to Dixie: Accessibility and Modernization in the South, 1855–1935*. Knoxville: University of Tennessee Press.

Public Purpose. 2000. *Urban Transport Fact Book.* http://www.publicpurpose.com, accessed January 8, 2005.

Raitz, Carl. 1996. *The National Road*. Baltimore, Md.: Johns Hopkins University Press.

Rakeman, Carl. 1795. "The Philadelphia and Lancaster Turnpike Road, 1795." *The Paintings of Carl Rakeman*. Federal Highway Administration, U.S. Department of Transportation. Courtesy of http://www.fhwa.dot.gov/rakeman/1795.htm, accessed September 2003.

Rakeman, Carl. 1823. "First American Macadam Road Drawing, 1823." *The Paintings of Carl Rakeman*. Federal Highway Administration, U.S. Department of Transportation. Courtesy of http://www.fhwa.dot.gov/rakeman/1823.htm, accessed September 2003.

Regional Traffic Bureau. 1992. *Monthly Report of the Number of Registered Motor Vehicles.* Administration Section, Ground Technology Safety Division, Regional Traffic Bureau, Japanese Ministry of Transport.

Reps, John W. 1965. *The Making of Urban America: A History of City Planning in the United States.* Princeton, N.J.: Princeton University Press.

Richmond, Jonathan. 1989. "Theories of Symbolism, Metaphor and Myth, and the Development of Western Rail Passenger Systems, or Penis Envy in Los Angeles." Presented at the 31st Annual Meeting of the Association of Collegiate Schools of Planning, Portland, Oreg., October 7.

Richmond, Jonathan. 2001. *The Private Provision of Public Transport.* Cambridge, Mass.: Harvard University, Taubman Center for Sate and Local Government.

Richmond, Jonathan. 2003. *Transport of Delight: The Mythical Conception of Rail Transit in Los Angeles.* Akron, Ohio: University of Akron Press.

Riley, Robert Q., 1994. *Alternative Cars in the 21st Century: A New Personal Transportation Paradigm.* Warrendale, Pa.: Society of Automotive Engineers.

Ringwalt, John L. 1888. *Development of Transportation Systems in the United States.* Philadelphia: Railway World Office.

Road Transport Bureau. 1959, 1960, 1970. *Annual Report of Road Transport Statistics*. Japanese Ministry of Transport.

Rocky Mountain Institute. 2003. *Transportation Fuel Savings*. http://www.rmi.org/sitepages/pid397.php, accessed September 18, 2003.

Rodrigue, Jean-Paul. 2002. "Historical Evolution of Transportation, Part II." *Transport Geography on the Web*. Hempstead, N.Y.: Hofstra University, Department of Economics and Geography. http://people.hofstra.edu/geotrans/eng/ch1en/conc1en/ch1c3_2en.html, accessed January 15, 2005.

Rogers, Everett M. 1962. *Diffusion of Innovations.* New York: Free Press of Glencoe.

Rogers, Everett M. 1995. *Diffusion of Innovations*, 4th ed. New York: Free Press.

Rosenstein, Mark. 2000. "The Rise of Maritime Containerization in the Port of Oakland: 1950 to 1970." Master's thesis, Gallatin School of Individualized Study, New York University, September 11.

Ryan, Barry, and Thomas F. Stinson. 2002. "Road Finance Alternatives: An Analysis of Metro-Area Road Taxes Report #9." Transportation and Regional Growth Study. Minneapolis: Center for Transportation Studies, University of Minnesota.

Rydell, Edmund W.F. 2000. *The Transportation Renaissance: The Personal Rapid Transit Solution*. Philadelphia: Xlibris Corporation.

St. Clair, David J. 1986. *The Motorization of American Cities*. New York: Praeger.

Samuel, Peter, Robert Poole, and Jose Holguin Veras. 2003. "Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation." Policy Study 294. Los Angeles: Reason Public Policy Institute.

Santini. Daniel W. 1988. "A Model of Economic Fluctuations and Growth Arising from the Reshaping of Transportation Technology." *The Logistics and Transportation Review* 24: 121–151.

Sauerbier, C.L. 1956. *Marine Cargo Operations.* New York: John Wiley.

Schipper, Lee. 2001. *International Experience in Saving Oil in Transport: Lessons for California?* Sacramento: California Energy Commission, September.

Schon, Donald A. 1963. *Displacement of Concepts.* London: Tavistock Publications.

Schor, Judith B. 1991. *The Overworked American: The Unexpected Decline of Leisure.* New York: Basic Books.

Schordock, James (General Manager). 1985. "Union Pacific Intermodal" *UP Magazine*, May.

Schultz, Stanley K. 1989. *Constructing Urban Culture: American Cities and City Planning, 1800–1920*. Philadelphia: Temple University Press.

Schumpeter, Joseph. 1934. *The Theory of Economic Development*. Cambridge, Mass.: Harvard University Press.

Schwartz, Gary T. 1976. "Urban Freeways and the Interstate System." *Southern California Law Review* 49(3):406– 513.

Science Museum, London. 1829. "The Rocket in Its Original Form, Inventory Number 1862-5." *Mechanics Magazine* frontispiece, October 24.

Seely, Bruce E. 1987. *Building the American Highway System: Engineers as Policy Makers.* Philadelphia: Temple University Press.

Sellnow, Greg. 2000. "Coal Train Coming." *Rochester Post-Bulletin*, March 4. http://www.postbulletin.com/dmeproject/index.stm, accessed July 15, 2004.

Senkus, William M. 2000. *Trains on U.S. Stamps and Postal Stationary*. http://alphabetilately.com/US-trains-06.html, accessed February 22, 2004.

Shallat, Todd. 1994. *Structures in the Stream: Water, Science, and the Rise of the U. S. Army Corps of Engineers*. Austin: University of Texas Press.

Sheriff, Carol. 1996. *The Artificial River: The Erie Canal and the Paradox of Progress 1817–1862*. New York: Hill & Wang.

Sherow, James E. 1990. *Canals for the Nation: The Canal Era in the U.S., 1790–1860*. Lexington: University of Kentucky Press.

Shoup, Donald. 1999. "The Trouble with Minimum Parking Requirements." *Transportation Research* 33A(7/8):549–574.

Siddall, William R. 1974. "No Nook Secure: Transportation and Environmental Quality." *Comparative Studies in Society and History* 16(1):2–23.

Sigafoos, Robert A. 1984. *Absolutely Positively Overnight! The Story of Federal Express*. New York: Mentor, New American Library.

Simmons, Jack. 1986. *The Railway in Town and Country*. Newton Abbot, U.K./North Pomfret , Vt.: David & Charles.

Simon, H. 1959. "Theories of Decision-making in Economic and Behavioral Sciences." *American Economic Review* 49(3):253–283.

Slater, Clifford. 1997. "General Motors and the Demise of Streetcars." *Transportation Quarterly* 51(3):45–66.

Slater, David W. 1992. "Transportation and Economic Development: A Survey of the Literature, Directions." *The Final Report of the Royal Commission on National Passenger Transportation*, Vol. 3. Ottawa, Ontario: The Commission, 1992.

Small, Kenneth. Clifford Winston, and Carol Evans. 1989. *Road Work: A New Highway Pricing and Investment Policy*. Washington, D.C.: Brookings Institution.

Smiles, Samuel. 1858. *The Life of George Stephenson, Railway Engineer*. Boston: Ticknor & Fields.

Smith, Adam. 1776. *An Inquiry into the Nature and Causes of the Wealth of Nations*. Indianapolis, Ind.: Liberty Classics, 1981.

Smith, C. O. 1990. "The Longest Run: Public Engineers and Planning in France." *American History Review* 95:657–692.

Snell, Bradford C. 1974. *American Ground Transport: A Proposal for Restructuring the Automobile, Truck, Bus, and Rail Industries*. Presented to the Subcommittee on Antitrust and Monopoly of the Committee of the Judiciary, U.S. Senate, February 26. Washington, D.C.: U.S. Government Printing Office, 16–24.

Sobel, Dava. 1996. *Longitude: The True Story of a Lone Genius Who Solved the Greatest Scientific Problem of His Time*. New York: Penguin Books.

Sommer, Melanie 2002. "DM&E—Resources and Links." *Minnesota Public Radio News*, March 11. http://news.minnesota.publicradio.org/features/200203/11_mainstreet_dme-m/resources.shtml, accessed July 15, 2004.

Spanhake, Dawn. 2001. "Specialized Transit and Elderly, Disabled, and Families in Poverty Populations." Minneapolis: University of Minnesota, Center for Transportation Studies, March.

Spartacus Educational Webpage. 2004. *Drawing of the Blutcher.* http://www.spartacus.schoolnet.co.uk/RAblutcher.htm, accessed February 2004.

Spengler, Edwin H. 1930. *Land Values in New York in Relation to Transit Facilities*. New York: Columbia University Press.

Spielburg, F.L., and P.S. Shapiro. 2000. "Mating Habits of Slugs: Dynamic Carpool Formation in the I-95/I-395 Corridor of Northern Virginia." *Transportation Research Record* 1711:31–38.

Standage, Tom. 1998. *The Victorian Internet: The Remarkable Story of the Telegraph and the Nineteenth Century's On-line Pioneers*. New York: Walker.

Statistics and Survey Department. 1964, 1966. *Statistical Survey of Land Transport*. Japanese Transport Minister's Secretariat.

Stephenson, Neal. 1992. *Snow Crash*. New York: Bantam Spectra Books.

Stevens, Michael, L. 2000. *The Birth, Rise, and Fall of Canals in England*. Mike Stevens' UK Inland Waterways Pages, July. http://www.mike-stevens.co.uk, accessed January 15, 2005.

Stigler, George. 1951. "That the Division of Labor is Limited by the Extent of the Market." *Journal of Political Economy* 59:185–193.

Stine, Jeffrey K. 1981. "Nelson P. Lewis and the City Efficient: The Municipal Engineer in City Planning During the Progressive Era." *Essays in Public Works History* No. 11. Chicago: Public Works Historical Society.

Storm, George. n.d. *A Sectional Canal Boat in the Hitching Shed, Date unknown*. Painting images courtesy of National Park Service. http://www.cr.nps.gov/nr/twhp/wwwlps/lessons/23allegheny/23visual3.htm, accessed September 2003.

Stover, John F. 1987. *History of the Baltimore and Ohio Railroad*. West Lafayette, Ind.: Purdue University Press.

Sullivan, Dan. 2000. "Dulles Greenway Begins Construction of Additional Lanes." Sterling, Va.: Dulles Greenway press release, June 2.

Summerton, Jane (ed.) 1994. *Changing Large Technical Systems.* Boulder, Colo.: Westview Press.

Szostak, Rich 1991. *The Role of Transportation in the Industrial Revolution*. Montreal: McGill-Queens University Press.

Takeda, Izumi and Fijio Mizuoka. 2003. "The Privatization of the Japanese National Railways, The Myth of Neo-liberal Reform and Spatial Configurations of the Rail Net in Japan—A View from Critical Geography," in Nicholas Low and Brenden Gleeson (eds.), *Making Urban Transportation Sustainable.* New York: Palgrave Macmillan, 149–164.

Taniguchi, Mamoru. 1992. "High Speed Rail in Japan: A Review and Evaluation of the Shinkansen Train." Working Paper No. 557, Table 1. Berkeley: University of California, Institute of Urban and Regional Development.

Tanner, J.C. 1981. "Expenditure of Time and Money on Travel." *Transportation Research* 15A(1):25–38.

Tarde, Gabriel. 1940. *The Laws of Imitation* (original printing 1890, trans. 1903). Gloucester, Mass.: Peter Smith.

Thurston, Robert H. 1878. *A History of the Growth of the Steam-Engine.* New York: Appleton. http://www.history.rochester.edu/steam/thurston/1878/Chapter5.html, accessed March 2004.

Transportation Canada. 2002. *Canada veh km/veh data: Transportation in Canada 2002 c.7 Road Transportation, Table 7-3 Distribution of Vehicle Activity by Vehicle Body.* http://www.tc.gc.ca/pol/en/Report/anre2002/7D_e.htm, accessed March 2004.

Tugwell, Franklin. 1988. *The Energy Crisis and the American Political Economy: Politics and Markets in the Management of Natural Resources.* Stanford, Calif.: Stanford University Press.

Turnbull, Gerald L. 1979. *Traffic and Transport: An Economic History of Pickfords*. London: Allen & Unwin.

Turvey, Ralph. 2003. "Road and Bridge Tolls in Nineteenth Century London." *Journal of Transport History* 17:150–164.

U.S. Congress. 1961. *Final Report of the Highway Cost Allocation Study, Part VI: Studies of the Economic and Social Effects of Highway Improvement.* House Document No. 72, 87th Congress, First Session. Washington, D.C.: U.S. Government Printing Office.

U.S. Department of Transportation. 1976–1987. *Northeast Corridor Improvement Project, Joint Annual Report.* Washington, D.C.: Federal Railroad Administration, annual.

U.S. Department of Transportation. 1981. *Rail Passenger Corridors, Final Evaluation.* Washington, D.C.: Federal Railroad Administration and National Railroad Passenger Corporation.

U.S. Department of Transportation. 1995. *National Transportation Statistics, 1995.* Washington, D.C.: Bureau of Transportation Statistics.

U.S. Department of Transportation/Iteris. 2002. *National ITS Architecture Version 5.0.* http://www.iteris.com/itsarch/html/static/home.htm, accessed January 9, 2005.

U.S. Environmental Protection Agency (EPA). 2001. *Air Quality Planning and Standards, 2001.* http://www.epa.gov/airs/criteria.html, accessed September 2003.

U.S. Federal Highway Administration. 1977. *America's Highways 1776–1976*. Washington, D.C.: U.S. Department of Transportation.

U.S. Federal Highway Administration. 1985. *The Feasibility of a Nationwide Network for Longer Combination Vehicles*. Washington, D.C.: U.S. Department of Transportation, May.

U.S. Federal Highway Administration. 1990. *Assessing the Relationship Between Transportation Infrastructure and Productivity.* No. 4 in a Policy Discussion Series. Washington, D.C.: U.S. Department of Transportation.

U.S. Federal Highway Administration. 1997. "1997 Federal Highway Cost Allocation Study Final Report, Figure IV-1." *2000 Distribution of Federal Highway Revenues by Broad Vehicle Classes, Trends and Forecasts of Highway User Revenue*. http://www.fhwa.dot.gov/policy/hcas/final/four.htm, accessed March 2004.

U.S. Federal Highway Administration. 2002. *Statistics 2001 Fuel Prices for Selected Countries, Table IN-5 Vehicle Travel for Selected Countries, Table IN-4*. Washington, D.C.: U.S. Department of Transportation, October.

U.S. Federal Highway Administration. 2004. *A Look at the History of the Federal Highway Administration*. http://www.fhwa.dot.gov/byday/fhbd0817.htm, accessed March 2004.

U.S. Federal Railroad Administration. 1990. *Assessment of the Potential for Magnetic Levitation Transportation in the United States*. Washington, D.C.

U.S. General Accounting Office. 1987. *Highway Needs: An Evaluation of DOT's Assessment Process.* GAO/RCED-87-136. Washington, D.C.

U.S. General Accounting Office. 1996. *Airline Deregulation: Changes in Airfares*. GAO/RCED-96-79. Washington, D.C.

U.S. Maritime Administration. 2002. "Top 20 Merchant Fleets of the World as of July 1, 2002." *Maritime Statistics*. http://www.marad.dot.gov/Marad_Statistics/mfw_top20.htm, accessed March 28, 2002.

Verhoef, Eric. 1994. "External Effects and Social Costs of Road Transport." *Transportation Research* 28A:273–287.

Ville, S.P. 1990. *Transport and the Development of the European Economy, 1750–1918*. New York: St. Martins Press.

Viner, Jacob. 1926. "Urban Aspects of Highway Finance." *Public Roads* 6:233–235, 240, 260–268.

Voith, Richard. 1991. "Transportation, Sorting and House Values." *AREUEA Journal* 19(2): 117–137.

Wachs, Martin. 1982. "Ethical Dilemmas in Forecasting for Public Policy." *Public Administration Review* 42(6):562–567.

Wachs, Martin. 1990. "Ethics and Advocacy in Forecasting for Public Policy." *Business and Professional Ethics Journal* 9(1/2):141–157.

Walmsley, David, and Ken Perrett. 1992. *The Effects of Rapid Transit on Public Transport and Urban Development.* Wokingham, U.K.: Department of Transport, Transport Research Laboratory,

Ward, J. R. 1974. *The Finance of Canal Building in Eighteenth-century England*. Oxford: Oxford University Press.

Washington Business Journal. 1999. "Greenway Finally Going Somewhere," December 3.

Washington Post. 1996. "Private Ways and Public Follies," January 14, C08.

Washington Post. 1996. "Missed Payments Put Dulles Greenway at Risk of Foreclosure." August 4, B01.

Webb, Sidney, and Beatrice Webb. 1913. *English Local Government: The Story of the King's Highway*. London: Longmans, Green.

Webber, Melvin. 1963. "Order in Diversity: Community Without Propinquity," in Lowdon Wingo (ed.), *Cities and Space.* Baltimore, Md.: Resources for the Future.

Webber, M. M. 1976. "The BART Experience: What Have We Learned?" *Public Interest* No 45 (Fall): 79–108.

Weiner, Edward. 1983. *Urban Transportation Planning in the United States.* Washington, D.C.: U.S. Department of Transportation, Office of the Secretary.

Wellington, Arthur Mellen. 1906. *The Economic Theory of the Location of Railways* (6th ed., corrected). New York: John Wiley.

Whyte, William H., Jr. (ed.) 1958. *The Exploding Metropolis.* Berkeley: University of California Press.

Willeke, Rainer. 1993. "Zur Frage der externen Kosten und Nutzen des motorisierten Strassenverkehrs." *Zeitschrift für Verkehrswissenschaft* 64:215–236.

Wilson, James Q. (ed.) 1980. *The Politics of Regulation*. New York: Basic Books.

Wilson, William H. 1989. *The City Beautiful Movement*. Baltimore, Md.: Johns Hopkins University Press.

Winfrey, Robley. 1968. *Economics of the Maximum Limits of Motor Vehicle Dimensions and Weights.* Federal Highway Administration Report No. FHWA-RD-73-69-70. Washington, D.C.: Federal Highway Administration.

Wood, Andrew. 2004. *View of General Motors Highway and Horizons Exhibit, Fair Theme Center and Futurama.* http://www2.sjsu.edu/faculty/wooda/149/149syllabus. 11summary. html, accessed March 2004.

Yago, Glenn. 1984. *The Decline of Transit: Urban Transportation in German and U.S. Cities, 1900–1970*. Cambridge: Cambridge University Press.

Yamada, Susan. 2004. *Postcard View of Futurama, Streamlining: Norman Bel Geddes and the Rhetoric of Modernism.* http://www2.sjsu.edu/depts/commstudies/woz/woz3/woz3a.html, accessed March 2004.

Yamamoto, Luci. 2003. "Railroading BART." *The Monthly* (Emeryville, Calif.) 33(5):13–17.

Yamins, D., S. Rasmussen, and D. Fogel. 2003. "Growing Urban Roads." *Networks and Spatial Economic* 3:69–85.

Yerra, Bhanu, and David Levinson. 2005. "The Emergence of Hierarchy in Transportation Networks." *Annals of Regional Science* (in press).

Young, Adam. 2001. *The Rise and Fall of Pan-State Airways.* http://www.lewrockwell.com /orig/young4.html, accessed January 15, 2005.

Young, Arthur. 1970. *General View of the Agriculture of the County of Sussex.* London: David & Charles Reprints (reprint of 1813 and 1817 editions).

Zahavi, Yacov. 1974. *Travel Time Budget and Mobility in Urban Areas*. Washington, D.C.: Federal Highway Administration, U.S. Department of Transportation, May.

Zahavi, Yacov. 1979. *The "UMOT" Project* (*U.S. Department of Transportation Report No. DOT-RSPA-DPB-20-79-3, Chapter 3)*. Washington, D.C.: U.S. Department of Transportation.

Zahavi, Yacov, and James Ryan. 1980. "Stability of Travel Components over Time." *Transportation Research Record* 750:19–26.

Zahavi, Yacov, and Antti Talvittie. 1980. "Regularities in Travel Time and Money Expenditures." *Transportation Research Record* 750:13–19.

Zuckermann, Wolfgang, Mary B. Sanger, and M. A. Levin. 1992. "Using Old Stuff in New Ways: Innovation as a Case of Evolutionary Tinkering." *Journal of Policy Analysis and Management* 11:88–115.

Index