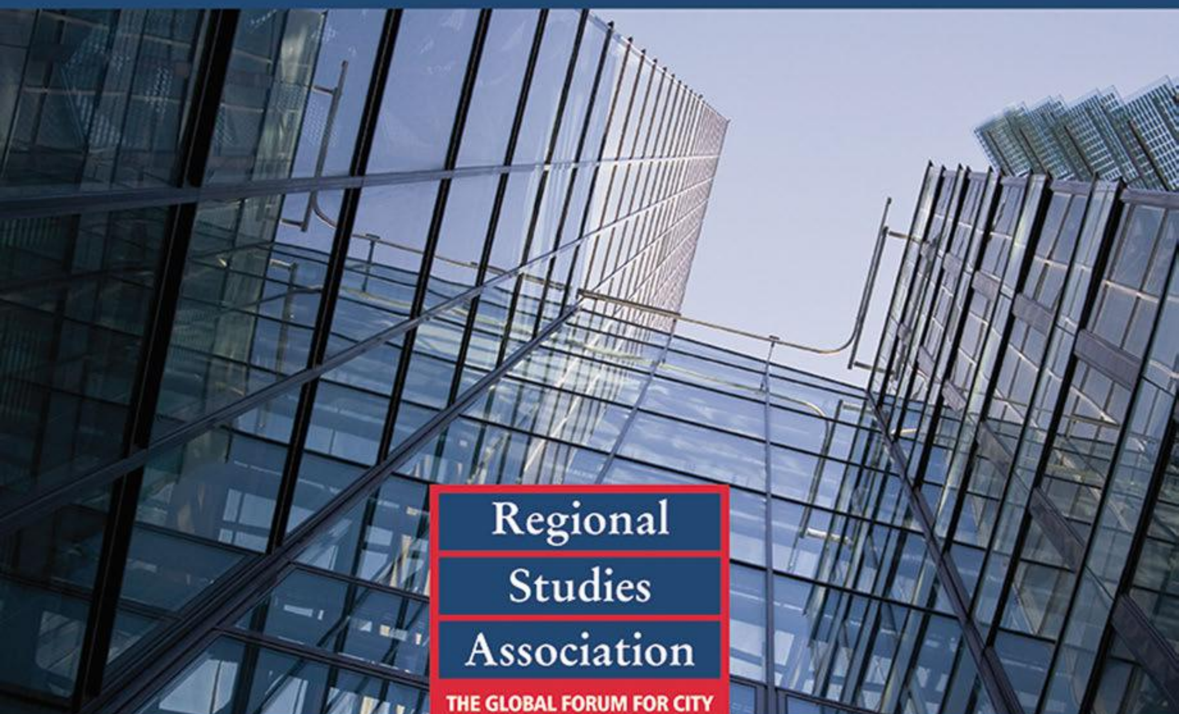
ROUTLEDGE

URBAN INNOVATION SYSTEMS

WHAT MAKES THEM TICK?



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REGIONS AND CITIES

WILLEM VAN WINDEN, ERIK BRAUN, ALEXANDER OTGAAR AND JAN-JELLE WITTE

Urban Innovation Systems

Why are some regions and cities so good at attracting talented people, creating high-level knowledge, and producing exciting new ideas and innovations? What are the ingredients of success? Can innovative cities be created and stimulated, or do they just flourish by mere chance? This book analyses the development and management of innovation systems in cities in order to provide a better understanding of what makes such systems perform.

The book opens by developing a conceptual model that combines insights from urban economics with economic geography, urban governance, and place marketing. This highlights the relevance of path dependence, different types of proximity (and the role of clusters, networks, and platforms), institutional conditions, place attractiveness, and place identity in the evolution of local innovation systems. The authors then draw on this conceptual framework to structure empirical case studies in three cities with a relatively high innovation performance: Eindhoven (the Netherlands), Stockholm (Sweden), and Suzhou (China). Through these case studies, they provide a detailed analysis of how successful innovation systems evolve and what makes them tick.

Unique to this book is the linking of analysis to concrete policy and management responses. The book ends with a discussion on six themes in the development of successful urban innovation systems: firm capabilities and leader firms, higher education and research, attractive environment, place branding, institutional environment, and entrepreneurship. Each theme is examined fully, drawing lessons from the case studies and from recent insights and other cases discussed in the literature.

This title will be of interest to students, researchers, and policymakers involved in regional innovation systems, knowledge locations, and cluster development.

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Routledge
Taylor & Francis Group
LONDON AND NEW YORK

First published 2014
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN

and by Routledge
711 Third Avenue, New York, NY 10017

Routledge is an imprint of the Taylor & Francis Group, an informa business

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication Data

Winden, Willem van.
Urban innovation systems : what makes them tick? / Willem van Winden, Erik Braun, Alexander Otgaar and Jan-Jelle Witte.
pages cm. — (Regions and cities ; 72)
Includes bibliographical references and index.
1. Cities and towns—Technological innovations. 2. City planning.
I. Title.
HT153.W56 2014
307.76—dc23
2013040531

ISBN: 978-0-415-72778-5 (hbk)
ISBN: 978-1-315-85202-7 (ebk)

Typeset in Times
by Apex CoVantage, LLC

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Acknowledgements

This book is based on an international comparative study that has been carried out on behalf of Skolkovo Foundation. We would like to thank Skolkovo Foundation and in particular Oleg Alekseev, Vera Bunina, and Artyom Morozov for their support and Marcel Vroom (MVADV) for bringing us together.

The case studies could not have been carried out without the assistance of local contact persons who helped us identify discussion partners and organize the field visits. In the case of Eindhoven, our acknowledgements go to Linco Nieuwenhuyzen of Brainport Development. For the organization of the Kista Science City case study, we are grateful to Åke Lindström (Kista Science City), Mattias Durnik (City of Stockholm), and Egon de Haas and his Swedish colleagues of PwC. The case study of Suzhou Industrial Park has been arranged with support of Shi Jianwei (SIP Venture Investment) and our colleagues of Shanghai Normal University: Rachel Xiang Feng and Yanchao Wang.

Finally we thank Scott Allison for his contribution to the case studies of Eindhoven and Kista Science City and Monique Valkenburg for her organizational support from our secretariat.

Rotterdam, October 2013
Willem van Winden, Erik Braun,
Alexander Otgaar, and Jan-Jelle Witte

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Abbreviations

BIC	Brainport Innovation Campus
CEO	chief executive officer
DAC	Digital Art Center
FDI	foreign direct investment
FOF	Fund of Funds
HTC	high-tech campus (Eindhoven)
ICT	information and communication technology
IPR	intellectual property rights
IT	information technology
LQ	location quotient
KTH	Royal Institute of Technology (Sweden)
MNC	multinational company
NUSRI	National University of Singapore Research Institute
OEM	original equipment manufacturer
R&D	research and development
SIP	Suzhou Industrial Park
SIPAC	SIP Administrative Committee
SIPIVT	SIP Institute of Vocational Technology
SND	Suzhou New District
SME	small and medium enterprises
SWOT	strengths, weaknesses, opportunities, and threats
TNO	Netherlands Organisation for Applied Scientific Research
TU/E	Technical University Eindhoven
VC	venture capital

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1 Introduction

1.1 Background

A consensus has emerged among both academics and practitioners that innovation is the key for economic growth. Moreover, it is becoming increasingly clear that innovation has a territorial dimension (Jaffe *et al.* 1993). Great differences exist among cities in their level of innovation capacity, and in the world economy, a handful of highly innovative cities has played a disproportionally large role in the knowledge economy. From the 1980s onward, economic geographers, regional economists, and other scholars of regional economic development have put the study of these highly innovative cities and regions at the centre of attention. Their aim is to understand why some cities thrive in the knowledge economy while others struggle to adapt.

The resulting literature has shown that innovation is a complex process in which a large number of different actors – both public and private – need to align themselves and collaborate. Both the quality of these individual actors and the networks and linkages that allow them to cooperate and learn from each other have been identified as relevant conditions for a city's innovation capacity to grow. Together, these actors and the networks and linkages between them form a system that, if running smoothly, is able to produce the innovations that constantly renew a local economy. The local environment, including its resource availability, built environment, and institutional context, can facilitate or hinder the operation of this system. There is a rich body of literature on the factors that influence the successful development of local innovation systems[1] (e.g. Cooke 1992), which includes – in our view – studies that label innovation systems differently. This explains why our review of innovation system enablers also refers to studies that build on the concept of clusters (e.g. Porter 1990).

The study of local innovation systems has usually taken the form of case studies, which provide the level of detail necessary to understand their full complexity. Large numbers of these studies have been carried out, studying well-known innovative regions like Silicon Valley (e.g. Saxenian 1994), but also more mundane cities with varying levels of innovation capacity situated in very different environments. These studies have resulted in a long list of factors that are associated with successful regional innovation systems (for a recent review, see Brenner and Mühlig 2013). However, these studies tend to study innovation systems when they are fully developed and pay less attention to how they got there. Success factors learned in this way say little about how cities can increase their innovation capacity if they want to develop a successful innovation system from scratch, departing from a situation in which the capacity is relatively low. Moreover, these studies have been criticitzed for their 'recipe approach', more or less assuming that what works in one region also works in another. In this book, we state that such an approach is not realistic because cities evolve along historic development paths that create constraints and opportunities for innovation system development. So despite the large number of studies, surprisingly little is known about how successful local innovation systems emerged and developed over time and how their development in different stages was impacted by contextual factors.

Policymakers have taken note of research on regional innovation systems. Despite the many uncertainties, they have taken concepts like the innovation system, clusters, science cities, and knowledge hot spots to develop new regional economic policy in the post-industrial knowledge economy. Policy measures have been applied to steer existing systems into new directions but also to build something new from scratch. In Russia, for example, the government is building a new science city – named Skolkovo – in a greenfield location near Moscow (see Box 1.1). The widespread application of regional innovation policy makes it urgent to get a deeper understanding of how innovation systems emerge and develop over time and what contextual factors and policy interventions facilitate this process and help to create the 'right conditions'.

Box 1.1 Skolkovo, building a science city from scratch in a greenfield location

In 2010, the Russian government revealed its plans to develop a new high-tech hub near Moscow. This Russian equivalent of Silicon Valley is to become a leading research and innovation centre, bringing together researchers and businesses in five selected clusters: IT, biomed, energy, space, and nuclear technology. The Skolkovo Foundation facilitates cluster development by providing grants and tax incentives to companies with 'innovative solutions' in the five clusters. These so-called participants of the innovation centre can use several services (e.g. legal, accounting, human resources) on preferential terms. In February 2012, 355 companies had become participants of Skolkovo project, with the following distribution over the five clusters: 104 in biomed, 90 in energy, 119 in IT, 15 in space, and 27 in nuclear technology (source: www.sk.ru).

The ambitious project includes the development of a new town – 'the city of the future' – covering approximately 4,000 hectares, giving home to around 20,000 permanent residents with different nationalities. The Skolkovo Foundation is responsible for developing this technopole with international status from scratch. The ambition is to create a 'smart city' with state-of-the-art services (not only in transport, communication, and security but also in health, social services, and education) and a living lab for innovative approaches and sustainable urban development.

An important catalyst for the development of the innovation centre is Skolkovo Tech (Skolkovo Institute of Science and Technology): a newly founded university that aims to employ 200 professors and 300 post-graduates, with educational programmes for about 1,200 students (and in the long run, 1,800). In 2011, Skolkovo Tech signed a collaboration agreement with Massachusetts Institute of Technology (MIT) to develop this 'world-class research university'. The university will become fully operational in 2014, but several research centres and pilot educational programmes will start earlier.

1.2 Aims, problem statement, and research questions

This book contributes to a better understanding of the emergence and development of local innovation systems. It draws on a wide range of theory to form a theoretical framework that is able to study the development trajectory of systems emerging in different environments. Specifically, it focuses on innovation in cities, which explains the book title: 'urban innovation systems'. The sub-title of this book – 'what makes them tick?' – refers to our ambition to gain insight into how urban innovation systems develop over time. In order to reach that goal, the present book addresses the following questions:

- How do urban innovation systems evolve and develop?
- What contextual factors influence the emergence and development of urban innovation systems in their various stages?
- Through what policy interventions can the emergence and development of urban innovation systems be influenced? What are the main challenges?

Hence, we do not focus solely on what ingredients are needed for the desired end result (the recipe approach) but show how cities from different starting positions can move towards a successful innovation system over the course of decades. We take a long-term perspective, paying special attention to the start-up phase: how to ignite the engine of a growing innovation system. Moreover, we give insight into the complexities and challenges faced during this development trajectory, discussing the possibilities of policy intervention, with specific examples from practice.

1.3 Method and organization of the book

In Chapter 2, we review relevant literature and develop a model for the development and management of urban innovation systems, borrowing insights from two well-known best practices: Silicon Valley (US) and Sofia-Antipolis (France). In Chapters 3 through 5, we apply the model to three case studies:

- Chapter 3 discusses the case study of 'brainport' Eindhoven (the Netherlands), one of the most innovative regions in Europe, which has been confronted with a changing role of leader firm Philips, with far-reaching consequences for its innovation system.

- Chapter 4 introduces the case study of Kista (Sweden), the world's leading cluster in wireless ICT and a major knowledge hot spot in the City of Stockholm that is being transformed from a science park into a science city.
- Chapter 5 presents the case study of Suzhou Industrial Park (China), the first large-scale national-level science park in China, jointly set up by China and Singapore, which evolved from an industrial location to an important centre of science and innovation.

The case studies are based on both desk research (data collection and literature review) and field research. In each of the three cities, we held semi-structured interviews with a great variety of representatives from companies (big and small), academia, the VC community, local government, developers, and the like. In total, we interviewed 41 people for this study.

In Chapter 6, we formulate conclusions by answering the research questions and summarizing the main challenges for policymakers involved in the development and management of urban innovation systems.

Note

1 Regional innovation systems (RIS) is the more common term. In this book we introduce the concept of urban innovation systems.

Sources

Brenner, T. and Mühlig, A. (2013), Factors and mechanisms causing the emergence of local industrial clusters: a summary of 159 cases, *Regional Studies,* Vol. 47, pp. 480–507.

Cooke, P. (1992), Regional innovation systems: competitive regulation in the new Europe, *Geoforum* Vol. 23, Issue 3, pp. 365–382.

Jaffe, A., Trajtenberg, M. and R. Henderson (1993), Geographic localization of knowledge spillovers as evidenced by patent citations, *The Quarterly Journal of Economics,* Vol. 108, pp. 577–598.

Porter, M. (1990), *The competitive advantage of nations,* New York: The Free Press.

Saxenian, A. (1994), *Regional advantage: culture and competition in Silicon Valley and route 128,* Cambridge (MA): Harvard University Press.

2 The development and management of urban innovation systems

2.1 Introduction

This chapter draws on three decades of research in economic geography, regional economics, urban planning, and related disciplines to build a framework for understanding under what conditions cities are able to sustain high innovation capacity over long periods of time. It does not attempt to cover the full breadth of theories and streams of literature but instead focuses on the most broadly accepted and most frequently applied theoretical concepts. Specific attention is paid to research findings that open avenues for policy intervention and the management of urban innovation system development. Extensive empirical examples are offered to illustrate the practical implications of theoretical concepts and discussions.

Section 2.2 begins with a discussion of the innovation process in general. It argues for a complex and systematic understanding of innovation in place of older conceptualisations of innovation as a linear and predictable process. Moreover, section 2.3 argues that if innovation is a complex process, it can only be fully understood if the geographical dimension of innovation processes is taken into account. This is explained by showing the importance of networks and proximity in making complex cooperation and coordination in innovation processes possible. Section 2.4 then introduces the concepts of clusters and regional innovation systems as tools for understanding how actors in different regions have come up with unique solutions to the challenge of facilitating complex innovation processes. Moreover, it discusses some recent discussions and findings from the literature on the long-term development of clusters and regional innovation systems.

The reader is then offered two examples of regional innovation systems in practice in order to give meaning to the theoretical concepts introduced in this chapter. Section 2.5 discusses the development of the regional innovation systems of Silicon Valley and Sophia-Antipolis (France), illustrating both the strengths of well-developed regional innovation systems as well as the challenges they face to secure long-term innovation capacity. In section 2.6, the discussion then moves from general concepts of innovation systems to a discussion of the specific factors that have been proposed in the literature as explanations for the exceptional success of some regional innovation systems. While regional innovation systems have unique and irreproducible features, some factors appear to be relevant in most instances of successful regional systems of innovation. Moreover, some contextual conditions, such as being located in a transition country, introduce special challenges to innovation system development. The discussion turns to the question of the management of innovation system development in section 2.7. First the rationale for policy intervention in regional innovation system development is discussed, and then some approaches to policy intervention are introduced that have been proposed in the literature. Finally, this leads to a model of the development and management of urban innovation systems, introduced in section 2.8. This model forms the frame of analysis that will be applied to case studies in the later chapters.

2.2 Models of innovation

Traditionally, the relative economic strength of nations and regions was explained by factors such as richness in natural resources and the abundance of low-cost labour. Over the last decades, however, researchers from regional economics and management studies to economic geography have found increasing evidence that rising productivity is the real key to sustaining high levels of income and employment and that productivity growth is in turn driven by innovation. This finding led to a great research effort to understand how innovation works and how entrepreneurs and policymakers can increase the rate of innovation.

While stimulating the innovation capacity of firms and industries is an opportunity for increasing the standard of living, a neglect of innovation can lead not just to economic stagnation but even to decline. As the ‘father of innovation studies’ Joseph Schumpeter warned, innovation is a double-edged sword. Those who initiate innovation gain a temporary monopoly over the new products they develop, allowing them a period of high profits and employment. But at the same time, existing products and techniques become obsolete because of innovation, and those that do not stay ahead of this process of creative destruction can go from wealth to poverty in a very short time.

The famous scholar of urban development Jane Jacobs described many examples of entire cities that grew in wealth and importance on the wave of new products created by their entrepreneurs, only to sink back into insignificance when innovation was not sustained and the temporary advantage of an early technological breakthrough ran out (Jacobs 1969). More interestingly, however, she also found examples of regional economies able to sustain their innovation, developing one new product after the other and thereby staying ahead of creative destruction.

Although most entrepreneurs and policymakers are now aware of the importance of innovation, many still struggle to understand how innovation works and what can be done to support it. They often confuse the concepts of invention and innovation: an invention is merely the idea or the scientific breakthrough that is the starting point of a long process that may eventually culminate in an innovation. An innovation is a new product, a new production process, or a new service that is successfully implemented by a firm. Implementation means the commercialization of a new product or service or the adoption of a new production process (OECD 1997).

The linear model of innovation

Traditionally, innovation was seen as a linear process. The linear model describes innovation as a step-by-step process starting with scientific researchers who, while driven by curiosity about the workings of nature, occasionally find potential solutions to current problems or opportunities for improvement of the products and production processes in use. When scientific exploration leads to such inventions, the next step is to create a prototype or proof of concept to better understand the possibilities of the invention. Assuming that sufficient funding is available, the prototype is then subjected to rigorous testing while engineers work out whether application at a large scale is feasible. The few inventions that survive this rigorous selection process are then produced and introduced in the market. Another selection process takes place when consumers assess the usefulness and price of the new product, production process, or technique. After successful adoption by consumers, the process has resulted in an innovation.

The linear model is useful in showing that innovation is a complex and long process and that at every step, the process can come to an end because of a lack of funding, interest, talented researchers, engineers, or entrepreneurs. Economists such as Nelson (1959) have found that many nations invest too little in scientific exploration because the potential benefits of basic research are not necessarily enjoyed by those who invest in it. For example, the first scientists to describe the possibility for generating electricity probably received very little reward for their great breakthrough, while even the engineers who designed the first useable generators appropriated only a tiny fraction of the profits created from their work. This led policymakers to understand that public investment in research and development is needed to compensate for this market failure.

Moreover, research using the linear model of innovation has shown that even when sufficient scientific research takes place, the benefits from these investments still often disappoint. The main reason for this is that the step from scientific exploration to product development is difficult to take and that many inventions are never exploited at all. Scientific researchers are rewarded for intellectual breakthroughs in the form of published articles but usually receive no incentive or funds to engage in the exploitation of their inventions.

Incremental and radical innovations

While these insights are useful, the linear model of innovation has proven to be too simplistic to provide real insight into how innovation works. The key limitation is that this model suggests that every innovation process takes roughly the same path from the laboratory to the market, but in practice, innovation processes are as varied as innovations themselves. A key distinction is between incremental and radical innovations.

Incremental innovations are small improvements on current products or production techniques that can be implemented without producers or consumers having to learn how to apply them effectively. Rather than originating from scientific research, these incremental innovations tend to result from learning by doing on the work floor and can sometimes be implemented within firms. This particularly applies to firms that operate with a Toyota model of production, in which independent production workers are stimulated to come up with ideas for improving their own production techniques and to implement them independently in teams of workers.

Radical innovations are products or techniques that break away from previous ways of producing and consuming and that involve a steep learning curve before firms and consumers can exploit their full potential. Radical innovations tend to be based on scientific research and often go through an innovation process much more complex than the linear model can describe. Many more actors are involved in the process of creating radical innovations. Also, the interactions between these actors go far beyond simple market-based transactions, as long-term intensive collaboration may be required. This creates far higher costs and risks, but at the same time the potential pay-off of radical innovations is much greater.

Complex innovation processes

While incremental innovations improve product quality and production efficiency, they only give firms a very small and short advantage over their competitors. The innovations that according to Schumpeter and Jacobs are necessary to rejuvenate a regional economy and stay ahead of creative destruction are radical innovations. Nurturing radical innovation in cities requires a far more extensive understanding of complex innovation processes, with three important features to be considered:

1 *The number of actors.* The first feature of a complex innovation process is the great number of different actors involved. They include scientific institutions (providing basic research and specialized human capital), investors (including private venture capitalists and government programmes for investment in R&D), and a network of firms ranging from product developers, testers, and designers to business service providers that explore potential product markets and solve legal barriers for the introduction of new products. Also included are the (potential) consumers of the innovation, which can range from retail consumers to firms buying intermediate goods to use in their own production process to governments that often function as launching customers. Besides their roles as investors and customers, governments also play a crucial role in the protection of intellectual property and the rule of law. In some regions, an additional set of actors has emerged in the form of intermediaries, whose role is to strengthen the innovation system itself by addressing weaknesses in the system and facilitating the interaction between different actors.

2 *Communication and cooperation: The need for trust.* The second key ingredient of complex innovation processes follows directly from the first. The great

diversity of actors involved in the innovation process means that effective communication channels and cooperation mechanisms need to exist between the different actors. Both communication and cooperation are much more complex because each interaction involves knowledge. For example, it is relatively easy for firms and traders to exchange information on current market opportunities, as this information can be gathered at relatively low cost and loses its value quickly. In complex innovation processes, though, innovating firms and their partners can only effectively communicate and cooperate by exchanging some of the knowledge they developed at great cost and which they depend on to keep an edge on their competitors. While firms clearly have an interest in limiting such knowledge spillovers, they cannot avoid sharing knowledge, for example, when they (a) set up collaborated innovation projects with other firms; (b) try to convince public or private investors to invest in their innovation projects; or (c) communicate their needs for research and training with scientific research institutes. The high costs of the knowledge exchanged explain why trust is needed before interactions can take place.

3 *Mutual understanding: Tacit knowledge.* Besides the need for trust, actors in the innovation system also need to understand each other if they want to exchange valuable knowledge. Some of the knowledge used by firms is in the form of codified knowledge, which can be written down and understood by qualified knowledge workers without further explanation. But the most important knowledge comes in the form of tacit knowledge: the type of knowledge that gives firms an edge over their rivals. Tacit knowledge was first described by the famous polymath Michael Polanyi (see Polanyi 1944). After an experienced researcher or entrepreneur writes down all the knowledge he possesses, what is left unwritten is the insight or feeling of how to approach new problems, what to expect from machines or scientific models (rather than how they function per se), and all the other insights, tricks, and educated guesses that workers develop from work or research experience. Transmitting this tacit knowledge to another worker takes time and commitment and is sometimes only possible by working as colleagues and observing each other's actual work habits rather than simply explaining them in person or in writing.

The need to bring together large number of actors who need to collaborate closely, form relations of trust, and find ways to communicate their tacit knowledge creates a daunting challenge for both national and local knowledge economies. The discussion now turns to building up the tools that are available for addressing this challenge.

2.3 Proximity and networks

Researchers from several disciplines have pondered the question of how successful communication and cooperation between different actors can come about. One way to succinctly synthesize the findings from this research is by using the concept of multidimensional proximity (Boschma 2005). The basic idea is that actors can be brought together through several dimensions of proximity, and the more proximity is established, the better actors become able to communicate complex ideas and align themselves in risky, costly cooperation projects.

Geographical proximity

The most basic meaning of proximity is the extent to which actors are nearby each other in space, in terms of the absolute distance between them or the travel time needed to meet each other. This can be referred to as geographical distance. Starting with Jaffe and colleagues (1993), an extensive literature has emerged that has built up evidence that knowledge transfer takes place mostly in geographical proximity. The reason for this is probably that the higher the geographical proximity between two actors, the easier it is for them to arrange frequent face-to-face meetings. There is increasing evidence (from a variety of disciplines) that the development of trust and the transmission of tacit knowledge require repeated face-to-face meetings (e.g. Storper & Venables 2004). Besides meetings being more convenient to organize in geographical proximity, it is also more likely that unplanned, chance meetings occur when two actors spend much time in close geographical proximity. This is important because unplanned meetings can play a crucial role in complex innovation processes. Innovation is an unpredictable process that often starts with a chance meeting of minds that sparks a serendipitous idea, which by definition cannot be planned to occur.

While early research tended to assume that actors in geographical proximity naturally discover collaboration partners and build up trust and mutual understanding, recent research has found that geographical closeness is not a sufficient condition for successful communication and collaboration. Instead, actors are now understood to operate within networks of other actors whom they trust and understand. The existence of a strong network between actors has more and more become accepted as a necessary condition for cooperation, and it can be questioned to what extent geographical proximity is still necessary when a strong network is in place (Boschma 2005). More research needs to be carried out to show this definitively. The concept of networks can be unpacked by adding other dimensions of proximity besides geographical proximity. Three dimensions are discussed below, namely cognitive, institutional, and social proximity.

Cognitive proximity

Communication is facilitated when actors have similar educational backgrounds and interests. Scientists and engineers from around the world can cooperate in so-called communities of practice because they share each other's passion and understand the same technical language. A great challenge in complex innovation processes, however, is the involvement of a diverse mix of actors, from scientists and entrepreneurs to investors and policymakers. These actors tend to have very different cognitive backgrounds and often find it difficult to understand each other. Potential solutions to this challenge emerge when cognitive proximity is complemented by the other dimensions of proximity described below.

Institutional proximity

Countries differ in terms of (business) cultures, legal systems, and particular traditions, implying that firms from different countries have different expectations, habits, and implicit codes of conduct. In countries where the rule of law is limited, firms tend to develop their own rules and customs to complement the underdeveloped official legal and judicial system. These informal rules often derive from (sometimes distorted versions of) the different cultural traditions of countries. In particular, the informal institutional systems *blat* in Russia and *guanxi* in China have been studied (Puffer *et al.* 2009). While such informal rules have both advantages and disadvantages, they tend to be difficult for outsiders to understand and work with.

Institutional proximity also concerns the 'distance' between standards and expectations that different types of actors are bound to. For example, while scientists are judged by the quality of the education they provide and, with increasing importance, the number and quality of their scientific publications, firm managers judge their workers mostly on the commercial value they create for the firm. These different rule systems create obstacles for cooperation and network formation and may lead to a gap between scientific exploration and commercial exploitation when scientists and entrepreneurs are not allowed or incentivized to work together (e.g. Ponds *et al.* 2007).

Social proximity

Another facilitator of cooperation and communication is social proximity, which describes the bonds of friendship and affection that make it easier for actors to trust each other and work together. This dimension comes close to the definition of a social network. Because innovation is a complex process, it is very difficult beforehand to describe what roles different actors in the innovation process will play, what challenges are to be overcome, and what results are to be expected. Hence it is very costly and practically impossible to fully describe a cooperative innovation project in a contract (in other words: the transaction costs are high). Only through trust can actors accept that a level of uncertainty exists that cannot be fully covered in formal contracts. Social proximity allows actors to believe that their partners won't hide risks and rewards from them and won't exploit the knowledge sharing that necessarily occurs in an innovation project.

Research applying and testing the concept of multidimensional proximity is active and ongoing. An open question is to what extent a shortage on one dimension of proximity can be compensated by a higher level of proximity on another dimension (for example, a high level of cognitive proximity compensating for a lack of social and institutional proximity). Also, the relation between geographical proximity and the other dimensions of proximity is still unclear. Findings from research on the importance of face-to-face meetings suggests that even given high proximities on the other dimensions, some personal meetings are still needed for collaboration to succeed. Moreover, it is likely that cognitive, institutional, and social proximity are strengthened when actors have frequent face-to-face meetings. The need to have frequent meetings does not necessarily translate into a need for geographical proximity but is still greatly facilitated by it.

2.4 Clusters and regional innovation systems

Having discussed the role of geographical proximity vis á vis other dimensions of proximity, it is now possible to address a key phenomenon that has intrigued economic geographers and regional economists since at least the 19th century. Starting with Marshall (1890), economists and geographers have noticed that firms of the same or related industry sectors tend to cluster together in the same city or region.

Clustering

Possible explanations of this clustering process that have been proposed in the literature include lower transportation costs of intermediate products (when firms are in a buyer–supplier relationship) and the advantage that when many firms in similar industry sectors are located together, this results in a large local pool of workers with specialized skills relevant for most firms located in that cluster. While lower transportation costs are mostly relevant for traditional manufacturing firms rather than firms in high-tech and service sectors, for whom transportation costs only represent a tiny fraction of total production costs, the benefit of a shared pool of specialized labour is still very relevant for the modern knowledge economy.

The most important benefit of clustering, however, is that firms become more able to learn from each other and to cooperate in complex innovation processes. Firms that are located in the same district, city, or metropolitan area are able to organize frequent, regular, face-to-face contact between their business executives, but also between their R&D workers and other personnel involved in decision making, research, and product development. Because of the convenience and low cost of meeting in person, it even becomes possible for firms to have their knowledge workers cooperate in inter-firm project teams. Such inter-firm collaborated research can sometimes be the only way for smaller firms to afford expensive research and product development projects they would not be able to finance individually, which implies that they have to accept some knowledge spillovers.

Besides these planned forms of collaborated knowledge and product development, unplanned learning effects can arise in a dense cluster of firms. Key personnel belonging to different firms are more likely to have chance encounters that spark new ideas if they spend their work days in the same district and visit the same restaurants for lunch or the same pubs after work. Moreover, by observing the activities of nearby firms, given that they operate in related industry sectors, firms gain new ideas and may discover early on if they start falling behind their rivals. In these various ways, the clustering of related firms helps address the challenges raised by complex innovation processes, enabling them to carry out innovation projects that would likely be beyond the capacity of firms operating in relative isolation.

Starting from these basic observations, large numbers of theoretical and empirical studies have been carried out to understand in more detail what happens in clusters of related firms. First, firms were found to be only one type of actor in complex innovation processes. Research institutes (as sources of knowledge and specialized graduates) and venture capital investors also play vital roles in stages of the innovation process, and complex feedback loops can exist between the producers and consumers of innovations and new products. Moreover, the understanding of the multiple dimensions of proximity makes it clear that bringing these various actors together through geographical proximity may not be enough to allow effective communication and cooperation, since cognitive, institutional, and social proximity are also needed.

Fostering these dimensions of proximity is a highly complex process, and empirical research has found that in different local economies, different mechanisms have evolved for this purpose. For example, in the region known as the Third Italy (roughly North-Central and parts of Northern Italy), industry clusters have been identified in which firms have established strong cooperation networks and derived a high level of competitiveness from this. In this case, the mechanism of creating trust and understanding between actors was found to be strong personal relationships, or a high level of social proximity. Moreover, institutions emerged in this region that encourage loyalty and long-term collaboration while using reputation-effects to punish firms that abuse the high level of trust in collaboration networks (Becattini 1990). Several alternative mechanisms of creating trust and understanding can be envisaged – for example, cooperation within ethnic communities or communities of practice.

Regional innovation systems

Many different concepts and models have been developed to capture the mechanisms of interaction and cooperation between the actors involved in complex innovation processes. One avenue of research is led by Michael Porter (1990), who addressed this question by expanding the concept of the cluster to refer to the network of all relevant actors that contribute to the competitiveness of a set of strongly related industry sectors. The facilitation of innovation processes may be the focus of this network of actors if they perceive this as their main source of competitive advantage. But a cluster may just as well revolve around securing some of the other agglomeration externalities proposed by Marshall, such as cost savings due to shared infrastructure.

Moreover, while Porter acknowledges that geographical proximity between key actors can be a major factor in driving the competitiveness of this set of related sectors, he departs from Marshall by transforming the concept of a cluster to essentially a network that may or may not be concentrated in space. In this way, the cluster concept becomes very broad (some would say vague or even chaotic: Martin and Sunley 2003), as by Porter's definition it can be applied to networks not only at the scale of cities or regions but also across countries or even groups of countries (Porter 1990). As a result, Porter's cluster concept is less suitable for studying innovation in cities, since it places the central focus neither on innovation nor on the role of cities and regions in facilitating innovation processes.

Other concepts have been developed that do focus on the scale of cities or regions (see Moulaert and Sekia 2003 for a survey), but often they are only applicable to certain types of local economies or, more in general, they lack the breadth and inclusiveness needed to capture all factors relevant for facilitating complex innovation processes. A concept that is, however, inclusive enough and still applicable to the scale of cities and regions is the regional innovation system (RIS; Cooke 1992; Braczyk *et al.* 1998). According to Cooke and colleagues (2007), an RIS consists of two parts. The first part is the regional production structure, which consists of regional firms that are active in innovation processes. The second part is the regional innovation support system, 'which consists of public and private research laboratories, universities and colleges, technology transfer agencies, vocational training organizations, etc.' (Cooke *et al.* 2007:297). When these two parts or subsystems are 'systematically engaged in interactive learning, it can be argued that a regional innovation system is in place' (Cooke *et al.* 2007:297).

An RIS should not be conceived of as a self-contained entity. The form and strength of its interactions with its wider spatial-economic context and with other regional innovation systems (also at the global scale) may be some of the most important characteristics distinguishing more successful systems from less successful ones. But an RIS does exhibit a certain level of internal cohesion and often also exists as a governance entity (Cooke *et al.* 2007). This means that not every region can be said to include an RIS, and actually 'very few regions have all the attributes of an RIS' (Braczyk *et al.* 1998:17). The appropriate scale for identifying regional innovation systems has not been precisely defined and may differ between regions, but it should be thought of as the meso or regional scale. For example, the concept of RIS can be applied to regions, cities, or cities and their hinterlands. The city and its hinterland can differ in their relative importance for hosting and animating the RIS. For example, a city may form the anchor of the RIS or, conversely, only host some actors that contribute to the system (Cooke *et al.* 2004).

From the discussion so far, it becomes clear that the cluster and the RIS are partly overlapping yet distinct concepts. The habit of some researchers of using the two concepts interchangeably is unhelpful and has led to considerable confusion. The concept of RIS may be seen as either a substitute or a complement to the concept of the cluster. Porter's conceptualization of the cluster potentially overlaps with the concept of RIS in scope and spatial scale but without functioning as a useful focusing device for studying innovation in cities. In this sense, the cluster is a less helpful alternative conceptualization that can be left out in favour of the regional innovation system. However, the RIS concept does not fully cover all of

Marshall's cluster advantages, leaving out those that are not related to knowledge and learning. A convention has emerged in the economic geographic literature to retain the concept of the cluster but insist that it only refers to co-located firms and can only be applied at the local level (instead of Porter's conceptualization, which is open to even supranational scale levels). A helpful definition, which has subsequently been picked up in the literature (Asheim and Coenen 2005), is found in Isaksen and Hauge (2002:14): 'A concentration of "interdependent" firms within the same or adjacent industrial sectors in a small geographical area'. Such clusters, which can also be called regional or geographic clusters, can then be used alongside the concept of regional innovation systems. This definition will be used in the remainder of this book when referring to clusters.

Within a regional innovation system, these dense concentrations of related firms, or firm clusters, can emerge and develop but also transform or disappear over time. Several clusters can co-exist within the same RIS, but at any point in time, an RIS can also be found to function without identifiable clusters. Conversely, a region may be found to host one or more industry clusters but lack an innovation support system coherent enough to be called an RIS. Both clusters and regional innovation systems can have a relatively high or low consistency, as the strength and configuration of their internal networks differ. Moreover, both have porous boundaries, since their actors not only have local network linkages but also create bonds with non-local actors. Besides clusters and regional innovation systems, one more concept is essential in the toolbox for understanding how complex innovation processes are facilitated and managed in some cities and regions, namely that of knowledge locations.

Knowledge locations

Besides clusters and regional innovation systems, which are relatively abstract terms, a host of concepts have emerged to describe the specific spaces in which heightened levels of innovative activity are seen or expected to occur. This includes, among others, science parks, innovation parks, technology hubs, and knowledge hot spots. Many of these concepts were created by planners and policymakers rather than the scientific literature, and they tend to be vaguely defined. However, it seems worthwhile to seriously consider the underlying hypothesis that specific spaces, with the scale of city districts or even smaller, may play a key role in the development of clusters and/or regional innovation systems. Moreover, as will be discussed in section 2.7, a further hypothesis behind such concepts is that these spaces of knowledge and learning can be created, and hence that policy intervention can to some extent steer the spatial-technical structure of regional innovation systems.

Carvalho (2013:1) proposes the term 'knowledge locations' to cover these various kinds of spaces of knowledge and learning. He defines knowledge locations as 'planned area-based initiatives aimed at agglomerating knowledge-intensive activities in a designated area or city district'. A wide variety of knowledge locations exist, and their aims differ from the creation of knowledge-intensive jobs to seeding the development of a new firm cluster and finally to kick-starting the transformation of the RIS as a whole. Hence, knowledge locations differ strongly in their importance for the RIS, and they may be absent in a specific RIS altogether.

Long-run development of clusters and innovation systems

Having introduced and discussed the three key concepts of clusters, regional innovation systems, and knowledge locations, the final topic discussed in this section is the long-run evolution of regional innovation systems. This topic will only be touched upon, and the interested reader is referred to other sources that discuss it in more detail.

So far it has become clear that in a region, a network of actors and associated formal and informal institutions can emerge that enables cooperation in innovation processes. When such a regional innovation system produces a radical product innovation, this may spawn the creation of a new firm cluster within that region. The firms in this cluster then focus on the exploitation and further development of the newly developed product. The relation between a regional innovation system and a region's clusters can, however, be far more complex, as the growth of firm clusters can in turn have important consequences for the region's innovation system. In other words, there is a process of co-evolution at play between a region's innovation system and its clusters, as the development of one creates opportunities and constraints for the development of the other.

In some cases, the new opportunities for product exploitation and development opened up by a radical product innovation may be so large that the new cluster grows to the point of coming to dominate the entire regional economy in terms of absorbing much of the available workforce, investment funds, and other (regional) assets. At the same time, the RIS may also become geared to supplying this dominant cluster with the knowledge necessary to further grow and develop. When this occurs, the regional economy becomes heavily specialized around a dominant product, and its RIS can be said to have become 'locked in' to this same specialization. As the region's firms and knowledge infrastructure both become locked in to the same field of specialization, a high level of coordination and efficiency may be achieved, as the region's key actors have attained much the same focus and objectives. A period of high growth rates may then ensue, as long as the product underlying the region's specialization continues to perform well on its relevant marketplace. However, if and when this dominant product becomes a standardized commodity, competing on price rather than quality against numerous competitors outside the region, or even becomes technologically obsolete as a result of a new round of radical innovation, the specialization and lock-in becomes a burden rather than an asset. In the extreme case, the region's dominant firms become unable to sustain profitability and employment, while the region's knowledge institutes can do little to help firms stem their decline, as their knowledge has become obsolete along with the dominant product.

Described above is an idealized example of an industry life cycle and its possible consequences for the long-term development of a cluster and, in this case, also the entire regional innovation system. The concept of the life cycle was introduced in international economics by Vernon (1966) to understand the emergence, maturation, and decline of individual products. It then entered into economic geography, to describe first the development of industry sectors and then firm clusters (Audretsch and Feldman 1996). Since then, the concept of cluster life cycles has been considerably refined (e.g. Menzel and Fornahl 2010), resulting in a model of life cycle stages that usually include the stages of emergence or birth, followed by growth, maturity, and decline, and then possibly followed by the rejuvenation or disappearance of the cluster. The cluster life cycle model is an ideal-type model that is unlikely to be found in precisely this form in real-world cases. However, it has proven to be a useful construct in empirical studies (see, for example, Klepper 2007 for an application to the Detroit automobile cluster) and offers an explanation for problems of regional lock-in to mature industries (for example, Grabher 1993).

More in general, the concept of the life cycle introduces the study of regional innovation and cluster development to the important concept of path dependency. When a development process is path dependent, the probabilities of different possible outcomes of the development process change over time. Before the development of a dominant cluster, a regional economy has many potential development trajectories open to it. These different outcomes may have similar probabilities, and hence the region's development process may at this point be highly unpredictable. However, as soon as a dominant cluster has emerged within the region, and especially if the regional innovation system specializes to nurture this specific cluster, alternative development trajectories may become increasingly less likely. In other words, the development history of that regional economy (in this case, the fact that a dominant cluster emerged) creates powerful constraints and opportunities for further development, marking the region's further development as a path-dependent process. However, the conceptualization of the cluster life cycle model as one example of path dependence in regional economic development also suggests that many alternative development paths are possible, which may not fit this idealized model (Martin and Sunley 2006).

Martin and Sunley (2011) propose an alternative model for understanding the long-term development of regional economies as path-dependent processes, namely the adaptive cycle model. This model and its underlying theoretical basis (complexity theory) are recent developments and have not been fully crystallized yet in economic geographic theory, and for this reason the interested reader is referred to Martin and Sunley (2011) for a more detailed discussion. But its key implication for the long-term development of regional innovation systems is that rather than going through stages in a fixed life cycle, they instead continually face a trade-off between connectedness and resilience. In terms of an RIS, connectedness refers to a system in which a strong network exists among the different actors (e.g. firms, research institutes, policymakers) in the system, and hence that the system has a high level of cohesion and resistance to change. Resilience, on the other hand, is 'a measure of system vulnerability to and recovery from shocks, disturbances and stresses' (Martin and Sunley 2011:1306).

The extreme example described above of a highly dominant cluster triggering lock-in of the entire RIS to one industrial specialization shows that a high level of connectedness (lock-in to an industrial specialization) may lead to a reduced level of resilience. The locked-in region becomes less able to adapt to changed circumstances and may suffer in terms of loss of profitability and employment in case of an adverse shock to its dominant industry. So besides the ability to create connectedness, another important characteristic of an RIS is its ability to reduce connectedness when needed to safeguard its level of resilience. In the extreme example, that would mean to break the lock-in to a mature industry specialization (a painful process involving the destruction of previously valuable regional assets) and to reconfigure the regional economy to begin new development trajectories. Finally, the level of connectedness and resilience of any particular regional economy changes over time, and these changes may again follow regular stage-like patterns (Martin and Sunley 2011). The issue of the resilience of a regional economy is further discussed in Christopherson and colleagues (2010). For more on the application of the concept of complex adaptive systems to regional innovation systems, see Cooke (2012).

In this section, a set of concepts has been introduced for understanding complex innovation processes and the functioning and long-term development of regional innovation systems. Following this still-abstract discussion, the next section provides the reader with two real-world examples of relatively successful regional innovation systems. Both examples, Silicon Valley (US) and Sophia-Antipolis (France), have been studied extensively by economists, management researchers, and geographers. While section 2.5 can be skipped, it may be helpful for illustrating the concepts introduced so far and giving a feeling for their often turbulent development over time.

2.5 Best practices

Silicon Valley

Silicon Valley, which roughly corresponds with the southern part of the San Francisco Bay area (much of Santa Clara County), is the archetypical regional innovation system that is commonly used as a benchmark to assess other innovation systems worldwide. After a gradual buildup during the 1940s and 1950s, it had become a well-developed system by the 1970s and went on to play a dominant role in several industry sectors through the 1980s and 1990s and beyond by setting off the ICT revolution. While it is difficult to precisely demarcate the region, by the most common definition, it included about 430,000 jobs in high-tech sectors in 2008, which is down from a peak of more than 520,000 in 2001 (Bureau of Labor Statistics 2009). Because of the large scale and importance of Silicon Valley, its development trajectory is complex, and the key factors driving its development are further obscured by the many stories and myths surrounding its phenomenal growth trajectory. The description here is purposely simplified in order to focus on some of the most important aspects.

Most explanations of the rise of Silicon Valley focus on the role of a small number of highly gifted individuals who founded the first key knowledge location in the region, Stanford Industrial Park, and the first key firms that set off a self-reinforcing process of spin-off formation. As one firm was the source of several spin-off firms, and many of those spin-offs themselves produced spin-offs of their own, a dense network of start-up firms grew up from which one breakthrough technology after another emerged. This understanding of the rise of Silicon Valley explains part of the story and will be described in more detail below. But recent research has shown that in the early stage of development, a second parallel process took place that was at least as important, namely large firms based outside of Silicon Valley that set up R&D laboratories in the vicinity of Stanford and, to a lesser extent, Berkeley University to profit from the excellent research carried out there and from the large pool of highly qualified graduates of these universities. These R&D laboratories contributed to the buildup of a critical mass of high-tech activity and were a training ground for many of the engineers and entrepreneurs who, after gaining experience at external R&D laboratories, would set up spin-off firms of their own. These two development mechanisms co-existed from the 1950s through the 1970s, and only from the 1980s onwards the entrepreneurial culture of start-up firms that Silicon Valley is famous for becoming the dominant development mechanism, while the role of external R&D laboratories faded into the background (Adam 2011).

The first development mechanism of the Silicon Valley regional innovation system, start-up formation, can be traced back to the work of two gifted engineers, Frederick Terman and William Shockley, who by chance and largely independent from each other decided to put their technological ideas into practice in Palo Alto, a city 50 km south of San Francisco. The area that was to become Silicon Valley was an agricultural area with very little industrial development up to the 1950s. It did have a high-quality university (Stanford) that was founded on a mission to support the economic development of the then relatively backward region of Northern California and developed a specialization in electronics decades before the Silicon Valley cluster came into being. One professor of this university, Frederick Terman, played a crucial role in supplying not just the necessary skills in electrical engineering but also the initiative and energy needed to translate these technical skills into marketable products.

Terman energetically supported his students in setting up high-tech start-up firms to bring innovations to the market based on scientific inventions done at Stanford or based on research at the qualitatively better MIT at the other side of the United States. Besides helping these academic entrepreneurs with his scientific knowledge, he also employed his extensive network to arrange financial support or even invested in start-ups from his own pocket. Finally, in 1951, Terman convinced Stanford University to use part of its free land to create a knowledge location, Stanford Industrial Park, offering start-up firms an affordable location close enough to the university to have frequent face-to-face contact with university researchers. Terman's support and investments directly led to the founding of several of the great firms that would become the core of the Silicon Valley innovation system, while the industrial park helped to keep these firms in close geographical proximity to each other. While Terman's individual role was certainly important, his initiatives might not have succeeded were it not for the supportive environment at Stanford University. In sharp contrast to the technologically more advanced MIT on the east coast of the US, Stanford nurtured entrepreneurial activity for the valorisation of its scientific knowledge and showed great flexibility in providing funds and land to the start-up firms created by its graduates.

The other individual who played a crucial role in the development of the Silicon Valley innovation system is William Shockley, the co-inventor of the transistor. Like Terman, he decided by chance to carry out his ideas for technology development in Northern California, setting up a firm for the commercial development of semiconductors staffed by a handpicked team of some of the brightest engineers in the United States at that time. While, in contrast to Terman, Shockley was hostile to the development of spin-off firms from his own laboratory, most of his engineers went on to start spin-off firms that would make Silicon Valley the world leader in computer hardware. Again chance is only part of the story, since Shockley chose to locate in Palo Alto only after being disappointed by the lack of support for entrepreneurial initiative at MIT at that time.

So by the late 1950s, a network of researchers and entrepreneurs, many of them former classmates or co-workers and united by a shared passion for technology and its commercial application, was taking shape. This network was further intensified by the ample opportunities for face-to-face meetings at the Stanford Industrial Park and informally at bars and restaurants in its vicinity (some of which have became famous as the birthplaces of breakthrough technologies). Besides facilitating knowledge spillovers, this strong social network also helped to create one of the key characteristics of the Silicon Valley innovation system, namely its open and flexible business climate. When a firm's key workers move to a competitor or leave the firm to set up a start-up firm that may compete with the parent company, this may inflict a heavy cost on that firm. So while it is reasonable for firms to be hostile to labour mobility and spin-off formation and frequently use formal contracts to limit it as much as possible, Silicon Valley firms are famous for their flexible attitude. Rather than trying to keep workers by force, they are enticed to stay through attractive working conditions, and when they do leave, the parent firm tries to keep in contact in order to establish a connection with the firm the worker is moving to. In addition, Californian labour regulations are exceptional in not allowing non-competition clauses in work contracts except for special cases, giving workers more freedom to change jobs or start their own firms. Frequent labour mobility and close geographical proximity meant that technological advances would quickly spread and firms needed to focus on continual innovation rather than hoarding patents and company secrets and trying to exploit them as long as possible. Finally, the strength of social networks in Silicon Valley had a strong impact on the formation of venture capitalists. While, certainly at that time, in other regions the allocation of investments in R&D tended to be a highly formalized and hierarchical process with financial experts with limited expertise and passion for technology making most decisions, in Silicon Valley, an alternative funding mechanism developed in the form of bottom-up fundraising through the network of researchers and technologically savvy entrepreneurs. Engineers who successfully turned their technical knowledge into marketable products often used the resulting profits to invest in new high-tech projects started either by themselves or by friends or colleagues. The trust that existed within the network allowed entrepreneurs to share enough inside information on their technological ideas to convince investors of the feasibility of their projects, while these investors had sufficient technical knowledge to assess their plans. The result was a more flexible system in which high-tech start-ups had relatively easy access to funds and in which even some of the most risky and ambitious plans could find so-called angel investors (a type of actor absent in many other innovation systems) willing to give them a chance. And finally, the acceptance of failure as a 'badge of experience' can be linked to the fact that many Silicon Valley investors are experienced engineers who understand that science and technology development are risky processes with uncertain outcomes. Again, regions with more formal investment channels in which investors have a financial rather than a technical background did not develop this risk-taking and failure-accepting attitude (Castells and Hall 1994).

While the entrepreneurial culture in Silicon Valley gave rise to many of its most influential firms, the bulk of firms and workers originated instead from the R&D laboratories set up by firms from outside of Silicon Valley and by the United States Army and NASA (during the 1950s and 1960s, more than half of the transistors produced in Silicon Valley were bought by the US Army). While contributing less to radical innovation and entrepreneurial activity, these laboratories provided funds and employment for local graduates besides attracting the most talented engineers of the United States and later worldwide to live and work in the Valley. In this way, they created a critical mass of knowledge workers, which made Silicon Valley world famous as the place to be for ambitious scientists and engineers who wanted to take part in the most exciting innovative breakthroughs of the century. Moreover, research has found that by the 1980s, no less than 97 per cent of the start-up firms in Palo Alto had at least one (co-)founder who had previous work experience in a Silicon Valley–based firm, which in most cases was one of the external R&D laboratories. So thanks to the decision of external firms and government institutions to set up subsidiaries in Silicon Valley, which in turn is largely due to the attracting role especially of Stanford University and the pool of excellent graduate students it created, Silicon Valley had all the necessary ingredients to set off self-sustaining development in the 1980s (Adam 2011).

When the entrepreneurial culture with its flexible business networks and the availability of bottom-up venture capital was combined with the critical mass of knowledge workers and a worldwide reputation for technological excellence, Silicon Valley became the archetypical successful regional innovative system, which other regions have tried to learn from ever since. While investments from the army and NASA declined and Japanese low-cost competition in transistors and low-end electronics caused a loss of market share in these sectors, rather than going into stagnation, Silicon Valley was reinvented as the world's hotbed of ICT innovation, which it has remained up to this day. As in earlier phases, Stanford University still plays a key role in nurturing the development of Silicon Valley, since throughout the 1980s and 1990s half of all added value created by firms based in Silicon Valley was produced by Stanford's graduates and former employees (Adam 2011). The Valley continues to attract the most gifted and ambitious engineers from the United States but also countries like China, Russia, and India. A sociological survey in 1985 showed that workers in Silicon Valley showed exceptionally high levels of job satisfaction while working significantly longer hours than the United States average. A much higher percentage of its workers identified their work as their main sense of meaning and identity, deriving satisfaction mostly from the work itself rather than from its financial rewards, which are again far above the United States average (Castells and Hall 1994). While these data are somewhat dated, there is no sign that this situation has changed. In other words, Silicon Valley has succeeded in attracting the best workers worldwide and also in realizing the talents it has attracted. Silicon Valley universities have retained their strong specialization in applied science and business without neglecting basic science fields such as physics and biology. Moreover, the Stanford Industrial Park, now renamed the Stanford Research Park, has remained the preferred location for some of the leading innovative firms, hosting about 140 firms with more than 23,000 workers. Finally, Silicon Valley–based firms have remained magnets of worldwide R&D investments while still retaining their bottom-up sources of venture capital and angel investments in the most cutting-edge (and most risky) innovation projects.

Sophia-Antipolis

The Sophia-Antipolis International Science Park, located near the town Antibes in Southern France, is one of the largest and widely known knowledge locations in Europe. After a difficult start-up phase, it seeded the development of two substantial clusters, one based on ICT and the other on life sciences, which between them represented more than 1,250 legal entities, mostly high-tech firms, and nearly 26,000 workers in 2011. The creation of the science park, with the clusters nurtured within it, kick-started the development of a reasonably extensive innovation system in the region, where hardly any knowledge-intensive activity had been conducted previously. In fact, only as the clusters seeded in the park have started to spread out over the surrounding area and other actors besides firms have been drawn into a strengthening network can we speak of Sophia-Antipolis and its surrounding region as an emerging regional innovation system. While largely seen as a successful case of innovation system development, the development process of Sophia-Antipolis also illustrates some of the challenges facing policymakers. As will become clear, Sophia-Antipolis has a very different origin and development trajectory than Silicon Valley, with a much larger role for policy intervention.

The Sophia-Antipolis science park started in 1969 as the private initiative of a board member of a French Grande École who envisaged a community of scientists living and working in the attractive Sun Belt of the Côte d'Azur region. After much of the physical construction of the park was completed, the project nearly collapsed due to a lack of funds and a mismatch between the initial costs and revenue of the project. It only survived because the local government took over the project, injected new funds, and set up an advertisement strategy to promote the project internationally. As the project changed from a private to a public initiative, its focus changed from a national and academic orientation to a more regular industrial park aimed at attracting international firms, especially their R&D units. The reason local government was willing to take over the project and cover its high maintenance costs is that it solved a problem in their economic development strategy. Rather than having to choose between supporting industrial development in the Côte d'Azur, whose negative externalities might harm the tourist industry, or preserving the region's natural beauty, the science park allowed high value-added and knowledge-intensive jobs to be attracted while leaving the tourist industry unharmed (Quéré 2007).

Partly because of the attractive local infrastructure and climate and partly because of favourable historical circumstances,[1] many large French and foreign firms, especially from the United States, responded to the advertisement campaign and opened R&D units in the science park. At first, these R&D units came from an almost random diversity of industrial sectors, but gradually a specialization in ICT and life science became dominant in the park and the seeds of two distinctive firm clusters became visible.

While this growth process took the park from an employment level of near zero in the early 1970s to around 10,000 in 1990, Quéré (2007) argues that in this first period of growth, Sophia-Antipolis still did not develop the character of a well-developed innovative system. The reason is that since in the early phase, the park mostly contained R&D units controlled by an external head office rather than independent firms, local knowledge sharing and network formation were almost non-existent. Research goals and business strategy of the research labs originated from outside of the region, and local actors did not need to search for funds and other needed inputs within the region itself. In other words, the science park was an attractive location for firms to carry out their R&D, but the park did not have an added value in allowing firms to benefit from inter-firm cooperation and knowledge spillovers and hence did little to build up innovation capacity in the region. While social networks and friendships emerged between employees of the R&D labs in Sophia-Antipolis, inter-firm networks did not form. Moreover, since the Côte d'Azur has seen very little industrial development, firms in Sophia-Antipolis did not benefit from proximity to consumers of high-tech goods and services. In this phase, the park did build up a critical mass of firms and human capital, and by the mid 1980s, the university of Nice-Sophia-Antipolis located its PhD training in the science park, gradually building up graduates with local contacts and a place-attachment with the park.

The transition towards a fully developed innovation system can be identified in the mid-1990s. A cyclical economic shock hit many of the firms, especially in the IT sector, while at the same time EU integration was reducing the need for non–EU firms to carry out R&D within Europe for product localization. The result was for many of the R&D units to be closed or relocated to cheaper locations.

However, many of the workers involved refused to relocate because they had grown attached to their living and working location, some of them having graduated from the University of Nice-Sophia-Antipolis and others having built up friendships in the area. Instead, these knowledge workers started their own high-tech firms within the Sophia-Antipolis science park.

These start-ups depended on local sources of funds and knowledge, and because their founders were strongly embedded in local social networks, they were also able to access these local resources. A number of large ICT firms, especially Lucent, Alcatel, IBM, and Texas Instruments, even encouraged and supported their employees to start their own spin-off companies. And finally, the University of Sophia-Antipolis had by this time become a key source of specialized human capital and academic entrepreneurs. The result was a network of small and very small firms (more than half of them having 10 or fewer employees) emerging in the science park, with about 75 per cent of them active in the ICT sector.

In sharp contrast with the earlier R&D units, the small, young start-ups developing from the 1990s onwards depended heavily on local collaboration and knowledge sharing for their survival. Many of these firms can only survive as long as they stay within proximity of the science park and continue to enjoy the knowledge externalities they could only enjoy while being located there. With these knowledge externalities now fully developed Sophia-Antipolis has, four decades after its inception, become the core of an emerging innovation system. However, a continuing weakness of Sophia-Antipolis and its surrounding region as an innovation system is the absence of a sizable market for high-tech goods and services outside of the science park, and in this tourism-dominated region unfit for (heavy) industry, it is unlikely that such a market will develop in the near future. This issue is likely to prevent the innovation system from seeing significant growth beyond its current development level until it finds access to sufficient sources of demand.

Observations

The two benchmark cases help to clarify the confusion between innovation systems, clusters, and knowledge locations and give a first sense of possible long-run development paths a regional innovation system can take. Silicon Valley and Sophia-Antipolis are two innovation systems within which several distinct clusters emerged over time. In the case of Silicon Valley, a succession of clusters emerged, locked in to a dominant product or technology, and after some time started to mature and experience falling profits. When this happened, Silicon Valley as an innovation system repeatedly showed a remarkable ability to break away from these maturing technologies and seed new clusters to replace the stagnating ones. In other words, Silicon Valley has shown a remarkable resilience in adapting to new market and technological circumstances. In Sophia-Antipolis, identifiable clusters have only recently started to emerge, and its innovation system only gradually took shape decades after the first firms moved in. In other words, it is still building up its level of connectedness, while its resilience to shocks has not yet been sufficiently tested.

Another difference between the two cases is the relative importance of their main knowledge location in the development of their clusters and innovation system. In the case of Silicon Valley, its main knowledge location, Stanford Industrial Park, arguably helped to speed up the build-up of critical mass and the network formation among firms and between firms and the Stanford University as the key education and research institute in the region. However, the Silicon Valley innovation system and its main clusters quickly outgrew this knowledge location, and it is unlikely to still play a decisive role in the system's further development. In stark contrast to this, the Sophia-Antipolis innovation system and its two emerging clusters (one in ICT and the other in life science) most likely would not have existed were it not for the creation of the knowledge location named Sophia-Antipolis International Science Park. In other words, while for Silicon Valley several different roots can be identified that together gave rise to its current innovation system, Sophia-Antipolis's emerging innovation system only started developing following the creation of the science park.

The two benchmark cases show regional innovation systems developing along very different trajectories and in very different environments. To some extent, the factors that influenced the direction and level of success of their development are unique to these regions, but they may also contain more general lessons applicable to other regional innovation systems. This question is taken up in the next section.

2.6 Development factors

A great number of empirical studies (see Brenner and Mühlig 2013 for a recent review), albeit from different theoretical backgrounds and under different headings, have been carried out to compare the characteristics of different regional innovation systems and from this explain differences in their innovation performance. This section draws on this body of literature, including insights from the two benchmark cases of Silicon Valley and Sophia-Antipolis, to discuss a selection of some of the most commonly found factors influencing the innovation performance of regional innovation systems.

Firm-specific capabilities and leader firms

Since a regional innovation system consists of both the regional production structure (firms active in innovation processes) as well as the regional knowledge infrastructure, an important factor influencing its developing is formed by the specific characteristics of its constituent firms. This refers in particular to the willingness and ability of firms to access knowledge and adapt it for use in the innovation processes they take part of, also known as their absorptive capacity. Most regional innovation systems contain a few key firms that possess capabilities that increase the innovation potential of the entire system, having an exceptionally high absorptive capacity. Studies using network analysis have tended to identify so-called knowledge gatekeepers that are central to the innovation system. These are firms that combine a strong global network from which they receive up-to-date information about ongoing research and innovation projects outside of the region and a strong knowledge base within the firm that allows it to absorb the knowledge it gains from its global network. If they are also integrated in a strong regional network and willing to spread the knowledge gained from their global network with their local partners, these leading firms play a vital role in continually feeding and rejuvenating the local innovation system. However, in some cases the firms that would have been able to act in this way as knowledge gatekeepers refuse to take on this role, since they see no incentive in helping weaker local partners (Morrisson 2008, and see Giuliani 2007 for an empirical application).

Another aspect of firm-specific capabilities stressed in recent research is that of dynamic capabilities. Firms involved in innovation need to be skilled in both exploration (the development of new knowledge) and exploitation (the commercialization of knowledge). Since exploration is costly and only exploitation is likely to result in profits, it is natural for firms to focus on exploitation and become skilled in this. However, a complete neglect of exploration can cause firms to lose their capability to adapt to change and stay ahead of creative destruction. A small number of industry leaders, like Apple and Google in the computer hardware and software sectors, consistently succeed in combining the ability to explore and exploit knowledge. They possess strong dynamic capabilities, meaning the ability to uproot their routinized activities and procedures to adapt to more effective ones. This requires a strong capacity to recognize and absorb important new knowledge, the ability to shift their network relations when necessary to develop new opportunities, and the ability to replicate their effective routines in new locations (Ter Wal and Boschma 2011). While it is unlikely for all firms in an innovation system to possess strong dynamic capabilities, it may be of great importance that the system contains at least a few of these firms anchored strongly in the region.

A few or even a single key firm (also known as leader firms or anchor firms; e.g. Wolfe and Gertler 2004, and see Nijdam 2006, for an application to the Rotterdam logistics cluster) can also play other crucial roles for the development of a regional innovation system besides those related to knowledge and learning. Klepper (2007) shows how a small number of firms functioned as a seedbed and training ground for large numbers of entrepreneurs, who through spin-off processes accumulated firm clusters around these anchor firms. In other words, leader firms can play a decisive role in seeding the emergence of specific firm clusters. Moreover, leader firms can take the role of the *animateur* (Braczyk *et al.* 1998), taking the lead in the formation of networks and networking platforms that increase the connectedness of a regional innovation system.

Whether or not a region's leader firms are willing to take up the roles described above may depend crucially on their level of attachment to the region, which in turn may depend on the origin of these firms. Sophia-Antipolis in its first decades depended almost exclusively on firms attracted from outside the region and for a large part also from outside the country. When market and legal changes (European integration) made location in Sophia-Antipolis less attractive for most of these exogenous firms, many of them shortly thereafter left the region, threatening the continuity of the development of Sophia-Antipolis. Only the appearance of endogenous firms, originating from within the park itself, avoided the risk of an abortive development. In Silicon Valley, endogenous entrepreneurship started much earlier in its development process but only became dominant about two decades after its innovation system had already taken shape.

Research and education infrastructure

Besides the constituent firms of a region, another key actor is formed by institutes of research and education. While this section will refer simply to 'universities' to cover this category of actors, it is acknowledged that a wide diversity of institutes exists that contributes to different forms of research and post-secondary education.

The literature on regional innovation systems has traditionally focused mostly on the research function of universities. Universities are thought to conduct research of direct (applied) or indirect (basic) use for firms active in innovation processes. The assumption is made that this knowledge is, to some extent, accessible to firms and that this access is facilitated by proximity to research institutes. This was at first conceptualized rather simplistically with the university as 'knowledge factory', producing chunks of knowledge picked up by local firms that turned them into patents and new products. The nature of university research and its effects on regional innovation systems has since then been problematized and refined. The idea of a unidirectional flow of knowledge from universities to industry has been questioned in favor of bi-directional knowledge flows. Moreover, knowledge transfer is now understood as a more complex process. Several different transfer mechanisms may exist besides the production of patents and publications, for example, the transfer of knowledge through university spin-offs (Etzkowitz *et al.* 2000) and graduate and worker mobility (see Uyarra 2010, for a recent review of this line of research).

Another key contribution of universities is their function as education institutes, supplying firms with the specialized human resources needed for participating in complex innovation processes. It is not obvious that this role of universities should be seen as a regional role, since inter-regional and even international migration may weaken the link between local education and the local availability of specialized workers. However, specialized knowledge does have a distinct geography, as workers with specialized skills are concentrated in some cities and regions while being relatively scarce elsewhere (Gabe and Abel 2012). Besides on-the-job and other forms of learning, universities continue to supply many of these specialized skills. Moreover, the hypothesis that universities contribute mostly to regional pools of human resources rather than to a labor force on the national scale has found partial empirical confirmation (Abel and Deitz 2012) but cannot be taken for granted in individual instances. For example, in the UK it was found that certainly not all universities have a clear regional role in contributing to the regional availability of specialized workers. Rather, a class of recently founded universities (Coalition of Modern Universities, CMU) with an explicit regional mission, often located in relatively peripheral or old industrial regions, in particular play such a regional role (Faggian and McCann 2009). Arbo and Benneworth (2007) provide an in-depth review of the historical evolution of the regional role of higher education institutes and the increasing attention for this among policymakers.

Finally, universities can function as animateurs for promoting the formation of regional cooperation networks and platforms, enhancing the level of connectedness of the regional innovation system (Caniëls and Van den Bosch 2011). Benneworth and Hospers (2007) find this especially in old industrial regions, where the need for innovation system reform is greatest. Moreover, they argue that universities are especially able to help these often relatively peripheral regions gain access to sources of knowledge outside the region by using their global academic network to construct global–local pipelines accessible to actors in the regional innovation system.

The two benchmark cases illustrate the possible regional roles of universities. In Silicon Valley, the role of universities as research institutes and as educators of high-quality human capital was vital, both for the inception and for the subsequent growth of the innovation system. In Sophia-Antipolis, the local university only developed in a later stage, but it did help to anchor workers and start-up firms to the region.

Entrepreneurship and venture capital

Another important factor influencing the way a regional innovation system develops is the rate of new firm formation. A large body of research has studied the link between differences in rates of new firm formation of regions and their economic development. For example, Baptista and Preto (2011) find that regions with higher numbers of start-up firms per year have higher employment growth, especially if those firms are knowledge-based start-ups (active in knowledge-intensive industry sectors, such as, for example, ICT and biotechnology).

Besides these general effects of start-up rates on regional development, new firm formation also plays a key role in the development of regional innovation systems. As described above, Klepper (2007) shows how start-up formation and in particular spin-off formation plays a key role in the growth of firm clusters from an initial seed (e.g. a leader firm) into extensive concentrations of technologically related firms. Moreover, besides building up critical mass in a region, start-up entrepreneurs also play deeper roles in the formation of innovation systems. Feldman and colleagues (2005) in a case study of Washington, DC (United States), describe how the emergence of firm clusters depends on the initiative of entrepreneurs to discover and bring together resources within and outside the region when a market opportunity occurs. In other words, the emergence of firm clusters, knowledge networks, and an entrepreneurial culture begins with the action of entrepreneurs rather than being set in motion through, for example, government policy.

However, even when business opportunities are present, it is not a given that high rates of start-up formation will follow. Starting a firm is a risky endeavour, involving not only financial risk in case of business failure but also damage to one's reputation. Cultures (as in regional or national cultures; but note that ethnic groups and other cultural units intersect and cross geographical boundaries) differ in the extent of reputation loss that typically follows a business failure. The bankruptcy of a start-up firm may be perceived in different cultures as anything from a devastating embarrassment to the individual and his family to a 'badge of courage' and sign of entrepreneurial spirit and experience. Through these dominant cultural values, cultures can either stimulate or deter individuals from taking the risk to start their own firm. Hofstede (1980) is a seminal work in the study of cultural differences, among others setting off a stream of literature on differences among cultures in their dominant values concerning risk taking.

Besides macro-scale cultural groupings, regions can also form a relevant scale for studying differences in cultural values that impact rates of entrepreneurship. Within economic geography, Saxenian (1994) found marked differences between Boston on the east coast of the US and Silicon Valley on its west coast. She found in Silicon Valley prevalent cultural values that promote entrepreneurship and offer moral support in case of even repeated failure. In this way, Silicon Valley shows the possibility for an innovation system to take on a strong entrepreneurial culture. This is also visible in the mission of Stanford University, which was founded with an aim of supporting regional economic development at a time when many universities still eschewed any involvement in industry and commerce.

Besides the willingness of talented individuals to take the risk of starting their own firms, another important issue is the ability to access seed capital. While entrepreneurs potentially have access to a range of sources for their initial funding needs, for example, their own or their family's savings, a key source is formed by venture capital (VC). VC investors provide the initial funding to enable an entrepreneur to turn an innovative business idea into a company. As described earlier in this chapter, innovation processes are complex and unpredictable, making them unattractive propositions for most investors. This is especially true for radical innovations, which are most unpredictable but, if implemented successfully, have the highest potential for rejuvenating a regional economy. In other words, the innovations with the highest potential impact on the regional innovation system may be the least likely to find funding from traditional sources, such as banks. Availability of VC is therefore seen as an important condition for allowing high rates of new firm formation.

If firms can access venture capital from all parts of the country they are located in or even across borders, then the presence of VC investors within a region is not a necessary condition for allowing high rates of start-up formation there. While more research is necessary, there are signs that access to VC funding has a spatial dimension. Fritsch and Schilder (2011) find that in Germany, VC investors prefer to be proximate to the start-up firms they invest in so they can monitor their development and quickly respond to problems or opportunities related to their investment portfolio. However, rather than necessarily having to attract VC investors to your region, they find that it is also possible for VC investors to overcome the obstacle of distance through syndication, or the formation of networks of VC investors. Through their network, syndicated VC investors are able to indirectly monitor the start-up firms they invest in, even if these are located too far away for regular visits to be practical.

Sector structure

Another important subfield in the study of regional innovation is the impact of regional sector structure on the innovation capacity of firms in that region (Duranton and Puga 2004; and see Beaudry and Schiffaurova 2009 for a review of this literature). Section 2.5 already discussed that in the long run, regional innovation systems can experience a process of increasing specialization in a single dominant industry sector and face adverse consequences from this when this dominant sector matures and faces declining profitability. The vulnerability of a regional economy to the decline of, or asymmetrical shocks to, one of its industry sectors can be reduced by having a diverse rather than a specialized sector structure.[2] The higher the diversity in a region and the less a region's industry sectors are related to each other (in other words, the higher the *unrelated variety* in the region), the higher the protection of this *portfolio effect* against asymmetric shocks (Frenken *et al.* 2007).

But there are also reasons to argue that a specialized sector structure provides benefits for a regional economy. The strength of the Marshallian agglomeration effects introduced in section 2.4 are thought to depend on the sector structure prevalent in a region. Cost savings arise when co-located firms have the same requirements in terms of infrastructure, raw inputs, intermediate products, and worker skills among others, since they will be able to some extent to share common facilities and each draw on an enlarged local pool of (human) resources. If, however, the firms in a region tend to be active in unrelated industry sectors (e.g. design, textile production, and production of military hardware), it is unlikely that any such cost savings will occur.

Moreover, in the Marshallian framework, co-located firms can benefit from knowledge spillovers. This can happen, for example, when chance meetings between the knowledge workers belonging to different firms lead to exchange or recombination of ideas or when a worker previously employed by one firm is hired by the next, bringing some of the unique knowledge and experience prevalent at his previous workplace with him. Again, it is hard to imagine such knowledge spillovers will generate usable knowledge or ideas if firms are active in unrelated industry sectors.

Viewpoints differ on whether a specialized sector structure is conducive to knowledge spillovers. On the one hand, firms in the same industry sector are likely to face similar challenges and hence benefit from each other's knowledge and experience about dealing with these challenges. Moreover, firms are likely to be able to absorb new knowledge that is within their field of expertise, which is likely to be true for knowledge spillovers originating at firms active in the same industry sector. On the other hand, firms may learn few new or out-of-the-box ideas from other firms active in the same industry sector, as the ideas, rules of thumb, and explicit and implicit assumptions made by firms that share the same specialty and location might show a high degree of overlap. Even worse, received wisdom and taken-for-granted assumptions may spread among co-located firms active in the same industry, blinding them to new opportunities and solutions that may be crucial for ongoing innovation. In this way, knowledge spillovers can even become a force of lock-in and conservatism rather than a source of innovation (for example, see Grabher 1993 for a discussion of cognitive lock-in in an old industrial region).

Recent research (Frenken *et al.* 2007) suggests that a sector structure of *related variety* may constitute a good middle road that avoids the drawbacks of specialization while still affording knowledge spillovers. Related variety refers to a sector structure in which most firms are not active in precisely the same industry sector but in sectors that are related in terms of the (human) resources and knowledge needed for firms to operate. Besides Frenken and colleagues (2007), evidence supporting the beneficial effects of related variety is found by Boschma and Iammarino (2009) and Boschma and colleagues (2013), while Hartog and colleagues (2012) find a positive relation between related variety and employment growth only for firms in the high-tech sectors as opposed to medium- or low-tech sectors. Cooke (2012) links the concept of technological relatedness to the concept of transversality, or 'the process whereby knowledge emanating from one industrial or institutional source is successfully introduced, analysed and adopted, with modifications, to facilitate the creation of an innovation in a different industry or institution' (Cooke 2012:67). In this way, the spillover of knowledge can be understood as a complex process rather than an automatic and unproblematic one. For a framework for policy implementations based on related variety, see Asheim and colleagues (2011b).

Regional attractiveness

When entrepreneurs exploit a technological or market opportunity, their success has the potential to attract workers, resources, and other firms (who wish to supply to or learn from the emerging leader firm) towards a region. When this agglomeration process achieves a critical mass, Marshallian externalities may occur and give the region a strong position within one or more industry sectors. The process of agglomeration can be accelerated if that region has certain features that make it an attractive living and working environment. Conversely, a congested, polluted, and for other reasons unattractive location is expected to see slower agglomeration processes than might have been possible based on technological and market opportunities.

Regional attractiveness is traditionally thought of in terms of amenities such as an attractive climate and natural environment, as well as leisure facilities such as sports centers and cultural offerings. Recent research has proposed a number of further elements to regional attractiveness, some of them relevant for the attraction of firms and others for the attraction of (knowledge) workers.

As evidenced by the benchmark case of Silicon Valley, the local labour market can play a dual role in supporting the development of the innovation system.

First, a pool of high-quality university graduates attracted external firms to the region, which in turn provided job opportunities sufficient not only to keep local graduates in the region but also to attract talent from all around the world. This is a self-strengthening process that may seem a 'chicken-or-egg' problem, but in this case the buildup of attractive human capital seems to have come first. In other words, the availability of high-quality human resources forms an attraction factor for firms, while the presence of a dense concentration of innovative firms in turn forms an attraction factor for highly skilled workers. The more specialized the skills of a worker are, the greater the benefits from living in a region where a range of employers are located who require those specialized skills.

Recent work by Richard Florida suggests another angle to regional attractiveness. He finds evidence that knowledge workers, in addition to designers and other creative professionals, have particular requirements for their living and working environment (Florida 2004). These include openness to ethnic diversity, tolerance of non-mainstream lifestyles, and a common attitude of respecting individual merit and initiative. In other words, if foreigners and people with alternative lifestyles (which may include different religious preferences or sexuality) feel welcome, this may be just as important to the attraction of foreign firms and workers as climate, natural environment, and wage level. Moreover, Florida proposes that besides attracting creative professionals to the region, tolerance, diversity, and creative amenities also make those professionals more productive once they have settled there. Florida's work has been criticized as having a North American bias besides drawing too-strong conclusions from limited quantitative evidence (see Glaeser 2005 for a critical reading of Florida's most popular work), and subsequent research challenges his strong emphasis on 'creative' amenities as opposed to more traditional attraction factors (e.g. Lawton *et al.* 2013).

Identity and branding

A development factor that is related to but should nevertheless be clearly distinguished from regional attractiveness is the identity and branding of a regional innovation system and its clusters. Maskell and Malmberg (2007:613) argue that the 'establishment of the place as a brand of the dominant local industries' is one of the factors that reinforces the specialization of an innovation system and helps set the 'frame for the kind of activities that might be possible to perform in the future in that area'. What does this mean: establishing the place as a brand? Anholt and Hildreth (2005:164) have used an interesting description to introduce what a brand is. It is 'nothing more and nothing less than the good name of something that's on offer to the public'. Essentially, this 'good name' or reputation exists in the minds of the relevant audiences (in this case firms, investors, research institutes, governments). Hence, a brand is a network of associations in target audiences' minds (Keller 1993) and similarly, Braun and Zenker (2010) define a place brand as a network of associations in the mind of the target audience. This implies that apart from the past performance (or 'track record') of a regional innovation system, it is equally important to communicate its development to the outside world and by doing so establish the regional innovation system as a brand. The importance of place brand building for innovation system development was also identified by Lundequist and Power (2002) in a study concerning Swedish regions. It is especially relevant for attracting investment, venture capital, skilled workers, and new entrants.

Furthermore, a strong place brand can help the innovation system to adapt to rapidly changing circumstances, as observed by Staber and Sautter (2011) in the case of Tuttlingen, a region in southwest Germany that is dominated by its medical instruments cluster. Despite fundamental changes, that region's reputation (labelled as Tuttlingen Quality Products) has safeguarded the attractiveness for new investors from outside the region. Additionally, Staber and Sautter (2011) observed that this reputation is rooted in the place, people, firms, and all other stakeholders involved.

Place brand building was also an important factor in the Sophia-Antipolis case: the knowledge location that formed the core of its innovation system only really started growing after a successful advertisement strategy; but the character of that advertisement had a strong influence on its early development: the park was *branded* as a location with a good physical infrastructure and an attractive Sun Belt location in the Côte d'Azur, with an international advertisement strategy. It was not branded as having a strong entrepreneurial character (like Silicon Valley) or offering start-up support. So it attracted foreign R&D units (especially American), not entrepreneurs looking for a place to start a new firm. The initial branding decision influenced the character and the development of the regional innovation system for a long time and helped kick-start the development. The indigenous start-up firms slowly started to emerge decades after the founding of the science park and enriched the place brand of Sophia-Antipolis with another valuable place brand association.

In sum, regional innovation systems can over time develop a distinct identity, which can be strengthened or adjusted using a branding strategy. A strong identity can enhance the attractiveness of the region to firms that may decide to locate there. Moreover, the precise characteristics or *loading* of a regional brand has an influence on the type of actors that may be attracted and, hence, influence the development of the innovation system. The ability of stakeholders to change the identity and reputation of a regional innovation system is, however, limited, since the kinds of brands that can realistically be communicated to an external audience depends on the actual current characteristics of the region.

Local market for high-tech products

All factors discussed so far can be classified as supply-side factors, as they mostly impact the ability of firms and other actors to successfully carry out innovation processes and hence contribute to improving the price and quality of the products offered by that region's firms. These and other supply-side factors have received much attention in the research literature, while demand-side factors (Baptista and Swann 1998) have been relatively understudied (Keeble and Nachum 2002).

Access to sufficient market demand for knowledge-intensive products may, however, be crucial in the development of some innovation systems and can be the key reason specific firm clusters arise (or decline) within a regional innovation system. For example, based on examples such as Israel's demand for advanced irrigation equipment, Porter observes that: 'Clusters may [. . .] arise from unusual, sophisticated, or stringent local demand' (Porter 1998:84).

The benchmark example of Silicon Valley in the previous section also suggests that military demand for advanced high-tech products can play a role in facilitating the development of a regional innovation system (see Markusen *et al.* 1991 for an early study on the link between military demand and the geography of innovative industry). The opposite case is Sophia-Antipolis, a regional innovation system emerging in a region with very little proximity to large customers for high-tech goods. Keeble and Nachum (2002) find that demand-side factors, mainly access to a thick client base, are also of crucial importance for regions dominated by the service sector, in this case the business services cluster in London.

Besides the presence of (potential) clients per se, which may be end users or buyers of intermediate goods, of key importance is access to early adopters willing to be the first to try out new, innovative products. Newly introduced products tend to be more expensive than later versions, while the risk of malfunctions or price overruns can be higher. On the other hand, lead users may be able through their feedback to developers not only to help them successfully develop their new product but also to influence the precise specifications of the new product to suit their particular needs. Under the heading of the living lab, attempts are made to structure and enhance user–producer cooperation and communication (e.g., see Leminen *et al.* 2012 for a recent empirical study). In addition to the demand-side factors discussed so far, OECD (2011) also mentions the importance of public procurement policies, product standards, and regulation as well as consumer policies set by government bodies.

Development in a transition context

Most research so far has concentrated on innovation systems in developed countries, but recently interest has grown for the specific challenges of innovation system development in developing countries and transition countries (this book includes a case study of Suzhou Industrial Park in China). A number of factors are especially important. First, while transition countries tend to have a fairly developed infrastructure compared to developing countries, this infrastructure may have features that are not favourable to innovation system development. While more research on this topic is needed, this includes the tendency of planned economies to concentrate highly specialized industries in remote locations, with a strong focus on heavy manufacturing and resource extraction. This is in sharp contrast with the usual pattern of more diverse and organically grown clusters in accessible locations. Moreover, the still considerable importance of state-owned enterprises in most transition countries should be taken into account.

Besides physical infrastructure, the institutional infrastructure of transition countries may form a barrier to innovation system development. Transition countries often have a weaker rule of law and less developed legal and judiciary system, leading to problems concerning (intellectual) property protection. In the face of a less developed formal institutional system, firms and other actors tend to develop informal systems of cooperation, reciprocal support, and protection (Puffer *et al.* 2009). While these informal institutional systems may be effective adaptations for local actors, they can form an obstacle for cooperation and communication with foreign actors, as discussed in the context of institutional proximity.

A common characteristic of transition countries is that they have suffered from and sometimes continue to suffer from a process of brain drain of their most talented workers and entrepreneurs to other countries. While hurting their development in the past, this process has created a potentially powerful source of strength for the development of innovation systems. When conditions such as political stability and rule of law have developed far enough, overseas communities from transition countries may be enticed to return, bringing with them advanced knowledge, entrepreneurial experience, and the potential to develop powerful global networks between emerging country innovation systems and well-developed systems in developed countries. In this way, the Hsinchu high-tech cluster in Taiwan has become a gateway for technology transfer and access to foreign export markets, turning brain drain into brain circulation (Hsu & Saxenian 2006), while Russia and China also aim to stimulate this process (see Filatotchev *et al.* 2011 for early signs of success in the case of China).

2.7 Policy intervention

Regional innovation systems differ strongly in their innovation capacity. While all local actors have strong incentives for strengthening the innovation system, the complex nature of innovation systems means that the solution to structural weaknesses may not be delivered by market forces alone. 'Chicken-or-egg' problems may slow down the development of a regional innovation system. For example, high-tech firms may not locate in a region because of a lack of research and education infrastructure, while research and education institutions do not emerge for lack of local presence of high-tech firms to cooperate with and supply graduates to (a similar situation can be imagined with potential entrepreneurs being discouraged by a lack of local access to VC funding, while VC investors may not be interested in a region without high start-up rates). This is one example of what may be called system failure (an extension of the concept of market failure), and it opens a case for policy intervention to strengthen the regional innovation system.

System failure is a multifaceted concept currently under active study, and no single definition has yet been agreed upon. Gustafsson and Autio (2011) distinguish two elements of system failure, namely institutional inertia, 'structural deficiencies, and lock-in to established externalities inhibit efficient (from a welfare-economic perspective) knowledge exploration and exploitation', and inhibited emergence, 'due to socially and institutionally constrained sense-making, collective experimentation, learning and discovery within innovation, production, and technology use structures.' (p. 820). In short, it refers to the failure of an innovation system to develop in a region because of structural barriers or inertia. This section introduces some policy approaches proposed in the literature for strengthening or kick-starting the development of a regional innovation system.

Policy measures

While the concept of regional innovation systems was only formalized by the early 1990s, some forms of regional development policy earlier in the 20th century can be seen as precursors to current regional innovation system policies. A well-known example is French regional innovation policy based on the concept of the *growth pole*, derived from work by Perroux (1950). This policy focused on supporting a local leader firm active in an industry sector with growth potential, hoping it will build up a local supply chain and possibly a fully developed regional innovation system around itself. However, these policies have been criticized as 'picking the winner', with governments having to decide what firms in what sectors have the highest potential for future growth. Moreover, even if such policies were to succeed, they may result in single-industry company towns, vulnerable not only to shocks to one dominant sector but even to shocks to one individual firm.

By the 1990s, attention had shifted towards addressing specific barriers seen as preventing the emergence of a strong regional innovation system. As discussed in the previous section, the outcomes of university research are often seen as valuable inputs into innovative activities (e.g. new product development) carried out by firms located in proximity to universities. However, written and unwritten rules may prevent university researchers from being willing to disseminate their knowledge to industry. At the same time, firms may be unaware of the value of university research or may lack the absorption capacity to access this knowledge. These problems of technology transfer have triggered many countries and regions to develop policy interventions. This can take the shape of innovation vouchers stimulating firms to buy patents and other knowledge from universities), but it can also be institutionalized in the form of technology transfer offices that actively work with industry to assure that commercial opportunities raised by university research outcomes are exploited (see Etzkowitz *et al.* 2000 for an influential source on this topic).

Another route for making sure that commercially valuable knowledge does not remain unused within a university is to stimulate the formation of spin-off firms by university graduates or staff. This can take the form of seed funding and coaching programs offered to academic start-ups, and other series can be offered through incubation centers (Rothaermel *et al.* 2007 provide a comprehensive overview of the expanding literature on university entrepreneurship). Many other forms of local innovation policy have been proposed in the literature, and recently attempts have begun to synthesize these policy measures into a more integrated framework. Brenner and Schlump (2011) summarize these measures into six categories[3] (see Table 2.1).

Table 2.1 Policy measures for strengthening the regional innovation system

Policy category	*Policy measures*
Investing in education	• set up new universities or new departments in existing universities • stimulate education in topics and methods relevant for the regional innovation system • provide training in business skills for scientists and engineers • invest in the attraction of talented students and the retention of local graduates
Investing in public research	• set up laboratories for the provision of specialized services to local firms • invest in the attraction of talented researchers
Supporting private R&D	• (co-)finance the screening activities of local firms to identify useful external knowledge • (co-)finance firms' in-house R&D • (co-)finance local firms buying R&D services and laboratory access at local research institutes
Supporting start-ups	• raise awareness for entrepreneurship amongst scientists and engineers • provide training in business skills to start-up entrepreneurs • provide seed funds to start-ups • (temporarily) provide subsidized housing and laboratory access to start-ups
Supporting network formation	• (co-)finance inter-firm collaborated innovation projects • facilitate contact between firms and education and research institutes • facilitate contact between start-ups and investors • provide a physical space for interaction among actors in the innovation system • create a region-level organization to coordinate networking activities and to represent the region to external partners
Accessibility and local conditions	• provide shared infrastructure (depending on the sector specialization of the regional innovation system, this can include among others airport, harbour, railway, or highway infrastructure) • provide an attractive living and working environment

(Source: Brenner and Schlump, 2011)

Compared to traditional regional innovation policy, the measures summarized in Table 2.1 are far more flexible and generic. Rather than directing support to specific firms, it is directed to the regional innovation system in general so that a large number of regional (and in some cases also extra-regional) firms may benefit from it. Only start-up firms may still receive direct support, but usually only for a limited period and in some cases only in exchange for equity in the firm. The ultimate choice of direction for the innovation system and its clusters is left to the market, though it should be kept in mind that the state and its firms and organizations (for example, the military) may be important market players. The policy measures related to network formation may be crucial to trigger firms and other actors in the region to perceive themselves as being part of a wider system, which they can themselves contribute to.

Each of the policy measures introduced so far only addresses a specific aspect of system failure. Measures related to network formation may be an exception to this if they lead other actors in the region to organize a systematic effort to identify their innovation system's weaknesses and undertake action to address them. However, in most regions, some form of governance structure seems needed to bring together all relevant actors to strengthen their RIS. This often takes the form of a bricks-and-mortar platform, such as the knowledge locations (Carvalho 2013) discussed in the previous section. A bricks-and-mortar platform brings together in geographical proximity the technology-transfer offices, incubation centers, and other institutions set up as part of system building regional innovation policy. Often such a knowledge location is cantered on a university or leader firm and may include an extensive business park. However, it is also possible to bring RIS policies together not in a physical platform but in an organizational platform. This can take the shape of cluster organisations, development agencies, or more hybrid/informal organisation.

2.8 In conclusion: the frame of analysis

In this final section, we develop a frame of analysis building on the literature we reviewed above. This frame presents a succinct set of concepts and objects of study to guide the empirical research in the following chapters. This framework is specifically designed to study innovation in cities and hence refers to urban innovation systems, but most of its elements are likely to be applicable to any localized innovation system, whether urban or regionally based.

Urban innovation systems, clusters, and knowledge locations

From the literature review, we learned that innovation systems are complex, multi-layered entities that undergo the influence of a broad range of contextual factors. Figure 2.1 gives a schematic overview of the three scales we distinguish in our analysis of innovation systems.

At the highest scale level, we identify localized innovation systems, which, depending on their context, can be called urban innovation systems or regional innovation systems. Below they will be referred to as urban innovation systems. The innovation system is not an isolated entity and has a porous boundary. While some clusters may be strongly anchored in one specific urban innovation system, others can cross the boundary of several cities or regions as their constituent parts are distributed between different localities. An urban innovation system may or may not include one or more identifiable bricks-and-mortar knowledge locations (science parks or other knowledge hubs).

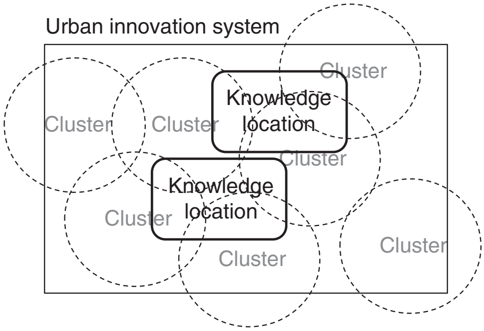

Figure 2.1 Three scales in the analysis of innovation systems

Innovation capacity and performance

The innovation capacity of an urban innovation system can be defined as the ability to secure and improve the system's innovation performance. This capacity evolves as an interplay of endogenous factors and external factors such as the performance of other competing systems, technological innovations, and changes in (global) market conditions. While the innovation performance of the system can be measured by indicators such as the number of patents, product launches, start-ups, and gazelles (fast growing companies), the innovation capacity is much more difficult to measure.

Actors, networks, platforms, and the environment

What factors influence the innovation capacity and performance of an urban innovation system? Figure 2.2 identifies the factors we consider most relevant, based on the literature review.

Actors. Urban innovation systems need particular combinations of actors, depending on the stage of development and the profile of the system (e.g. in terms

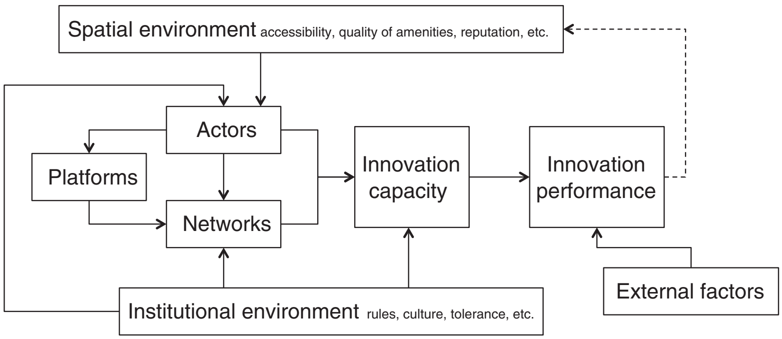

Figure 2.2 The innovation capacity and performance of an urban innovation system

of clusters it consists of). Examples of potentially relevant actors are (leader) firms, suppliers, start-ups, research institutes, venture capital investors, higher education institutes, knowledge location managers, intermediaries, and government agencies. Intermediaries are the most diverse category of actors and play an important role in specific instances of urban innovation systems. They may increase the strength and cohesion of specific firm clusters and/or the innovation system as a whole by conveying their vision to the other actors and mobilizing them to commit to shared goals. They may be independent leaders or role models or large dedicated organizations. An important insight from the literature is that each of these actors has specific capabilities and aims. Also, they differ in the extent to which they perceive themselves as local or non-local actors and in the extent to which they feel committed to strengthening the urban innovation system they form a part of. These characteristics derive from among others their different experiences, resources, and network position.

Networks. Besides the mix of actors and their individual characteristics, the innovation capacity of an urban innovation system also depends on the interactions and linkages between actors. Network position is a characteristic of individual actors, but at the system level, networks also have emergent properties that can only be understood at the level of the network as a whole. Different types of networks can be distinguished, ranging from formal, institutionalised, and business-oriented networks (e.g. supply chains, strategic alliances) to more informal, people-oriented networks (e.g. expat communities). Most networks stretch beyond the region, but in a strong urban innovation system, the city is a focal point with high network intensity. The morphology and dynamics of innovative networks vary per sector: they are different in, for example, biotech than in ICT. Networks can produce concrete innovative partnerships, alliances, and new ventures, which ultimately churn out innovative products for which there is a market and that produce economic value. An important force of innovation is the occurrence of unexpected cross-fertilizations between people from different trades and backgrounds, resulting in new ideas and initiatives. Cities typically offer a dense and rich variety of innovative actors – commercially oriented, but also ‘cultural innovators’ such as artists and counter-movements; networks at the intersection of sectors or groups can lead to radically new ideas.

Platforms. Many networks emerge automatically, at the interplay between actors. But successful urban innovation systems also have platforms that serve as hosts for networking and take care of constant innovation and network renewal. Platforms can take several shapes: they come as buildings (where firms are co-located, share facilities, and benefit from support services and networking opportunities), organizations (that promote network formation and promotion, such as branch organizations, regional development organizations, cross-fertilization platforms, etc.), congresses, meetings, and exhibitions (temporary platforms that allow people to meet, exchange ideas, and start new ventures), and websites (virtual platforms). Note that venture capital providers also play a key role in network formation, thus acting more or less as ‘platforms’ themselves: they help in finding investors for ventures and linking ideas, inventors, and research findings to managers and marketers that can make a business out of it.

Besides characteristics of the innovation system and its component parts itself, a great diversity of contextual factors has been identified in the literature review. These factors have impacts of differing magnitude on the development trajectory and innovation capacity of urban innovation systems. At the same time, an emerging urban innovation system also has an impact on the contextual conditions themselves, and in some cases (especially Silicon Valley comes to mind), a well-developed innovation system can radically transform the structural characteristics of its environment. Finally, some contextual factors are unique to specific cities, while others have emerged in the literature as key drivers of innovation systems in general.

Spatial environment. First, factors can be distinguished that relate to the spatial environment of the urban innovation system. This includes the location and accessibility of the city the innovation system is based in and also the range and quality of amenities that make it an attractive location for skilled labour, entrepreneurs, and firms. Different amenities exert an attraction effect on different types of actors, and broad categories like 'skilled labour' can be broken down into subcategories (young talents, international knowledge workers, highly specialized workers, creative class), which may respond to different kinds of amenities. Besides actual conditions on the ground, another important factor is the perception or reputation of the city in the minds of potential inhabitants, visitors, and incumbent firms. A developing urban innovation system can benefit if its city has a strong 'brand name', while at the same time the presence of well-developed clusters and knowledge locations can enable a city to develop a powerful brand name it did not previously possess. Besides attracting labour, entrepreneurs, and firms, the spatial environment may also allow those workers and firms already present in the city or region to become more productive or creative.

Institutional environment. A second group of factors relates to the institutional environment, which provides the basis for any business activity. It sets the rules of the game and defines business cultures and attitudes towards co-operation and towards entrepreneurship and thus has a deep impact in innovation processes. It includes formal rule systems like laws and regulations and enforcement mechanisms sanctioned by the state. But there is also a cultural-cognitive aspect, including accepted beliefs and values shared among individuals through social interactions that guide behaviour. Culture reflects the ideas, values, norms, and meanings shared by members of a society and perpetuated through families and communities; values consist of global beliefs or abstract ideas that transcendentally guide actions and judgments across specific objects and situations (Hofstede 1980). To a large extent, the institutional environment is a national phenomenon, related to national laws, traditions, and culture. But there are regional and urban aspects as well. Cities may differ in their business cultures, norms and values, and degree of 'openness' and tolerance (cf. the American east coast vs. west coast; big city vs. countryside). Economic transition has a strong impact on the institutional environment as both formal and informal rules may transform rapidly but often at unequal speeds.

External factors. Third, the development trajectory and innovation capacity of an urban innovation system is influenced by external factors such as the market and technological opportunities that arise at different times throughout the development of the system. Besides their own favourable conditions, the main reason some urban innovation systems are able to develop powerful firm clusters is because they offered the right kind of opportunities the moment a technological breakthrough took place. Well-developed innovation systems can also create their own technological opportunities, in which case technological opportunities become more of an internal rather than an external factor. The ability to do this depends on many of the factors described above and also on the specialized or diverse sector structure of the local economy. Similarly, market opportunities, which can emerge in response to a technological breakthrough but also because of other processes (for example, the opening of China to international trade), can play an important role in creating the conditions in which urban innovation systems can develop firm clusters. Local demand can be a crucial factor for allowing growth to take off, and in particular the presence of lead users who quickly adopt new products and provide valuable feedback to their developers. Besides private firms and individual consumers, the government or the military can also take this role. On another level, market circumstances, such as over- or undersupply of commercial space, sometimes play an important role in deciding whether specific knowledge locations can be created within an urban innovation system.

Governing the urban innovation system

Evidently, there is no single road towards a successful urban innovation system: every city has its own culture, institutions, and defining historic moments that may have ignited or fuelled the engine, and coincidences play their role. Also, every city has its unique mix of actors, networks, and platforms. At the same time, there are strong indications that this is not the full story: not everything depends on historic coincidences, deeply rooted cultural and institutional realities, or accidental decisions of individual firms taken in overseas headquarters: there is a role for active agency. Smart innovation governance at the level of the city or region matters. Therefore, in our case studies, we will analyse pro-active approaches designed to open up innovation processes and boost networking. We take for granted that any approach can only work when the actors are involved in the design and implementation of the policies. The governance of the system may address all the aspects of our framework:

- *Attracting companies and talents.* Offering (financial) incentives for companies and talents to locate in the area; investing in existing universities and making them top level.
- *Providing incentives for networking.* For example, by efforts to cross-fertilise sectors and ‘produce’ unexpected encounters and outcomes.
- *Creating and promoting the development of platforms.* This can be done by building science parks and campuses and setting up network organisations and events. Such platforms help transfer innovative business practices of global firms to local firms and people.

- *Changing the institutional conditions.* For instance, by law enforcement or policies aimed at improving tolerance and stimulating entrepreneurship.
- *Improving spatial conditions.* Investments in quality of life, accessibility, and culture and through smart marketing and branding approaches that improve the city's reputation.

Moreover, as proposed in the literature, we expect that different policy interventions will be effective at different stages of innovation system development. When an urban innovation system is dominated by young emerging firm clusters, different tools may be helpful than when its main clusters are already well developed, and still other tools may be called far when its clusters have matured and are in need of renewal. In line with this, the extent to which policy intervention can impact the development direction of an urban innovation system depends on its current development stage, with an especially large impact expected in the stage of emergence.

In our case studies, the governance of innovation ecosystems is a central concern. In each case, we will carefully study the type of organisations and platforms that are charged with promoting innovation in the region or science park. We will analyse how they work, which organisations are involved, which instruments they deploy, and why and to what extent they are successful.

Notes

1 At that time, non-European firms still needed R&D units within Europe to localize their products and deal with the still-extensive regulatory and institutional barriers within Europe and between Europe and other countries. EU integration has since largely removed this necessity.

2 Examples of asymmetrical shocks include sudden changes in demand, in input prices, or in government regulation, which adversely affect one industry sector only.

3 Brenner and Schlump (2011) operate from the perspective of cluster analysis, corresponding to the broader definition of clusters as proposed by Porter (1990). However, it is argued here that these measures can also be applied to regional innovation systems as a more general framework that includes the insights from cluster analysis.

Sources

Abel, J. and Deitz, R. (2012), Do colleges and universities increase their region's human capital? *Journal of Economic Geography,* Vol. 12, pp. 667–691.

Adam, S. (2011), Growing where you are planted: Exogenous firms and the seeding of Silicon Valley, *Research Policy,* Vol. 40, pp. 368–379.

Anholt, S. and Hildreth, J. (2005), Let freedom and cash registers ring: America as a brand, *Place Branding,* Vol. 1, Issue 2, pp. 164–172.

Arbo, P. and Benneworth, P. (2007), *Understanding the regional contribution of higher education institutions: a literature review,* OECD Education Working Papers, No. 9, OECD Publishing, available at: http://dx.doi.org/10.1787/161208155312

Asheim, B., Boschma, R. and P. Cooke (2011), Constructing regional advantage: platform policies based on related variety and differentiated knowledge bases, *Regional Studies*, Vol. 45.7, pp. 893–904.

Asheim, B. and Coenen, L. (2005), Knowledge bases and regional innovation systems: comparing Nordic clusters, *Research Policy,* Vol. 34, pp. 1173–1190.

Audretsch, D. and Feldman, M. (1996), Innovative clusters and the industry life cycle, *Review of Industrial Organization,* Vol. 11, pp. 253–273.
Baptista, R. and Preto, M. (2011), New firm formation and employment growth: regional and business dynamics, *Small Business Economics,* Vol. 36, pp. 419–442.
Baptista, R. and Swann, P. (1998), Do firms in clusters innovate more? *Research Policy,* Vol. 27, pp. 525–540.
Beaudry, C. and Schiffaurova, A. (2009), Who's right, Marshall or Jacobs? The localization versus urbanization debate, *Research Policy,* Vol. 38, pp. 318–337.
Becattini, G. (1990), The Marshallian industrial district as a socio-economic notion, in Pyke, Becattini and Sengenberger (eds.), *Industrial districts and inter-firm cooperation in Italy,* Geneva: International Institute for Labour Studies.
Benneworth, P. and Hospers, G. (2007), The new economic geography of old industrial regions: universities as global–local pipelines, *Environment and Planning C: Government and Policy,* Vol. 25, pp. 779–802.
Boschma, R. (2005) Proximity and innovation: A critical assessment, *Regional Studies*, 39:1, 61–74.
Boschma, R. and Iammarino, S. (2009), Related variety, trade linkages and regional growth, *Economic Geography,* Vol. 85, pp. 289–311.
Boschma, R., Minondo, A. and M. Navarro (2013), The emergence of new industries at the regional level in Spain: a proximity approach based on product relatedness, *Economic Geography,* Vol. 89, pp. 29–51.
Braczyk, H., Cooke, P. and M. Heidenreich (1998), *Regional innovation systems: the role of governances in a globalized world,* Routledge: London.
Braun, E. and Zenker, S. (2010), Towards an integrated approach for place brand management. Paper presented at the 50th European Regional Science Association Congress, Jonköping, Sweden, 19th–23rd August 2010.
Brenner, T. and Mühlig, A. (2013), Factors and mechanisms causing the emergence of local industrial clusters: a summary of 159 cases, *Regional Studies,* Vol. 47, pp. 480–507.
Brenner, T. and Schlump, C. (2011), Policy measures and their effects in the different phases of the cluster life cycle, *Regional Studies,* Vol. 45.10, pp. 1363–1386.
Bureau of Labor Statistics (2009), After the dot-com bubble: Silicon Valley high-tech employment and wages in 2001 and 2008, available at: www.bls.gov/opub/regional_reports/200908_silicon_valley_high_tech.htm
Caniëls, M. and Van den Bosch, H. (2011), The role of higher education institutions in building regional innovation systems, *Papers in Regional Science,* Vol. 90, pp. 271–286.
Carvalho, L. (2013), *Knowledge locations in cities: emergence and development dynamics,* ERIM PhD Series in Research in Management, 274.
Castells, M. and Hall, P. (1994), *Technopoles of the world: the making of twenty-first-century industrial-complexes*, New York: Routledge.
Christopherson, S., Michie, J. and P. Tyler (2010), Regional resilience: theoretical and empirical perspectives, *Cambridge Journal of Regions, Economy and Society,* Vol. 3, pp. 3–10.
Cooke, P. (1992), Regional innovation systems: competitive regulation in the new Europe, *Geoforum,* Vol. 23, Issue 3, 365–382.
Cooke, P. (2012), *Complex adaptive innovation systems: relatedness and transversality in the evolving region,* Abingdon (UK): Routledge.
Cooke, P., De Laurentis, C., F. Tödtling and M. Trippl (2007), *Regional knowledge economies: markets, clusters and innovation,* Cheltenham (UK): Edward Elgar Publishing Ltd.
Cooke, P., Heidenreich, M. and H. Braczyk (2004) [1998], *Regional innovation systems: the role of governance in a globalized world*, 2nd ed., London: Routledge.
Duranton, G. and Puga, D. (2004), Micro-foundations of urban agglomeration economies, in: Henderson and Thisse (eds.), *Handbook of regional and urban economics,* Ed. 1, Vol. 4, Chapter 48, Amsterdam: Elsevier/North-Holland, pp. 2063–2115.

Etzkowitz, H., Webster, A., Gebhardt, C. and B. Terra (2000), The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm, *Research Policy,* Vol. 29, pp. 313–330.

Faggian, A. and McCann, P. (2009), Universities, agglomerations and graduate human capital mobility*, Tijdschrift voor Economische en Sociale Geografie,* Vol. 100, pp. 210–223.

Feldman, M., Francis, J., and J. Bercovitz (2005), Creating a cluster while building a firm: entrepreneurs and the formation of industrial clusters, *Regional Studies,* Vol. 39, pp. 129–141.

Filatotchev, I., Liu, X., Lu, J. and M. Wright (2011), Knowledge spillovers through human mobility across national borders: evidence from Zhongguancun Science Park in China, *Research Policy,* Vol. 40, pp. 453–462.

Florida, R. (2004), *Cities and the creative class*, New York/London: Routledge.

Frenken, K., van Oort, F. and T. Verburg (2007), Related variety, unrelated variety and regional economic growth, *Regional Studies,* Vol. 41, pp. 685–697.

Fritsch, M. and Schilder, D. (2011), The regional supply of venture capital: can syndication overcome bottlenecks? *Economic Geography,* Vol. 88, pp. 59–76.

Gabe, T. and Abel, J. (2012), Specialized knowledge and the geographic concentration of occupations*, Journal of Economic Geography,* Vol. 12, pp. 435–453.

Giuliani, E. (2007), The selective nature of knowledge networks in clusters: evidence from the wine industry, *Journal of Economic Geography,* Vol. 7, pp. 139–168.

Glaeser, E. (2005), Review of Richard Florida's 'The Rise of the Creative Class', *Regional Science and Urban Economics,* Vol. 35, pp. 593–596.

Grabher, G. (1993), The weakness of strong ties, the lock-in of regional development in the Ruhr area, in: Grabher (ed.), *The embedded firm,* London: Routledge, pp. 255–277.

Gustafsson, R. and Autio, E. (2011), A failure trichotomy in knowledge exploration and exploitation, *Research Policy,* Vol. 40, pp. 819–831.

Hartog, M., Boschma, R. and M. Sotarauta (2012), The impact of related variety on regional employment growth in Finland 1993–2006: high-tech versus medium/low tech, *Industry and Innovation,* Vol. 19, pp. 459–476.

Hofstede, G. (1980), *Culture's consequences: international differences in work-related values,* Beverly Hills, CA: Sage Publications.

Hsu, J. and Saxenian, A. (2006), The Silicon Valley-Hsinchu connection: technical communities and industrial upgrading, in: Breschi, S. and Malerba, F. (eds.), *Clusters, networks and innovation*, Oxford, UK: Oxford University Press, pp. 176–199.

Isaksen, A. and Hauge, E. (2002), *Regional clusters in Europe,* Observatory of European SMEs report 2002, No. 3, Luxembourg: European Communities.

Jacobs, J. (1969), *The economy of cities*, New York: Vintage.

Jaffe, A., Trajtenberg, M. and R. Henderson (1993), Geographic localization of knowledge spillovers as evidenced by patent citations, *The Quarterly Journal of Economics,* Vol. 108, pp. 577–598.

Keeble, D. and Nachum, L. (2002), Why do business service firms cluster? Small consultancies, clustering and decentralization in London and southern England, *Transactions of the Institute of British Geographers,* Vol. 27, pp. 67–90.

Keller, K. (1993), Conceptualizing, measuring, and managing customer-based brand equity, *Journal of Marketing,* Vol. 57, No. 1, pp. 1–22.

Klepper, S. (2007), Disagreements, spinoffs, and the evolution of Detroit as the capital of the US automobile industry, *Management Science,* Vol. 53, pp. 616–631.

Lawton, P., Murphy, E. and D. Redmond (2013), Residential preferences of the 'creative class'? *Cities,* Vol. 31, pp. 47–56.

Leminen, S., Westerlund, M. and Nyström, A. (2012), Living labs as open-innovation networks, *Technology Innovation Management Review,* September 2012, pp. 6–11.

Lundequist, P. and Power, D. (2002), Putting Porter into practice? Practices of regional cluster building: evidence from Sweden, *European Planning Studies*, Vol. 10, No. 6, pp. 685–704.

Markusen, A., Hall, P. and S. Campbell (1991), *The rise of the gunbelt: the military remapping of industrial America,* New York: Oxford University Press.

Marshall, A. (1890), *Principles of economics,* London: Macmillan.

Martin, R. and Sunley, P. (2003), Deconstructing clusters: chaotic concept or policy panacea, *Journal of Economic Geography,* Vol. 3, pp. 5–35.

Martin, R. and Sunley, P. (2006), Path dependence and regional economic evolution, *Journal of Economic Geography,* Vol. 6, pp. 395–437.

Martin, R. and Sunley, P. (2011), Conceptualizing cluster evolution: beyond the life cycle model? *Regional Studies,* Vol. 45, pp. 1299–1318.

Maskell, P. and Malmberg, A. (2007), Myopia, knowledge development and cluster evolution, *Journal of Economic Geography,* Vol. 7, No. 5, pp. 603–618.

Menzel, M. and Fornahl, D. (2010), Cluster life cycles – dimensions and rationales of cluster evolution, *Industrial and Corporate Change,* Vol. 19, pp. 205–238.

Morrison, A. (2008), Gatekeepers of knowledge within industrial districts: who they are, how they interact, *Regional Studies,* Vol. 42.6, pp. 817–835.

Moulaert, F. and Sekia, F. (2003), Territorial innovation models: a critical survey, *Regional Studies,* Vol. 37, pp. 289–302.

Nelson, R. (1959), The simple economics of basic scientific research, *Journal of Political Economy,* Vol. 67, pp. 297–306.

Nijdam, M. (2010), *Leader firms: The value of companies for the competitiveness of the Rotterdam seaport cluster,* ERIM PhD Series Research in Management, 216.

OECD (1997), *The Oslo manual: proposed guidelines for collecting and interpreting technical innovation data,* Paris: OECD.

OECD (2011), *Demand-side innovation policies,* Paris: OECD.

Perroux, F. (1950), Economic space, theory and applications, *Quarterly Journal of Economics,* Vol. 64, pp. 89–104.

Polanyi, K. (1944), *The great transformation,* New York: Rinehart.

Ponds, R., van Oort, F. and K. Frenken (2007), The geographical and institutional proximity of research collaboration, *Papers in Regional Science,* Vol. 86.3, pp. 423–443.

Porter, M. (1998), Clusters and the new economics of competition, *Harvard Business Review,* Vol. 76, No. 6**[0]**, pp. 77–90**[0]**Porter, M. (1990), *The competitive advantage of nations,* New York: The Free Press.

Puffer, S., McCarthy, D. and M. Boisot (2009), Entrepreneurship in Russia and China: the impact of formal institutional voids, *Entrepreneurship Theory and Practice,* May 2010, pp. 441–467.

Quéré, M. (2007), Sophia-Antipolis as a 'reverse' science park: from exogenous to endogenous development, in Frenken, K. (ed.), *Applied evolutionary economics and economic geography,* Cheltenham, UK: Edward Elgar.

Rothaermel, F., Agung, S. and L. Jiang (2007), University entrepreneurship: a taxonomy of the literature, *Industrial and Corporate Change,* Vol. 16, pp. 691–791.

Saxenian, A. (1994), *Regional advantage: culture and competition in Silicon Valley and Route 128,* Cambridge, MA: Harvard University Press.

Staber, U. and Stautter, B. (2011), Who are we, and do we need to change? cluster identity and life cycle, *Regional Studies,* Vol. 45, No. 10, pp. 1349–1361.

Storper, M. and Venables, A. (2004), Buzz: face-to-face contact and the urban economy, *Journal of Economic Geography,* Vol. 4, pp. 351–370.

Ter Wal, A. and Boschma, R. (2011), Co-evolution of firms, industries and networks in space, *Regional Studies,* Vol. 45.7, pp. 919–933.

Uyarra, E. (2010), Conceptualizing the regional roles of universities, implications and contradictions, *European Planning Studies,* Vol. 18, pp. 1227–1246.

Vernon, R. (1966), International investment and international trade in the product cycle, *Quarterly Journal of Economics*, 80: pp. 190–207.

Wolfe, D. and Gertler, M. (2004), Clusters from the inside and out: local dynamics and global linkages, *Urban Studies,* Vol. 41, pp. 1071–1093.

3 Eindhoven

3.1 Introduction

In 2011, the Eindhoven region – which presents itself as Brainport Eindhoven – was selected as the most innovative community worldwide by the Intelligent Community Forum. Understanding the building blocks underpinning its current innovation performance yields insights into one route a region can take to become a strong urban innovation system. The analysis puts special emphasis on the umbrella of innovation strategies collectively known as 'open innovation'. Open innovation is widely adopted among firms and other stakeholders in the region and underpins many of its current development initiatives.

Location

Eindhoven is the fifth-largest city of the Netherlands with about 216,000 inhabitants (as of 2011). It is located in the southern part of the Netherlands in the Noord-Brabant province. The four larger cities (Amsterdam, Rotterdam, The Hague, and Utrecht) are all located in the economic core area (the Randstad) in the west of the Netherlands. While none of these four cities is located more than 75 km from the other, the actual travel distance from Eindhoven to these cities varies between 92 (Utrecht) and 143 (The Hague). This corresponds with a 1.15- to 1.45-hour drive by car: quite long for Dutch standards. The actual travel distance by highway to the Dutch capital at The Hague is almost 150 km, or more than 1.5 hours by car, and other cities in the core economic area of the Netherlands, the Randstad area in the western part of the Netherlands, are also well more than 1 hour driving distance by car.

By contrast, Eindhoven is located only 15 km from the Belgian border and 50 km from the German border. With a travel distance of 133 km Brussels, is closer to Eindhoven than The Hague, although it takes five minutes extra to get there by car (1.50 hours). On a European scale, Eindhoven is right in the economic core area of Europe, close to the Ruhr area in Germany and the European capital Brussels. The Netherlands has a reputation of being a gateway to Europe, with non–European firms locating in the Netherlands to service the European common market from there.

Although Eindhoven is not located in the economic core area of the Netherlands, the region has good international accessibility: a world-class harbour (the Port of Rotterdam) and an air-traffic hub (Schiphol, Amsterdam) are within 1.5 hours' driving distance. Moreover, Eindhoven has a rapidly growing airport of its own, which has grown from fewer than half a million passengers per year in the early 2000s to more than 2.5 million in 2011 and now has regular services to about 70 European capital and regional airports. Eindhoven Airport has the ambition for further growth in terms of passengers and destinations, but as of yet it does not provide direct intercontinental flights.

Demography

Eindhoven has a ring of smaller towns and villages around it, which over time have more or less coalesced with the city of Eindhoven. The largest of these are Veldhoven (43,600 inhabitants) and Best (28,800 inhabitants). Right next to Eindhoven at about 20 minutes' driving distance by car is the city of Helmond, with about 88,500 inhabitants. Beyond the ring of small cities and towns around Eindhoven is a less densely populated rural area. Together, this forms an integrated economic region, with many people working in Eindhoven and living in the region around the city. The 21 local communities of Eindhoven, Helmond, and their surrounding areas together form the South-East Brabant region, also known as Greater Eindhoven. With about 750,000 inhabitants, this is a significant concentration of population in the Netherlands.

3.2 Development trajectory

The development trajectory of Eindhoven's innovation system has followed a quite exceptional path. Eindhoven is part of a particular class of cities that depended greatly on a single firm for their emergence, growth, and further development. While cities like Turin and Detroit were already medium-sized cities before their leader firms (Fiat and Ford, respectively) propelled them into a period of rapid growth, Eindhoven was only a rural town of about 5,000 inhabitants when its leader firm Philips was founded in 1891. Just like cities such as Ludwigshafen (BASF) and Magnitogorsk (Magnitogorsk Iron and Steel Works), Eindhoven entered a period of rapid growth after the foundation of its leader firm and would continue to depend on this firm not only for jobs but also for its housing development, recreation facilities, and part of its healthcare and education system. Because of the great importance of Philips for the development of Eindhoven, the development of this firm will be discussed in some detail. It took more than a century before Eindhoven's development trajectory started to gradually become decoupled from that of Philips, as will be discussed in the next subsection ('economic crisis and reform').

Foundation of Philips

In the 19th century, Eindhoven was a small town with an economy largely focused on agriculture. When it became connected first to the canal system and later to the emerging railway system of the Netherlands and Belgium, a small tobacco and textile industry emerged. In 1891, Philips Electronics was founded by Gerard Philips when he bought an empty textile factory in Eindhoven for the production of light bulbs.

Trained as an engineer, Gerard Philips learned about electricity and lighting during a period of study in Glasgow (United Kingdom). After his studies, he spent some time working for a London-based Anglo-American firm involved in the development of light bulbs. Unable to convince his employers about the opportunity to build a factory in the Netherlands to service the local market, Gerard went back to his home country to carry out this plan by himself. Based on the academic knowledge he gathered in Glasgow, his experience acquired in London, and additional research carried out by himself after returning to the Netherlands, he founded the Philips light bulb factory in Eindhoven. Gerard Philips was not originally from Eindhoven and had no specific need to choose this location from the alternatives available. The reason he chose Eindhoven was most likely good accessibility by rail and the availability of an inexpensive factory space with room for expansion, which are hardly unique location factors (Heerding, 1989).

Characteristics of the Philips-dominated urban innovation system

Already from the early years, Philips developed its characteristic features that would deeply shape the Eindhoven innovation system. A first characteristic of Philips is its heavy focus on advanced research. Gerard Philips remained deeply interested in both basic and applied science and invested a relatively large fraction of the firm's profit into R&D. These investments were necessary because Philips soon faced heavy competition in the light bulb sector from such firms as General Electric, AEG, and Siemens. Rather than retreating into a niche market, Philips faced the competition head on and succeeded in gaining a large market share by introducing a succession of product innovations in lighting to the world market. As Gerard gathered excellent researchers in his firm, the world's first modern internal R&D laboratory took shape. Facing heavy competition in its core market from the advanced new products introduced by General Electric, Philips went on to add the NatLab (Physics Laboratory) to its research facilities in 1914 (Heerding, 1989). Located in Eindhoven, the NatLab was the world's largest R&D laboratory at that time and created a range of cutting-edge product innovations (Philips 2012).

Besides its world-class research capabilities, another reason for the rapid growth of Philips was the addition of Gerard's brother Anton to the firm's leadership. As a merchant, Anton Philips took charge of the commercial side of the firm and contributed to the second key characteristic of Philips, namely its international focus. Recognizing market opportunities in other European countries and fearing that the Dutch market would be too small to allow ongoing growth, Anton focused on securing export markets and turning Philips into a multinational company with a strong international sales network.

While Philips had both well-developed R&D laboratories and strong commercial capabilities, it was less successful in linking these two spheres together. Over time, this led to two structural weaknesses in Philips's innovation performance. First, the focus of Philips's R&D effort was as broad as the multi-disciplinary research interests of Gerard Philips himself, producing a wide variety of innovations, only some of which Philips was able to effectively bring to the market. Second and related to the first point, Philips researchers on multiple occasions pursued research projects that can reasonably be described as hobby projects with little practical relevance to the firm.

A third characteristic of Philips with far-reaching consequences for Eindhoven is its tendency towards horizontal and vertical integration. As mentioned, Philips had a very broad research agenda, with both planned and unplanned advances into new product sectors occurring frequently. For example, Philips's early specialization in light bulbs led it to do basic research in gas and glassmaking. Advances in these fields in turn allowed Philips to develop some of the earliest functional X-ray tubes and radio valves, and a decade later it continued to develop tanning beds, television, and radar. This horizontal integration was not limited to exploiting obvious market opportunities, as Philips was also willing to actively develop new product markets when it saw an opportunity. For example, it realized that its radio business would only take off if sufficiently attractive radio broadcasting would be available for radio listening. So Philips provided radio transmission equipment for free to radio enthusiasts in the Hilversum area, which would remain the key media cluster of the Netherlands up to the present. Similarly, after sensing an opportunity after the development of X-ray equipment, Philips invested heavily in its medical products even though they remained unprofitable for an extended period.

At the same time, when this horizontal integration was taking place, Philips vigorously undertook a strategy of vertical integration. This process started when the World War I disturbed Philips's supply lines for raw materials and intermediate goods. Out of necessity, but also in order to keep a high level of secrecy towards its competitors, Philips decided to set up its own factories for gas and glass production and even developed many of the machines and tools needed to produce these materials. As it used paper and cardboard for packaging its finished products, Philips built its own paper and cardboard factories. Similarly, from the 1920s onward, Philips developed research and production expertise in plastics and other polymers when this was needed for the production of its radios and other consumer products. Most of these factories were built in or near the Eindhoven region to ensure continuity of supply.

Rather than limiting the role of these factories to supplying the materials needed for the production of Philips's key products, Philips supported them with funds and research to enable them to develop their own product markets. For example, Philips's plastics factories would end up producing not only the casings for Philips radios and televisions but also plastic children's toys and toilet seats. When in the 1950s and 1960s rising labour costs made the production of these relatively low-end products unprofitable, Philips first moved them to other locations in the Netherlands and Belgium rather than closing them and simply buying the raw materials from independent suppliers. This tendency of keeping large, vertically integrated supply lines would remain a typical feature of the Eindhoven innovation system until the recent reform processes in the region (Heerding 1989; Otten 1995; Van Hooff 2008; Philips, 2012).

A fourth characteristic of the Philips-dominated innovation system is the heavy influence of the firm not only in the economic structure of the region but in nearly all aspects of its development. Since the Eindhoven region was originally a rural area without a history of extensive urban development, Philips had to bring in workers from neighbouring regions and even farther away. This process would continue with the attraction of foreign workers (so-called 'guest workers') from Southern Europe and Northern Africa in the 1950s and the currently ongoing attraction of international knowledge workers from all over the world to the Eindhoven region. Bringing together the necessary concentration of workers required a fast process of urbanization, and Eindhoven became an industrial boomtown with a diverse mix of population. The spatial planning of this boomtown was dominated by Philips in two ways. First, Philips's offices, laboratories, and factories were developed all over Eindhoven, both within and outside of the city centre. And second, Philips took a leading role in ensuring the provision of adequate housing for its workers through its own housing corporation, Hertog Hendrik van Lotharingen. Philips built several neighbourhoods for its workers, including the neighbourhoods Philipsdorp, Drents Dorp, and Philipswijk, with a total of more than 1,500 homes.

Philips's role in the local community went beyond the attraction and housing of its workers. Out of a sense of paternalistic care, the firm took on the responsibility of providing its workers with adequate education (it founded a local technical school and a library and used to provide much of the funding for the Technical University Eindhoven) and recreation (it founded the local football club PSV, created several parks and an expensive swimming pool for the city, and established many of the local cultural amenities). The high profits from Philips's innovative products enabled the firm to make these investments in the local community, and the corporate culture and personal values of its founders gave Philips the motivation to take on this role. Gerard and Anton Philips had family connections to Karl Marx, and the family would go on to have a strong socialist and progressive character (Otten 1995; Janssen 2011).

Philips's paternalistic role in the local community and its attraction of large numbers of workers from outside the region created a tight social group of workers with a strong loyalty to and dependence on Philips. Inhabitants of Eindhoven who did not work for Philips were excluded from some of its services and at times expressed resentment against its dominant position in the region. Its active role in the community gave the Philips family a strong influence on local politics, at the expense of other local actors. Philips's leaders personally founded and led the provincial business network BZW and strongly influenced the choice of local mayors and the leaders of the chamber of commerce. From its foundation up to the 1990s, many of the administrators and professors of the Technical University Eindhoven were handpicked by Philips (Beckers, 2008).

While Philips was the sole large employer in the Eindhoven region before WW II, the automobile producer DAF gradually emerged as a secondary leader firm in the city. Starting from the 1930s, it produced trucks and trailers, but it only really started to take off when in the 1950s and 1960s it received large orders for trucks from the Dutch army, and it became a major producer of passenger cars. DAF developed an extensive network of supply firms, first near Eindhoven but quickly expanding into the nearby Dutch province Limburg, and Belgium. But in terms of R&D investments, DAF only had a minor impact on the regional economy, and it did not play the same kind of role in Eindhoven's socio-cultural development and urban planning as Philips did. More importantly, the supply and R&D networks of Philips and DAF, while located in the same region, had very little functional overlap (Van den Berg *et al.* 2008). Philips's suppliers had little to offer to DAF and vice versa, and the firms had little to learn from each other's R&D. In other words, while Eindhoven was more than a single-company town, it did not function as a cluster of inter-related firms and hence did not constitute a dynamic urban innovation system.

Several cities close to Eindhoven followed a similar pattern, albeit at a much smaller scale, in terms of being dominated by a strong leader firm. Océ emerged as a major producer of copy machines and other office equipment in nearby Venlo, and in southern Limburg province, DSM, originally a state-owned mining company, developed itself as a high-tech firm when it diversified into the chemical industry from the 1960s onward. As the supply networks of firms gradually expanded in size and geographical extent, these firms are starting to play a role in the Eindhoven innovation system and may eventually become an integral part of it.

Signs of change

Halfway in the 1970s, both Philips and DAF reached a high point in employment and output, and the Eindhoven innovation system reached a point of maturity. In 1974, Philips reached its maximum employment level of 412,000 worldwide, of which 91,000 were in the Netherlands, but the number of workers in the Netherlands had already peaked in 1970 with 98,000. It achieved several technical breakthroughs between the 1960s and 1980s, among others with the introduction of the compact cassette, the compact disk (CD), and the DVD. A very expensive R&D effort also gave Philips advanced capabilities in transistor and chip production, but attempts to break through as a computer producer did not deliver significant results.

Two major changes occurred in the global economic context, which laid bare some of the weaknesses of the system as it had developed up to that point. On the one hand, as discussed in Chapter 2, competition in high-tech sectors became much more fierce and product life cycles shortened, and advanced academic and private research became much more widely distributed (Chesbrough 2003). In such a knowledge-rich world, increasingly high investments in R&D are needed to make a breakthrough with product innovation, and the time available to recover the expenses in exploiting the new product on the market has shortened. In other words, internal R&D became more expensive, and its returns became smaller or harder to capture. On the other hand, in low-end sectors, competition on price became fiercer, partly because of the rise of newly industrializing countries.

The Philips-dominated system of Eindhoven was not well prepared to face these challenges. First, the problem of decreasing returns to internal R&D was exacerbated for Philips because of the poor connection between its research and business departments. As mentioned, Philips had a very broad research portfolio containing many R&D projects with limited value to its business department. In other words, research was not aligned to the opportunities identified by the business department, but rather the research department had its own interests and preferences, regardless of business applications. When a fast response was necessary to exploit a market opportunity, Philips's R&D was not always able to respond successfully.

Second, increasing competition in the low-cost segment put pressure on Philips's extensive network of vertically integrated firms, many of which produced low-value-added goods that were hardly related to the core competences of the firm. It became increasingly clear that many of these factories, representing significant numbers of jobs in the region, would have to be closed. And third, it became clear that the innovation system's strong dependence on one leader firm made it vulnerable in times of economic change. For if Philips could not effectively adjust to changing circumstances, the entire network of suppliers, the Technical University, and other organizations dependent on Philips could remain locked in to an outdated model. As many industrial cities in Western Europe found out in this time of change, they could grow rapidly with the rise of their leader firm but could also get into a deep crisis when this firm's booming years ended.

Economic crisis and reform

In the context of the gradually emerging changes in the world economy described earlier, the oil crises in 1973 and again in 1979 put an end to the growth of both Philips and DAF. Consumption slumped in much of the Western world, and the export-oriented firms in the Eindhoven system were hit especially hard by this. But a national policy of wage reduction in the Netherlands (Wassenaar Agreement) and a resurgence of foreign consumer demand in the 1980s restored the export market of Philips and DAF (which by now had been acquired by Volvo), and both firms regained most of their pre-crisis production levels. During this new period of growth, industrial production capacity expanded strongly in many countries and DAF carried out an ambitious expansion into the UK market. When a new recession struck in the early 1990s, a slump in consumer demand was coupled with overproduction, and both Philips and DAF entered into a deep crisis. The response of local actors to this crisis reformed the system into its current shape. In little more than a decade, the region changed from a textbook example of a vulnerable company town to one of the world's most renowned innovation systems (for a detailed overview of this transformation process, see Van den Berg *et al.* 2008).

The first to respond to the crisis was Philips. The firm had already started to gradually trim down its extensive network of vertically integrated suppliers and no longer undertook the kind of major projects for the local community that had produced Philips libraries, Philips swimming pools, and other facilities in earlier times. In 1989, it even closed the prestigious technology museum Evoluon, which it had built for Eindhoven in the 1960s to celebrate Philips's 75-year bond with the city. In spite of these gradual reforms, Philips still faced urgent cash-flow problems when the 1990s downturn set in, and for a time bankruptcy of the firm was not impossible.

As a response, in 1990 Philips started the massive Operation Centurion, one of the largest corporate restructuring programs in the world at that time. This program included massive layoffs (about a quarter of its workers in just four years' time), the accelerated closure of its remaining activities not related to its core business, and a rationalization of its R&D efforts. The controversial restructuring succeeded in reducing Philips's overall costs by a third in just three years' time. For the automobile producer DAF, the crisis set in much more suddenly and caught the firm in the middle of ambitious expansion plans. Banks responded very strongly to DAF's cash-flow problems and suddenly withdrew all funding from the firm, forcing it into bankruptcy in 1993. Three years later, DAF was acquired by Paccar, an American firm, and restarted its operations, but by that time massive layoffs had already occurred.

The most visible consequence of the 1990s crisis and reform of the Eindhoven innovation system was the accelerated shift from low-end manufacturing to high-value-added and knowledge-intensive activities. While Philips closed down or off-shored much of the factory work in the region, it actually increased the concentration of its R&D activities in the Eindhoven region. Related to this change of focus, Philips shed all activities not directly related to its core competences, now defined as healthcare, lifestyle, and lighting. This excludes not only its low-end activities in, for example, glass and plastics production but also high-tech products like semiconductors and lithography. Rather than hastily selling off these operations, Philips supported them to become independent firms in a process of spin-off. Among spin-off firms, ASML would go on to become a worldwide, multibillion-dollar giant in lithography, and NXP became one of Europe's leading semiconductor firms.

While not all Philips spin-offs turned into viable companies, those that succeeded went on to become leader firms in the Eindhoven system. Rather than a system with one giant (Philips) and one smaller leader firm (DAF), each with a network of dependent suppliers around it, the innovation system evolved into a more interconnected network with multiple leader firms as its nodes. As suppliers were forced by the downturn to reduce their dependence on a single local customer, they chose a variety of strategies to survive and grow. For example, some DAF suppliers learned to broaden their capabilities to be able to supply Philips or one of its spin-off firms besides their core customer DAF. Another strategy used by suppliers was to work together in inter-firm alliances so together they could attain the capabilities to find new customers at a European or even global scale. The result has been a more integrated firm cluster as part of a more dynamic and less vulnerable urban innovation system.

Besides narrowing the focus of its R&D effort, Philips also embraced a new approach to the way it carries out its research and development. Under the old model of 'closed innovation', Philips tried to develop the knowledge needed for its operations in internal R&D labs, closed off to the outside world in order to safeguard the secrecy of its knowledge base. However, as achieving technological breakthroughs tended to become increasingly expensive while at the same time shorter product cycles reduced the time available to exploit the resulting product innovations, Philips realized that it had to tap sources of knowledge beyond the boundaries of the firm. As part of Operation Centurion, the firm started to think strategically on which R&D to carry out indoors and which to buy from external sources. When one of Philips's research staff read the book *Open Innovation* by Henry Chesbrough (2003), the firm embraced open innovation as a systematic new model for its R&D strategy.

The final and most fundamental consequence of the crisis and reform has been the changing social and organizational structure of the Eindhoven system. The coinciding downturn of the region's two biggest firms made local policymakers realize that the Eindhoven economy had become too vulnerable to the ups and downs of business cycles and that the region had to develop its organizational capacity to address this structural weakness. Up to this point, local government and university leaders had been relatively passive compared to their counterparts in other regions. Philips used to directly appoint research staff at the Technical University, and local government was often bypassed when Philips contacted national-level policymakers directly to address local issues normally under the authority of the city government. In a sense, local stakeholders had to learn how to take charge in the region now that Philips did not play its patriarchal role anymore.

A first move towards stronger regional-scale cooperation happened when in the 1980s, as a result of Dutch national policy, a regional authority for Greater Eindhoven was set up. Shortly thereafter, national government abandoned its policy for stimulating regional governance again, but the idea of regional cooperation kept its momentum among stakeholders in the region. Two important institutions were founded in the early 1980s: an economic development office (NV REDE) and a Brabant provincial development office (BOM). The administration of NV REDE is fully public, but it has an advisory council consisting of representatives of the local chamber of commerce, labour unions, and representatives of Philips and other major firms. Because of national regulation, NV REDE could only be set up as a voluntary cooperation organization, limiting its ability to address controversial issues at the regional scale, where conflicting interests have to be balanced. But it nevertheless proved successful in carrying out specific projects to address interests shared by regional stakeholders. At first it mostly focused on developing business parks, with the additional goals of stimulating innovation and facilitating the start-up of new firms. For example, it helped to create the Science Park Eindhoven, a selective business park admitting only innovative firms and specializing in ICT. Also, it started the development of a business park near Eindhoven

Airport, with the aim to build up a cluster of export-intensive firms that would benefit from being located close to the airport. While these projects may play an important role in the innovation system by themselves, the most important role of NV REDE was to strengthen the regional organizational capacity.

The other major catalyst in regional cooperation is the SRE, a regional alliance of municipalities in the region. When in 1993 Helmond joined the cooperation organization between Eindhoven and some of its neighbouring communities, the SRE was created and covered the entire Greater Eindhoven region. Like NV REDE, the SRE is a voluntary organization, and this has especially limited its ability to solve the region's traffic congestion problems, as infrastructure development remained highly controversial among local community governments. But whenever regional actors found a shared interest, NV REDE and SRE together proved very effective vehicles for putting them into practice. An important factor in making this work was the fact that in the 1990s, a small group of people in charge of the Eindhoven community government, the chamber of commerce, and the Technical University were able to work together and shared a sense of urgency. Through NV REDE and SRE, they mobilized regional stakeholders for a response to the region's economic crisis.

When the 1990s crisis hit, NV REDE responded in two main ways. First, they arranged temporary financing for firms threatened by bankruptcy. In this way, several supply firms that might have been dragged under by the reorganization at Philips and the bankruptcy of DAF were saved. And second, this emerging alliance of regional stakeholders also decided to apply for EU assistance. The mayor of Eindhoven took the initiative to invite representatives of the chamber of commerce, SRE, other local government representatives, local firms, and the Dutch secretary of Economic Affairs to set up a project proposal. Together they decided to start projects to strengthen the local research infrastructure, to stimulate R&D not only at big firms but also at smaller local firms and suppliers, and to stimulate spin-off formation. Another aim was to solve a growing mismatch at the labour market, with a high number of unemployed factory workers coinciding with a lack of skilled technicians. All municipal governments in the Eindhoven region were willing to contribute a fixed annual sum per inhabitant, and the Stimulus project was formulated to apply for EU regional funds. The resulting projects not only helped the region diversify and grow out of the downturn but also had a more subtle effect. Since EU funds cannot be targeted at any single firm, groups of firms had to be formed that together took part in an EU project. This stimulated the strengthening and broadening of inter-firm networks in the region.

When the Stimulus project finished, it was followed up by a new project named Horizon. The main difference was that Horizon was carried out more or less without subsidies and therefore had to be organized in a very different way. NV REDE took on a much more modest role in Horizon and let private firms and other local stakeholders take charge of its projects. This worked because firms were consulted extensively to find out what shared problems they faced and in what ways they would be willing to work together to address them. The Horizon project team of NV REDE would then help these private actors with paperwork and other practical and organizational issues. The Horizon goals (selected after consulting local stakeholders) were to address the lack of highly skilled technical workers in the region, to increase the commercial exploitation of private and university R&D, to diversify the local economy, and to strengthen the reputation or branding of the Eindhoven region in the Netherlands and abroad. After a few years, the 'Brainport' strategy replaced Horizon, keeping the same general targets and working style (Van den Berg *et al.* 2008).

In sum, in a short time, the Eindhoven region transformed itself into a more diverse region, keeping its high-tech profile but becoming less dependent on its leader firms. A strongly hierarchical network of leader firms, with their fully dependent suppliers, changed into a more interconnected cluster of large firms, SMEs, and knowledge institutions. And finally, the region went from a relatively weak local and regional governance structure to becoming a pioneer in public–private partnership, with an organizational capability strong enough to combat economic crises.

3.3 Current profile

The present section discusses the current profile of the Eindhoven region, presenting some indicators of its innovation performance and introducing the main innovation hot spots.

Innovation performance

The Eindhoven region is one of the most innovative regions in Europe, with a strong specialization in several knowledge-intensive sectors. With 2.4 per cent of GDP being spent on R&D, the province of Brabant receives more investments on research and development than the Dutch average (1.9 per cent) and the EU average (2.0 per cent). Remarkably, the government's share of R&D expenditures in Brabant is significantly lower than the Dutch average, leaving a much larger share for the private sector (see Figure 3.1).[1] The reasons for this low level of public investment in R&D may be found in the historical development trajectory of the city and its region. Eindhoven used to be perceived as a Philips company town, with not just the local supply chain but also the local university (TU/E) geared towards serving the needs of leader firm Philips.

Several indicators can be used to illustrate the region's innovation performance. Firms in the region derive a significantly higher share of revenue from new or improved products (17 per cent versus the average of 6 per cent), and R&D personnel are a much more substantial share of total employment in Eindhoven than in the overall Dutch economy (8 per cent versus 1 per cent; CBS-CIS 2008).

Patent data show that Eindhoven is the region with the highest absolute number of patents across Europe, also if measured per capita. In 2008, almost 1,000 patents were registered in the Eindhoven region – considerably less, though, than in 2001, when more than 2,000 patents were registered (Eurostat, 2008). Compared

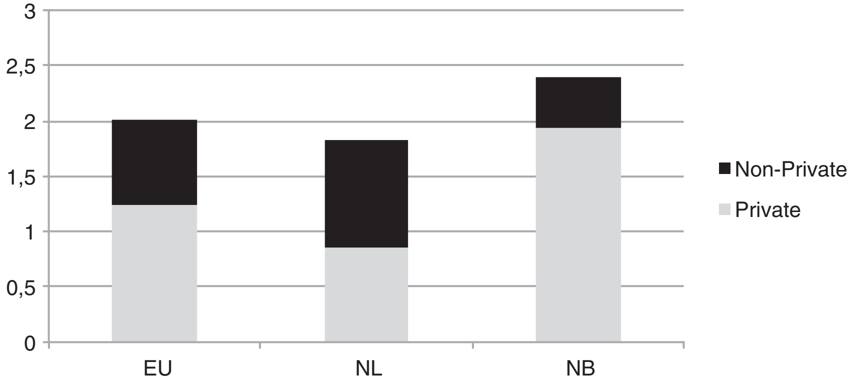

Figure 3.1 Public and private investment in R&D in 2009 as percentage of GDP, EU average, Netherlands, Noord-Brabant province
(Source: Eurostat)

with competing regions such as Munich and Stockholm, Eindhoven's patent output showed a remarkably rapid downward trend in the 2000s (see Figure 3.2).

Another remarkable trend is the declining dominance of Philips in the Eindhoven system. While Philips singlehandedly accounted for the great majority of R&D spending in the region in the early 2000s, it made a much more modest contribution by 2011. While still the number-one firm in R&D spending in the Eindhoven region in 2011, ASML's quick rise to prominence had already made it almost an equal to Philips. It should be mentioned that Philips's declining trend is to a large extent the direct result of its policy of downsizing, since the number-two (ASML) and number-three (NXP) firms were actually part of Philips before being spun off.

Data on the economic structure of the Eindhoven region show that the region is specialized in the automotive sector, life tech, design, and high-tech systems and

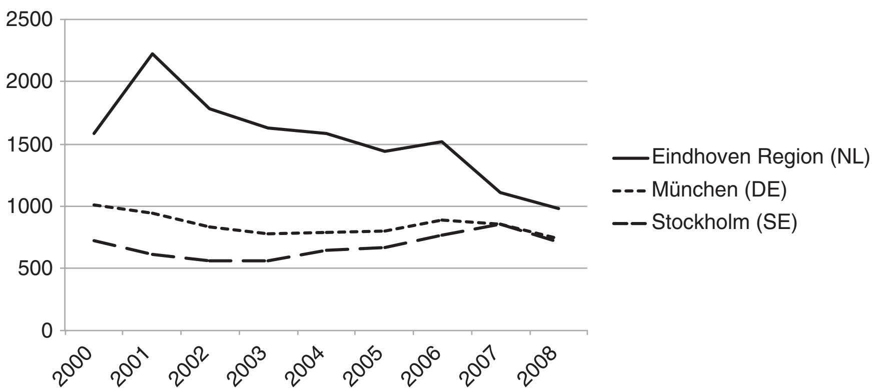

Figure 3.2 Patent output 2000–2008 (for Eindhoven, Munich, and Stockholm)
(Source: Eurostat, own calculations)

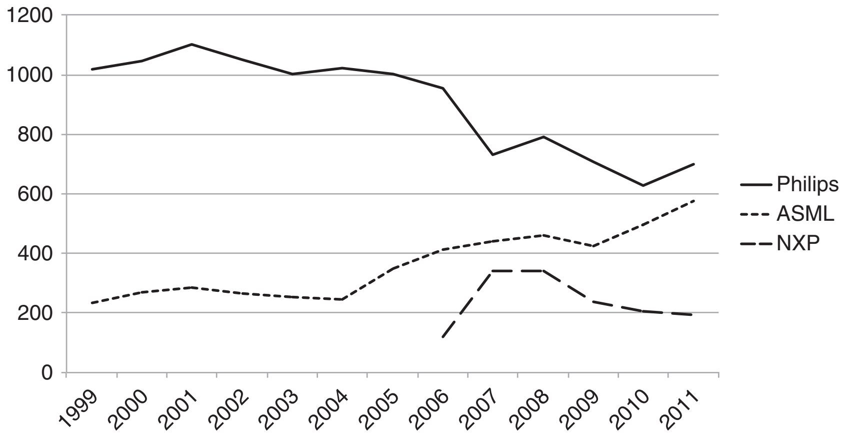

Figure 3.3 R&D expenditures of Philips, ASML, and NXP in millions of euros
(Source: Technisch Weekblad, own calculations)

materials. Location quotients (LQs) give an indication of the relative specialization of the region in these knowledge-intensive sectors compared to the Dutch average (see Table 3.1).[2] New firm creation (start-ups minus firm closure) can be observed in only two sectors: between 2007 and 2012, the number of firms in the high-tech systems and materials sector and the design sector increased with 43 and 53 per cent, respectively, while the two other sectors (automotive and life tech) remained relatively stable (CBS 2012).

In the Eindhoven region, knowledge-intensive sectors are concentrated in various innovation hot spots, to be introduced next. In section 3.4, we will analyse their development in more detail.

The High-Tech Campus

The High-Tech Campus (HTC) is a science park located on the outskirts of Eindhoven. It used to be a closed and secretive Philips lab, but in 2003, Philips decided to open it to other firms and research institutions. Philips provided a fixed budget

Table 3.1 Location quotients of number of firms in knowledge-intensive sectors, relative to Dutch average, 2007–2012

	2007	*2012*
Automotive	1.57	1.36
Design	1.07	1.14
High-tech	1.15	1.10
Life-tech	1.05	1.28

(Source: CBS, 2012, own calculations)

for the redevelopment of its private lab into a campus with all facilities necessary to attract both large firms and start-ups. In 2012, the first phase of redevelopment was completed and Philips sold the campus to a consortium of Dutch investors. Currently the HTC, an area of only about 1 square kilometre, houses a large number of firms, many of which are multinationals. Together these firms employ about 8,000 workers on the campus, most of whom are researchers and other knowledge workers; about 20 per cent are international knowledge workers. The park is exclusively a space for work and research; it does not include any residential space. While it aims to be a vibrant, attractive place during the day, the park closes at 8.30 p.m. during the week and the weekend and therefore offers only limited scope for becoming the centre of a social community.

Strijp S

Another relevant concentration of knowledge-intensive activities in the Eindhoven region is Strijp S, a former location of Philips. This 27-ha area is to become an attractive place for urban living and a hot spot for design and creative entrepreneurship. Strijp S is a roughly triangular space, bordering the railroad on one side and a residential area and business space on the other. Up till the opening of the area in the early 2000s, the area was popularly known as the ‘forbidden city’ because the general public was not allowed to enter the area. It housed the famous R&D laboratory NatLab, where most of Philips’s technical breakthroughs took place.

When Philips decided to downsize and focus on a small number of high-tech sectors in the 1990s, it closed most of its manufacturing on Strijp S and concentrated all its R&D on the High-Tech Campus. So while the HTC continued to play a key role for Philips, as an open campus rather than an exclusive Philips area, Strijp S quickly lost its relevance to the firm. Because of the proximity to the city centre and the high visibility of the area, and because of its many industrial heritage sites, local stakeholders in Eindhoven realized that they needed to come up with a vision to redevelop Strijp S. The city government of Eindhoven and the real estate company Volker Wessels together developed a vision to turn Strijp S into a multifunctional creative district, combining urban living and working and providing an anchor for the emerging design sector. They set up a management company (Park Strijp Beheer) in 2002 to set a general framework for the redevelopment project, which the social housing corporations Trudo and Woonbedrijf went on to implement together.[3]

TU/E Science Park

The third innovation hot spot in the Eindhoven region is the science park of the Technical University Eindhoven (TU/E), located at the attractive Dommel River valley and at walking distance of the central railway station. While it has been a major centre of education and research for decades, only recently the university decided to redevelop it into a multifunctional campus. In the 1990s, the first important changes took place. First, the connection between the city centre and the campus was drastically improved. A natural barrier between the campus and the inner city of Eindhoven, an undeveloped plot with low hills obstructing travel, was developed into the Kennispoort (knowledge gate). Pedestrian and bicycle transport access was created through the plot and the Kennispoort building was constructed, housing not only university offices but also the regional chamber of commerce. As the TU/E developed its incubation strategy, another part of the campus was designated as temporary business space for starting firms. However, this was still very limited in scale, and the TU/E campus retained the atmosphere of a monofunctional area dedicated to education and research. As the redevelopment of the other knowledge hot spots (HTC and Strijp) took off in the 2000s, the TU/E administration realized that the university could also play a more prominent role in the Eindhoven system. In its strategic plan for 2020, the university plans to double its number of students to more than 10,000 and strongly raise its international profile.

Brainport Innovation Campus

A location that in the near future could play a key role in the Eindhoven innovation system is the Brainport Innovation Campus, a high-tech business park that is still in the planning stage but is expected to be open for tenants by 2014. The 70-ha park will be located close to the airport and well connected to the city centre. The Brainport Innovation Campus (BIC) was conceived after a number of high-tech suppliers in the region, most of them suppliers of the semiconductor systems builder ASML, expressed an interest in co-locating in a new business park. As described in the previous section, OEMs like ASML demand increasingly high quality of their suppliers and stimulate them to work together to create an integrated value chain. To help them meet these high requirements, a group of high-tech suppliers united in the cooperation Brainport Industries (which currently has 65 members) decided to also integrate their value chain geographically by together creating the BIC in order to facilitate interaction and knowledge exchange (Buck Consultants 2010). Besides this, the new campus is also planned to house a vocational school that trains workers in the specialized technical skills needed by many supply firms and an incubation centre for start-up firms stemming from or relevant to the tenants of the BIC.

3.4 Key features

This section discusses the key features of the Eindhoven innovation system based on the findings of interviews with organizers and decision makers in the region.

Leader firms

The first key feature of the Eindhoven innovation system, identified by many of the interview respondents, is the presence of leader firms. The region possesses a small number of large leader firms with a strong bond with the region, including first and foremost Philips and to a lesser extent ASML, car-producer DAF, and the chemical and biotech firm DSM, located somewhat further away from Eindhoven. These firms are major innovators in their own right and also played a key role in strengthening the region's innovation system. Leaders firms not only played an important role in building a critical mass of specialized workers, tacit knowledge, and research infrastructure in the region, but they also facilitated spin-off formation to create a network of innovative intermediary suppliers, from which the next generation of leader firms could emerge.

The build-up of critical mass was most important in the early phase of the development of the innovation system. Once established, this critical mass of knowledge, workers, and infrastructure became a fertile ground for later knowledge-intensive economic activity, which continued to be valuable also when the leader firms around which the critical mass initially emerged took a more modest role in the regional economy. The build-up of critical mass is compounded by the process of spin-off formation, as spin-off firms tend to locate close to their parent firm and therefore add to the amount of economic activity in the region.

Especially in the 20th century, Philips was a prime example of an innovative firm that generated more potential projects, new product designs, and ideas than it was able or willing to exploit internally; the most viable of such projects were the seeds from which spin-off firms could grow. The company invested heavily in a wide range of R&D, ranging from advanced basic research to application-oriented R&D and design, which produced a local knowledge base from which several successful spin-off firms emerged. If resulting spin-off firms were active in relevant industry sectors, Philips could act as launching customer. Besides sufficient funds, this also required the trust and patience needed to work with young firms that still need to improve their products and overcome common start-up problems.

If besides an extensive and sustained R&D effort leader firms are also supportive towards workers with entrepreneurial ideas, then the formation of a cluster of spin-off firms is expected to speed up further. While in the past Philips tended towards secrecy, it set up entrepreneurship courses for its workers to promote spin-off formation as part of its strategy of restructuring from the 1990s onward. Moreover, it became active in spin-off incubation and, among other things, opened its clean rooms at the High-Tech Campus to start-up firms.

A further and sometimes overlooked aspect of spin-off formation is that a strong urban innovation system needs independent start-up firms rather than suppliers that remain fully dependent on their parent firm. ASML is an excellent example of how a leader firm can manage this process. While being a fairly recent spin-off of Philips, ASML has already gathered an extensive network of suppliers and spin-off firms around itself, most of which are located in the Eindhoven region. To promote the sustainability and growth prospects of this firm cluster, ASML stimulates its suppliers to find other customers besides ASML and, when needed, it helps these firms upgrade and gain access to a (international) network of customers. ASML benefits from this because firms with a diversified customer base are more reliable suppliers, less prone to bankruptcy (and supply discontinuity for ASML) during the frequent ups and downs that characterize the high-tech systems sector.

Regional governance

The second key feature of the Eindhoven system is the constructive cooperation within its regional public and private governance network. The region's economic difficulties in the 1990s constituted a trigger for local firms and governmental actors to organize themselves and approach national and EU-level authorities with a coherent vision for the future development of the region. While this crisis was already long past, the network that was created for combating the economic crisis turned out to be equally effective for the governance of the highly innovative and fast-growing Eindhoven system of the 2000s and beyond.

The Eindhoven innovation system is characterized by a pro-active public–private co-operation, able to quickly mobilize a network of actors when the need arises. For example, when a sharp cyclical downturn hits the region's industry or when an opportunity arises for attracting a key research institute to the region, an alliance of, among others, the Eindhoven city government and its mayor, the local chamber of commerce, and leaders of large firms can quickly organize and take action. Also, the Eindhoven region has a number of firms that are strongly embedded in and committed to the region. Firms like Philips and DAF (both of them originally family-owned firms) have a long history in the region, and its directors and workers have a strong sense of attachment and responsibility for the region. Downsizing and foreign ownership can make this regional embeddedness more limited in the future, but several younger firms have expressed an aspiration to take a similar role in the region when their firm size allows it.

In the 1990s, the high level of private-sector involvement was complemented by a reasonably effective regional government. Eindhoven is one of the few Dutch cities in which regional government (as a complement to national and local government) really took root in the shape of the cityregion Eindhoven (SRE). This alliance of 21 local governments is organized on a voluntary basis and has only been truly effective on policy areas for which consensus exists (for example, it has struggled to deal with problems of traffic congestion and oversupply of office space), but it has proven effective in the facilitation of high-tech industry. Part of its effectiveness stems from the fact that these 21 local governments are willing to contribute financially, enabling them to co-fund projects for which only partial funding is available (which is the norm for both Dutch and EU-level regional policy).

With these favourable governance conditions in place, a special public–private organization was able to grow out of the temporary crisis-fighting projects (Stimulus and Horizon) organized by local and regional actors. This organization called Brainport Foundation is a permanent public–private partnership charged with the implementation – through its subsidiary Brainport Development – and increasingly also the formulation of regional economic policy (see Box 3.1 for an in-depth analysis of public–private governance at Brainport Foundation).

Box 3.1 Brainport Foundation

Brainport Foundation is the organization in charge of public–private development projects in the Eindhoven region, which it implements through its development company Brainport Development. Brainport Foundation and Brainport Development evolved out of the project organization of the Stimulus and Horizon projects and have over time built up a strong reputation in the region. In 2005, an alliance of local stakeholders formulated the Brainport strategy, including plans to address what they identified as the major challenges and opportunities to the region in the near future. Because of their consensus on these issues, they formed an effective lobby at the Dutch government, resulting in the national government affirming its support for the plan. These local stakeholders include the mayor of Eindhoven, the chairman of Philips, the president of the Technical University of Eindhoven, and the chairman of the regional chamber of commerce. Brainport Development was set up to implement this strategy. It has about 50 employees, and in addition it has 28 project leaders who work part time for Brainport Development besides their function at a local firm or institution. Brainport Development has a permanent representation in Brussels to represent the region towards the European Union institutions.

While its predecessors originally focused on coping with the 1990s crisis, Brainport Foundation's mission has gradually become more and more ambitious. In its 2020 strategy, it aims to further strengthen the Eindhoven region as one of the world's leading high-tech regions. To reach this goal, its project teams keep a continuing dialogue with the region's firms and research institutes to identify problems and challenges. Based on this fieldwork, it formulates a coherent strategy resulting in specific action plans to be carried out. These action plans are then presented to local stakeholders, who are asked to provide funds and personnel to carry out the tasks identified. Brainport Development has a budget to help these private actors organize these projects and takes care of all legal paperwork involved.

Two concrete examples help illustrate this working style. When local firms informed Brainport Foundation of a widespread and growing lack of skilled technical staff, one of the action plans proposed was to organize activities in which primary and secondary school students are brought into contact with researchers of local high-tech firms in a fun and informal way. Many of the region's firms were then found willing to free up researchers for these activities, while Brainport Development made all arrangements with local schools.

A second example of a successful Brainport Foundation project is the 'knowledge workers plan'. When a deep recession hit the region's high-tech firms in 2008 and 2009, many firms had to lay off part of their research staff to avoid financial problems. However, they realized that as soon as the recession ended, they would face a shortage of knowledge workers again, made worse by the recent layoffs. Brainport Foundation arranged with the national Ministry of Economic Affairs to provide funding for local research institutions to temporarily employ the research staff to be laid off at local firms, ensuring that their research projects could continue through the recession. When the recession ended, firms hired back their research staff, and as a result, precious human capital was not wasted for the region.

While the voluntary participation of private stakeholders is one of the success factors behind Brainport Foundation, it also means that not every project can be realized as planned. While the Eindhoven Region is characterized by a culture of solidarity and collaboration, some action plans that are especially costly or difficult to carry out are sensitive to free-rider problems. By May 2012, some of Brainport Foundation's labour market-related projects suffered from this problem. Similarly, its program to strengthen the urban atmosphere in the Eindhoven city centre still depends on the efforts of a few stakeholders such as Trudo (see the discussion on Strijp S elsewhere) and has yet to develop a coherent policy network.

In the Eindhoven Region Brainport Foundation is generally regarded as a successful organizational platform that helps stakeholders in the innovation system identify and address shared challenges. Representatives of Brainport Foundation and many of the other stakeholders that were interviewed (independent of one another) mention the following as its major success factors:

1 It started small and began by carrying out concrete projects that achieved noticeable results within a limited time period.
2 Regional stakeholders shared a sense of urgency, causing them to be willing to begin far-reaching cooperation to address shared challenges. Moreover, when the immediate crisis was over, Brainport Foundation was successful in keeping this sense of urgency alive.
3 Regional development organizations like Brainport Foundation need sufficient funding to take care of project organization and to keep a permanent staff to continuously visit local firms and research institutions to ask them about problems and opportunities to be addressed in projects. But if its budget becomes too large, the organization may become too independent and complacent. Because the development company Brainport Foundation has a limited budget, it needs to mobilize private actors to carry out the projects formulated by Brainport Foundation, which requires constant dialogue and establishing strong relations. This, in turn, has shaped Brainport Development's organizational capacity. Similar projects in other regions have tended to fail simply because an overly generous budget lead their regional development organizations and their development companies to become too independent of private stakeholders.
4 Once a strong local network has been established, local actors will themselves realize when problems and opportunities exist for which Brainport Foundation can play a role. Once this point has been reached, the regional development organization has become a key intermediary in the innovation system, but constant dialogue with private actors is needed to maintain this position.

With Brainport Foundation, the region has a flexible tool – that fits well in the model of Triple Helix governance (see Brouwers *et al.* 2009) – for combating the effects of cyclical downturns and also for addressing long-term constraints and opportunities for the further development of the system. This is important for urban innovation systems because of their tendency to grow in leaps and bounds, alternating between periods of rapid growth and sudden cyclical downturns. In the Eindhoven model, the government acts more as a facilitator than as the sole decision maker in the project, while private actors take part in deciding the specific content of the projects (traditionally, government would monopolize this role) and sometimes provide co-funding. Moreover, public, private, and academic actors partly carry out their roles in the project directly, while other tasks are carried out through Brainport Foundation, in which all of these actors are represented.

Research infrastructure

The third source of strength of the Eindhoven system is its research infrastructure. Key elements in this network of research institutions include the Technical University Eindhoven (TU/E), the Netherlands Organisation for Applied Scientific Research (TNO), and the Holst Centre for collaborative pre-competitive research. Its research infrastructure has a number of peculiar features, leading to both strengths and challenges for the region.

The TU/E is a relatively young university with a reasonably strong reputation. With just more than 9,000 students and 2,000 academic staff, it is a medium-sized university. Philips was heavily involved in its founding in 1956, providing much of the funding and knowledge base of the university, handpicking most of its professors and taking in most of its graduates and R&D output. Over time, the TU/E became less dependent on Philips, but it continued to be perceived (and to perceive itself) as a university in service to local industry (Beckers 2008). With 11 per cent of its publications done in collaboration with industry (2002–2006; Tijssen *et al.* 2009), the TU/E is global leader in university–industry co-publications.[4]

This strong focus on cooperation with local industry has been a mixed blessing for the university. It allowed the TU/E to do cutting-edge research in a number of specialized fields (namely those fields Philips and other key local firms are specialized in) and assured that a large share of its research was actually usable for industry. Both the TU/E and local firms profited from this tight relationship, but the TU/E was more dependent on local firms than vice versa since most large firms also have internal R&D labs to do most of the R&D they need. Moreover, it reduced the ability for independent initiatives at the TU/E, which created a challenge when Philips retreated from its formerly dominant position in the region.

Currently, according to respondents within the university and from local industry, the main role for the university in the system is to attract and educate talented students, providing them with skills useful to local industry. While research is an equally important mission of the university besides education, in practical terms, this research again mainly has the function of training highly skilled knowledge workers. While the research carried out at the TU/E may often be too theoretical to be useful to firms, allowing PhDs to carry out (fundamental) research gives them the training and experience to work for the local industry after finishing their research. Besides these traditional academic roles, the TU/E also acts as an incubator for academic spin-off firms. So far it has been successful in creating a reasonably large number of start-ups, but few of these show the potential to grow into major firms. A recent change in approach to start-up incubation may change this (see Box 3.5 for a discussion).

Local stakeholders, both public and private, want to see the Technical University expand and take a stronger role in the innovation system. The Technical University has made plans for cooperating or even merging with the other two Dutch technical universities, forming the 3TU federation. This allows specialization, a combination of mass and focus, and a stronger branding abroad. However, so far, 3TU has mainly been a lobbying organization and discussion platform. At the same time, the Technical University Eindhoven plans to cooperate with geographically closer universities with a broader profile (not focused exclusively on technical disciplines). It remains to be seen whether this will make a big impact on the innovation system (Bits and Chips 2011). Another aspect of the expansion of the TU/E is its recent plan to restructure the university campus, creating a more attractive and internationally recognized TU/E Science Park.

Besides the TU/E, the region has a number of other key research institutes. TNO is a national research institute founded by the Dutch government in the 1930s with the aim of strengthening the innovativeness of the Dutch industry. It consists of a number of specialized research laboratories that carry out applied research for a specific industrial sector. TNO Industry – as this part of TNO was called until 2004 – focuses on high-tech systems and materials, as do most of the key firms in the region. While it was originally located in the Delft region (the other main high-tech region of the Netherlands, which is located in the Randstad urban core of the country and hosts several world-leading firms and research institutes), public and private stakeholders of Eindhoven together succeeded in convincing TNO Industry to move out of this highly attractive location and settle in Eindhoven instead. Because of the timely response to the opportunity of relocation and the well-developed proposal offered to TNO, the plan succeeded and TNO Industry moved to the TU/E campus (Beckers 2008).

TNO has the aim of generating spin-off firms from among its research staff. The institute works according to the principle that as soon as a specific R&D project has repeatedly proven to be valuable for private firms, it is ready to spin out of TNO. Some of the researchers involved in the project will then leave TNO along with the necessary patents to create an independent spin-off firm. To ensure the success of spin-outs during their initial phase, TNO created a separated non–state-funded entity to support the TNO spin-offs in raising funding, housing, and experienced entrepreneurs whose main task is to find additional funds for the start-up from private investors or large interested firms. In this way, TNO over the years created around 60 spin-offs.

Open innovation

One aspect of Philips's reorganization following its difficult period in the 1990s was to downsize and rationalize its R&D policy. Rather than funding a large number of internal R&D projects from a broad range of scientific disciplines, the firm decided to concentrate on a few core disciplines and use external sources of knowledge whenever possible. In 2003, Philips's directors connected their policy with the ideas of Henry Chesbrough on open innovation (Box 3.2).

Box 3.2 Open innovation

In his 2003 book *Open Innovation*, Henry Chesbrough argues for a new approach to innovation. In the old model of 'closed innovation', firms depended on their own internal R&D labs, in which researchers attempted to carry out the entire innovation process from basic research to product development in an atmosphere of secrecy. The goal was for firms to build up a stock of patents or trade secrets to use as competitive assets and trade barriers against new entrants who could not afford such great investments in internal R&D. Philips in its early days was a prime example of this approach to innovation and also serves to illustrate its limitations.

Carrying out the entire innovation process internally can be extremely costly, especially since only some of the innovation projects undertaken can be expected to result in a marketable, innovative product. And even when internal R&D leads to the development of a breakthrough innovation, firms will only be able to recover a fraction of the revenue produced by this innovation. And finally, closed innovation is based on the assumption that outside the boundaries of the firm, there is little publicly accessible research of use to the firm. Shorter product cycles and the rise of the quality and availability of public basic and applied science have made the closed innovation approach obsolete.

To address these problems, firms have begun to experiment with open innovation strategies. While open innovation is not one but a range of approaches, the most basic element of open innovation is to tap existing sources of knowledge whenever possible and conduct internal R&D mainly to fill in the gaps in existing knowledge. Open innovation implies the active creation of cooperation networks and shared research institutes to pool R&D investments, especially in pre-competitive research (research in the earliest stage of the innovation process, the results of which can be used by many firms rather than being relevant for one single application).

More elaborate open innovation strategies also include a role for spin-offs and venture capital. The internal R&D department of a company may produce knowledge that does not seem to have a practical use for the firm. One option is then for the firm to allow (or even encourage) some of its researchers to form a spin-off firm to further develop this knowledge into a product. When it is successful, the 'parent firm' can decide to buy back its spin-off or to establish a long-term cooperation with it.

The successful application of open innovation strategies puts high requirements on a firm's innovation system. When a system allows shared research institutions and spin-offs to thrive, this opens strategic options for the application of open innovation by the firms located in it.

Philips gave open innovation a specific meaning by creating the High-Tech Campus (HTC). This campus, located at the outskirts of Eindhoven, used to be an exclusive and highly secretive Philips research laboratory. When Philips made its turn towards open innovation, it removed all Philips signs from the area (a very symbolic gesture) and allowed other firms and institutions to locate on the campus. Currently, the HTC houses most of Philips's R&D labs, besides major Philips spin-offs like NXP and other major national and international high-tech firms and service providers. Moreover, it provides office space to new start-up firms and offers the Philips clean rooms for rent to firms that otherwise may not have had access to such an advanced research facility. Also, the Holst Centre is located on the HTC, placing it next to many of its key users. In sum, the HTC has been redesigned from a paragon of closed innovation to a space tailor-made to facilitate open innovation. Specifically it provides opportunity for inter-firm cooperation (through the geographical proximity of firms in related industry sectors), collaborative pre-competitive R&D (in the Holst Centre), and open innovation strategies based on nurturing and cooperating with spin-off firms.

It should be noted that not all stakeholders in the Eindhoven region agree with the notion that open innovation has become a paradigm of R&D policy in the region. Open innovation has become a well-known concept among actors in the region, but it is unclear to what extent actors besides Philips are really committed to applying it as a strategy. Some firms express that they only take part in collaborated R&D projects because this is often supported with government subsidy in the Netherlands. This casts doubt on the true added value of at least this form of open innovation (as explained in Box 3.2, open innovation also includes strategies based on spin-off formation). Moreover, a recent shift in Dutch innovation policy (the top sector policy) is likely to put pressure on the popularity of R&D collaboration. This policy involves stimulating firms to fund university research, basically subcontracting their internal R&D to university laboratories. While this may be interpreted as a form of open innovation (typically multiple firms would fund one university research group, sharing the resulting innovation outcomes), it is highly controversial among the firms interviewed and may be a step too far for some. One respondent notes that for most firms in the region, it would be more fitting to talk of shared innovation rather than open innovation. Firms do work together and share their knowledge with trusted partners, but they do so not in an open regional innovation network but rather with firms directly connected to them in the value chain. For example, OEMs increasingly entrust their suppliers with part of their R&D (helping them to upgrade to be able to take on this task), and suppliers among themselves also increasingly set up clusters within which R&D cooperation is carried out. While this can certainly be called open innovation, there appears to be a limitation on the extent of openness firms are willing to accept.

The software of open innovation: a regional mentality and the community around a leader firm

Having the hardware (e.g. the HTC) and the orgware (institutions such as the Holst Centre) is not enough: initiatives similar to the HTC and Holst Centre have failed in other regions because a third element, the 'software' of open innovation, was missing. R&D in general and pre-competitive research in particular is always an unpredictable process with uncertain outcomes. It is logical that firms and their researchers try to protect themselves against these uncertainties by working on the basis of contracts that seek to detail the division of investments and returns of the research project, but this often proves impossible in practice. As a result of this, many promising R&D projects are not carried out because the partners involved refuse to start working in the absence of a clear contract, and if research is carried out, it can end in conflict if its outcomes differ from those described in the contract.

In the Eindhoven region, contracts play a much smaller role in collaborative R&D. Researchers realize they can only work together if they trust each other. So at the Holst Centre and the related DevLab, it is common practice to work without binding contracts for the first 2 years of a research project, and only when concrete results are starting to emerge are contracts written down to set rules on property rights and returns of the project. When asked about the origins of this 'software' of trust and willingness to cooperate, stakeholders in the Eindhoven region point to the strong, historically rooted sense of local community.

Some discussion partners refer to a 'Brabant mentality'[5] based on long-term cooperation and live-and-let-live competition. At least in recent decades, firms in the region have had a tendency to search for a niche market in which they can prosper without having to compete directly with neighbouring firms. Firms operating in different but related niche markets are likely to depend on a shared knowledge base that they can strengthen through collaborative R&D without fearing that they are strengthening their own competitors. Moreover, the large OEMs of the region value continuity over cost minimization in their relations with local suppliers, allowing their suppliers healthy profit margins even if their local monopsonism power as the sole buyer of specialized intermediate goods would have enabled them to negotiate lower prices. Besides this, the region's OEMs tend to be happy to allow their suppliers to service other buyers besides themselves rather than forcing suppliers to accept them as exclusive buyers of their products. Having exclusive rights to buy strategic intermediate goods can give firms a competitive advantage over their rivals and may prevent knowledge of the OEM from leading to rivals through its supplier network, but it also makes suppliers dependent and vulnerable. Again, long-term continuity is favoured over short-term strategic advantages, and OEMs actively stimulate their suppliers to find more customers and reduce their dependency on a single customer.

Other respondents point to the 'Philips community' in the region. In its heyday, Philips was able to hire the best and brightest of the region's engineering graduates, and these people formed a strong bond in the tightly knit and exclusive Philips research community. As Philips became less dominant in the region and allowed several of its best divisions to spin off, many in this community of about 200 people spread around the other large firms and institutions in the region. They were raised in the Philips business culture of progressive employer–employee relations and strong attachment to the region, creating a shared set of values that facilitates cooperation. Also, the 1990s crisis at Philips created a realization of the vulnerability of their sector and region and of the need to work together to prevent similar crises in the future. In this way, the former Philips community constitutes a network between many of the region's firms and institutions in which trust and cooperation are possible. At the same time, any news of untrustworthiness and opportunistic behaviour would quickly spread through this network, creating a strong deterrent against cheating that further adds to the ability of this community to work together. Besides the ability for cooperation, the network is also able to take in new members and connect to wider networks. When the research centre TNO moved to Eindhoven (in 2007), it had very few existing connections with the region. However, as it started to hire local knowledge workers, many of them part of the former Philips community, it quickly became an integral part of the local community.

It is unlikely that Philips will continue to play a similar role in the local community in the future. New generations of knowledge workers are taking over who did not experience the heydays of Philips's massive R&D labs and cradle-to-grave care for its community of employees. Moreover, the rate of spin-off formation from Philips, which played a key role in spreading out the Philips community over the Eindhoven system, is likely to reduce due to its downsizing and focus on core competences. It remains to be seen to what extent the new leader firms of the region will have the strong business culture, including a high level of attachment to the region, and high spin-off rates that can create similar communities in the future. But there is no reason to assume that the Brabant mentality of trust and niche competition would disappear along with the Philips network, especially if (international) newcomers are successfully socialized in these informal rules.

Branding

Another key feature of Eindhoven's innovation system is its reputation and branding strategy. While Philips has been a famous firm throughout much of the 20th century, Eindhoven has been relatively unknown both in the Netherlands and abroad. It was regarded as little more than the environment in which Philips had happened to locate itself and was deemed to be of little importance to the national economy compared to the core Randstad area with its powerful cluster of financial and business services and logistics firms. As late as the 1990s, Eindhoven stakeholders had difficulty in gaining attention and being recognized as a member of the international network of highly innovative regions.

An effective branding strategy set up collectively by the region's public and private stakeholders was able to change this. Recognizing that Amsterdam (with Schiphol Airport) and Rotterdam (with the Rotterdam seaport) had gained great attention among national policymakers as the twin Mainports driving the Dutch economy, actors in Eindhoven agreed on a combined effort to add the region to this short list of key regions under the name of Brainport. By 2004, this effort had succeeded and a new spatial economic policy document called 'Peaks in the Delta' confirmed that the national government had recognized Brainport as an economic driver of national importance.

The next effort, which is still ongoing, is to raise the international awareness of the region. Again, Brainport was chosen as the brand name. Some of the ongoing efforts include lobby activities in Brussels carried out by a team of permanent representatives working for Brainport Development, the representation of Brainport at the 2012 Hannover Messe technology fair, and the organization of yearly international events like Dutch Design Week and Dutch Technology Week. By the late 2000s, the Brainport region had succeeded in gaining international recognition, and in 2011 the Intelligent Community Forum selected it as the world's most intelligent community for that year. One respondent notes that even though the region is quite small in size and population compared to regions such as Silicon Valley, its strong reputation gives it access to high-level collaboration partners.

Three related success factors in the Brainport branding strategy are mentioned by local stakeholders: there is regional consensus on the kind of brand the region wants to establish; it has a clear profile as the basis of its branding strategy (because the region is highly specialized in high-tech systems and design); and a number of large, innovative firms support the branding strategy. Because the region has a clear profile in technology and design, it was relatively easy to align local stakeholders behind a focused brand. Many branding strategies fail because cities or regions end up branding themselves as 'good at everything', being unwilling to make a choice and leave out those industry sectors and aspects of their development in which they do not excel. Brainport's focus on two areas (design and high-tech systems) in which it is highly competitive explains much of its success. Finally, the fact that the region has a number of internationally renowned leader firms with a strong attachment to the region and that recognize themselves in the branding Brainport Development is working to establish helped kick-start the branding strategy.

Restructuring and diversification

In the past two decades, actors in the Eindhoven region paid much attention to restructuring and diversification, not only because of its historically grown dependence on Philips but also due to the fact that the high-tech systems and material sector is especially vulnerable to cyclical downturns. As the region was emerging from its 1990s economic crisis, regional stakeholders undertook efforts to kick-start the diversification of the regional economy. Two sectors, the design and ICT sectors, seemed most promising and were stimulated with European and Dutch regional development funds (see Box 3.3 and Box 3.4).

Box 3.3 Stimulating the development of ICT in the Eindhoven Region

As the ICT boom of the 1990s took hold of the Netherlands, this sector was given especially strong attention, and a number of projects had been started to also develop this sector in Eindhoven. While the region did have considerable expertise in ICT, most of these activities were directly related to the specific needs of individual high-tech firms, for example, in the form of internal ICT departments. As a result, Eindhoven did not have an established reputation as an ICT hot spot. In order to develop a true ICT cluster in Eindhoven, the regional development organization NV REDE carried out a direct marketing campaign among ICT firms in the Randstad area of the Netherlands to try to convince firms to relocate to Eindhoven. Besides this, the local government commissioned research to find out what changes would be needed to make the region more attractive for ICT firms, which resulted in two specific projects.

In 1998, the development of the Twinning Centre on the TU/E campus was started with funds from the Stimulus project. It was organized as a national project, carried out locally by NV REDE. The idea was to bring young ICT start-up firms together in the same building in order to stimulate interaction and cooperation between them. Moreover, ICT start-ups were brought into contact with investors and experienced entrepreneurs through the Twinning Centre. At first, the project did not live up to expectations, partly because of unrealistic ambitions. As the ICT boom was nearing its apex, the expectation was that ICT starters would quickly be able to become publicly traded companies on the stock exchange and be able to grow out of the supporting environment of the Twinning Centre in a very short time period. When the dotcom bubble burst, these ambitions turned out impossible to achieve, and the number of starters housed in the centre remained below the expected number. While the national government had played a major (and not always constructive) role in the early phase of the project, control was fully turned over to NV REDE and the ambitions were made more realistic. As of May 2012, the Twinning Centre houses 31 ICT-related firms, ranging from technical and legal ICT consultants to software developers and server providers.

Another major project to stimulate the Eindhoven ICT sector was the Kenniswijk or 'knowledge neighbourhood' project started in 2000. The initiative was taken by the Dutch Ministry of Transportation, and the Eindhoven local government and NV REDE succeeded in convincing them to select a neighbourhood in Eindhoven for its implementation. In this neighbourhood, at that time still rare high-speed Internet connections were provided to all households, and local entrepreneurs were assisted to develop pioneering online shops. Besides this free, Internet courses were offered to inhabitants and local government services were for the first time offered online. Because of the dotcom crisis, ambitions for the Kenniswijk project had to be lowered, as was the case with the Twinning Centre. While the project resulted in the construction of valuable Internet infrastructure in the city, it did not lead to clear outcomes in terms of new business development (Van den Berg *et al.* 2008).

After about one and a half decades of stimulation policies, the ICT sector has not substantially changed its character. As in the 1990s, it today includes a number of healthy firms offering stable employment to a small fraction of the local labour force, but it did not take off as an independent sector besides the high-tech systems sector. However, some firms within the ICT sector show potential for becoming nodes in a more independent and mature ICT sector, as illustrated by the case of Sioux. Founded in 1996 as an ICT secondment firm, it was one of the most rapidly growing technology firms in the Netherlands, reaching 300 employees by 2012.

Besides service provision, Sioux expanded into product development, and in 2006 it co-developed the Phenom table-top electron microscope in a collaborated R&D project with opto-mechatronics specialist NTS. They originally developed the Phenom on a contract for the large optometrics firm FEI, but when FEI was unable to make it a commercial success, Sioux and NTS created a spin-off firm to exploit the potential of Phenom. The success of this venture led Sioux to carry out several other collaborated product developments, resulting in a number of viable spin-off firms and expanding Sioux from an ICT firm to a multi-disciplinary firm with expertise in electronics and industrial mathematics besides software. It aims to become a leading firm in the embedded computers sector and by developing new value chains, for which it now operates a spin-off incubator.

If other ICT firms follow the example of Sioux, their initiatives may provide the basis for the development of a sustainable ICT cluster in the Eindhoven region, which benefits from but does not depend on its relations with the high-tech systems sector.

The slow and limited emergence of the ICT sector in the Eindhoven region illustrates the limited scope for policy intervention to trigger and direct changes in a system's industrial structure. Recently there have been signs that the ICT sector is growing stronger and more independent, but it is difficult to identify any major role for policy interventions in having enabled this development. Rather, it seems to be driven by the private initiative of ICT firms to take part in collaborative R&D and spin-off incubation. While an expensive and complicated public policy initiative (Kenniswijk) produced few visible results, projects that tie in with already-occurring private initiatives (spin-off incubation) show more potential to speed up the slow diversification process.

Box 3.4 How the design sector emerged

In the Netherlands in general, the creative industry, and within it especially the design sector, is becoming increasingly important. While the sector does not have clear boundaries, the design sector can be understood as encompassing three main fields of work: graphical design (including advertisement), web design, and industrial design. Eindhoven has become an increasingly important centre of design in the Netherlands, especially for firms in industrial design (Frenken 2012).

As with many industry sectors in Eindhoven, the first emergence of the design sector can to a large extent be traced back to Philips. Early on, the firm realized that its focus on high-end consumer products meant that the firm had to invest deeply in product design and advertisement. At the same time, the strong focus on exploring new export markets forced Philips to employ product design to localize its products to a variety of markets. By the 1960s, Philips had gained a reputation for design and user friendliness, and since then the firm has continued to invest deeply in its design division.

The Eindhoven design sector really started to draw international attention when, in 1995, Philips established a design department in one of its monumental buildings in the city centre called the Witte Dame or White Lady. With 220 designers working under the leadership of the internationally famous top designer Marzano, Philips Design became the largest firm in this sector in Eindhoven. It was soon followed by the Design Academy, which also established itself in the Witte Dame building, while the European Design Centre opened an office on the TU/E campus. In the meantime, the TU/E had opened an industrial design faculty in 2001 with the support of Philips, which also provided some of the teaching staff. In 2004, NV REDE added its support to the fledgling design sector by creating a design incubator to help young entrepreneurs start up design firms. In 2006, redevelopment began to turn the former Philips area Strijp S into a design mecca, which should allow the Eindhoven design sector to really take off.

As of 2009, the design sector, by a slightly narrower definition, accounted for 10 per cent of the firms and almost 5 per cent of employment in the economy of Eindhoven, giving it the highest specialization rate in design of all Dutch cities (in absolute terms, the design sectors of larger cities such as Amsterdam and Utrecht still surpass Eindhoven; Research voor Beleid 2009). High growth rates since then have further deepened the level of specialization in design. The large OEMs of the Eindhoven region are still important customers of the design sector, but besides contributing to the export success of the high-tech sector, the design sector also contributes a significant share of exports by itself (close to 2 per cent of total exports by 2009; TNO 2011).

This is important since ongoing downsizing at Philips (which still boasts one of the world's largest design centres) and the rise of new OEMs that do not produce consumer products and hence are less likely to invest deeply in design (e.g. ASML) could mean that the design sector will need to become more independent in the near future. A possible barrier to its development is the weak self-organizing capacity of the sector, partly due to the fragmented nature of the design sector, which is dominated by sole traders and has an average firm size of only just over four employees per firm. Small firms are generally unable to achieve a strong reputation independently and lack sufficient funds to invest in innovation and new product development (TNO 2011).

It is expected that the development of the 'design hot spot' Strijp S will help the Eindhoven design sector overcome its fragmented nature. Within a firm cluster, many small, specialized firms can together achieve international visibility and branding and can pool their limited resources to engage in open innovation. Strijp S has already succeeded in the first years of redevelopment to raise international awareness through a series of successful events and especially the Dutch Design Week. Moreover, the district is planned to house many of the artistic and cultural firms and (educational) institutions that are thought to be essential in providing entrepreneurs in the design sector with the new ideas and talent, besides, for example, the exposition rooms they need to operate in this sector.

In this way, Strijp S may provide an anchor for the design sector to organize itself and increase its independent viability. However, a recent study of the Dutch design sector (Frenken 2012) suggests that expectations of Strijp S as a design cluster should not be exaggerated. The study does not find evidence for benefits for design firms from being located in geographical clusters of design, among other reasons because sole traders and very small firms simply have no need for external labour and can function without proximity to a strong local specialized pool of labour. Moreover, Frenken finds that rather than cultural facilities, an inspiring environment, and being located in a cluster with a strong reputation, design firms first and foremost choose their location based on the availability of affordable housing, proximity to family and friends, and proximity to customers. Whether or not Strijp S will be a necessary and sufficient condition for the strengthening of the Eindhoven design cluster, the sector will continue to be a focus of attention in the region, not least because of its potential to help the region diversify its highly specialized economy.

As was the case with the ICT sector, the design sector emerged from the initiative of the private sector, in this case Philips's design department. Moreover, Philips, rather than local government, took the initiative to help the TU/E develop expertise in industrial design, strengthening the development of the sector. However, once the design sector started to emerge, public–private initiatives played a role in accelerating its development, among others by setting up a start-up incubator and by helping organize events that raised international awareness for the fledgling design sector. By providing the sector with a physical anchor in the form of Strijp S, public and private actors are taking another step in supporting the development of the design sector. In sum, while it is questionable that public–private policy can be used to trigger the emergence of new sectors in order to diversify the regional economy, the ICT and especially the design sector in Eindhoven show examples of projects that seem to help accelerate developments that in the first place emerged by the initiative of private firms.

New firm creation and venture capital

While in some urban innovation systems the spontaneous initiatives of knowledge workers are sufficient for achieving high levels of start-up formation, Eindhoven is an example of a system that could benefit from public–private initiatives to boost entrepreneurship. Although the region has a reasonable number of start-up firms, it so far has had very few starters that grow into large firms. A wide range of start-up incubation initiatives has been undertaken to address this problem.

Start-up firms can originate from a variety of sources, of which the TU/E, TNO, and private firms are the main ones in the Eindhoven system. Most interview respondents agree that academic start-ups (started by researchers and graduates of the TU/E in the case of Eindhoven) are least likely to grow into large firms. Their entrepreneurs tend to be relatively young and lacking in commercial experience. The typical academic start-up is set up with the aim to develop an idea or project that emerged from scientific research, for example, a PhD research project. If this aim is reached and leads to some financial returns, the academic entrepreneur tends to be satisfied, either returning to scientific research or living comfortably off a small but profitable firm. However, for start-ups to grow into large firms, the entrepreneur has to continue expanding his market and convince more investors to support the firm, tasks that seem unattractive to most academically minded entrepreneurs.

On the other hand, start-up entrepreneurs who previously worked for a private company tend to be more experienced and more likely to have internalized a commercial mindset. If they stem from an internationally operating firm, they are themselves more likely to be 'born global', gaining access to export markets early in their development. Spin-offs from technological research institutes such as TNO take an intermediate position. Their entrepreneurs are said to have a less commercial mentality, but because their institution works directly with private customers, they do tend to start with a network of (potential) customers in place.

Most respondents argue that the main problem holding back new firm creation is a shortage of available venture capital. While small seed investments (e.g. 50,000 euro for the first one or two years of operation) are available from several sources, very few venture capital investors are willing to invest the much larger sums needed for a start-up to grow into a large firm (on the order of 1 to 10 million euro). A low level of VC investment can have two causes. On the one hand, there can be a shortage of investors who are aware of investment opportunities in a region's start-ups and who are willing to take the risk to invest sufficient amounts of capital in them. Alternatively, the issue can be caused by a lack of start-ups with sufficient quality and market opportunities and headed by a CEO willing to invest sufficient time and energy into convincing potential investors. While most respondents focus on a shortage of VC investors in the region, there are strong signs that the real problem is a combination of the two.

From the interviews, it became clear that in the case of Eindhoven, there is a limited willingness of knowledge workers to start a firm. Especially researchers at universities and research institutions but also most researchers at private firms are not eager to take the risk of becoming entrepreneurs, preferring instead the stability of salaried employment. Moreover, when knowledge workers do start a firm, they tend to be unwilling to devote themselves to the tasks of a CEO, which in the early phase of a start-up means presenting your business case to large numbers of investors until sufficient funds have been assembled. Instead, they tend to focus on the tasks of a CTO (chief technology officer), since this is what they have devoted most of their career to, while still being unwilling to give up the role of CEO to a more capable manager. The result is that many start-ups develop highly sophisticated innovative products but fail to have any success on the market.

Respondents suggest a number of possible solutions to stimulate new firm creation, some of which are currently being implemented. In order to raise awareness and train (future) knowledge workers in entrepreneurship skills, the TU/E has introduced obligatory courses on entrepreneurship for all science and engineering majors, while Philips employees similarly are offered entrepreneurship training courses. To improve the visibility of promising start-ups and investors, one discussion partner suggested setting up a 'relational phonebook' for the region. Both Silicon Valley and Sophia-Antipolis have such a public list of the region's firms, investors, and research institutes, and it helps innovators to quickly find out which people in what organizations possess the skills and knowledge they need. However, firms tend to be cautious about allowing such information to be made public because they fear their key knowledge workers may be lured away if their skills and knowledge are made public. At least start-up firms and investors, who are most in need of awareness and visibility, should be made public in a central relational phonebook.

Moreover, it is beneficial for a system to have the kind of VC networks that especially Silicon Valley is famous for. In Silicon Valley, VC investors are well known and openly announce their investment decisions, as much for strengthening their professional reputations as for the personal pride of having identified a promising opportunity overlooked by their peers. Such a VC network has the effect that when one VC investor is convinced by the value of a start-up initiative, he will then mobilize his network to raise more capital for it. In order to accelerate the emergence of such a VC network in the Eindhoven region, Brainport Foundation is facilitating the formation of the Brainport Network Financials, which includes not only investment firms and wealthy family funds but also, for example, the ICT firm Sioux, which is active in start-up incubation.

A popular way to implement the measures described is by setting up a start-up or spin-off incubator, offering a range of services to start-up entrepreneurs within one organization and usually also one geographical location. The Eindhoven case illustrates the broad range of actors that can play a role in this. Actors from universities and research institutes (TNO) to a housing corporation (Trudo) and several private firms (e.g. Philips and Sioux) have set up buildings for housing start-up firms. Examples include the Start-up Incubator on the TU/E Science Park (see Box 3.5), the Betagebouw on the High-Tech Campus, and the design incubator at Strijp S. Concentrating large numbers of start-ups in a single building has the advantage that together they have high visibility to VC investors (who sometimes open their own offices inside the incubator building), while at the same time there is the possibility that this close proximity of starters in related industry sectors leads to knowledge sharing and collective learning processes.

However, in the case of Eindhoven, some of these incubator initiatives offer little more than subsidized housing and focus on the quantity rather than quality of start-ups generated. Moreover, this proliferation of incubator initiatives has reduced the visibility of any individual incubator building. Respondents argue that many organizations do not realize that the successful incubation of start-ups is costly in money, energy, and time. While it may seem as if some spin-offs are able to make a running start, quickly gaining market access and profitability with minimal outside assistance, such start-ups tend to originate from a parent firm or organization that invested heavily in the intellectual property and product development that made this rapid growth possible. Such investments may not be visible to outsiders, creating the illusion of an exceptionally fast and cost-efficient start-up. Entrepreneurs who begin from scratch without an existing knowledge base to draw on need to fund this with VC investments, appearing much slower and costlier.

The TU/E start-up incubator called Innovation Lab is an interesting case to study in more detail. It started out as a traditional incubator offering housing and small seed funds to large numbers of young entrepreneurs but has recently changed its approach to incubation (see Box 3.5).

An important point raised by one respondent is that the expected level of new firm creation and the number of start-ups with significant growth prospects also differs by industry sector, and this also explains part of the situation in the Eindhoven region. For example, in the ICT sector, a start-up can relatively easily find a niche for itself and quickly expand, as it requires a significant knowledge base but little costly physical capital. The same may be true for firm creation in the design sector. But in the crucial high-tech systems sector it is much harder to grow into a major firm because of the need for physical capital and the entry barrier presented by scale economies of production and logistics. A large number of start-up entrepreneurs have been able to set up profitable firms in the high-tech systems sector

Box 3.5 Start-up incubation at the TU/E

In 2006, the Technical University of Eindhoven (TU/E) founded its incubation centre for stimulating academic spin-offs called Innovation Lab. During the first years of operation, this incubator produced a large number of small start-ups. Its strategy was to supply many small seed investments in order to give a large number of entrepreneurs a chance to introduce their product to the market. The assumption behind this strategy was that out of a large number of spin-offs, a few would grow into leader firms like Philips and ASML.

So far the incubation centre has indeed helped a large number of small start-ups be created, but so far very few of these have grown to become viable firms. Some local stakeholders criticize this approach to incubation as ineffective. First, it results in fragmenting the available funds for start-up firms into many tiny seed investments, with no solution being provided to growing start-ups that need larger follow-up investments to really break through in the market. And second, this form of incubation can result in pampering young entrepreneurs with subsidies rather than forcing them to think in a more business-like way and learn to become able to independently find funding.

Over the past two years, the TU/E Incubation Lab has radically changed its strategy. Its efforts are now limited to guiding students and researchers who are interested in carrying out contract research for local firms. These young entrevpreneurs receive guidance for the administrative and legal aspects of starting a firm and can apply for a seed investment. An important difference with the earlier strategy of Innovation Lab is that while it used to be flexible about the repayment of seed investments in case the start-up was unsuccessful, it now demands a repayment of at least 50 per cent if the spin-off fails to become profitable, while successful spin-offs are expected to pay back twice the amount they received as seed investment. The number of spin-offs is expected to decrease because of this change in strategy, but it is still possible for future leader firms to emerge from this incubation process.

consultants for the R&D projects of large OEMs, creating stable employment for one or a few workers but with very little scope for growth. Well-designed incubation initiatives can optimize the number and quality of start-up firms, but depending on characteristics of the dominant industry sector of the region, it may not be able to generate many large firms.

Campus development based on the concept of open innovation

In Eindhoven, open innovation is most visible at the High-Tech Campus (HTC). Realizing that firms pay above-average rental fees to locate on the HTC, the campus developers aimed to create a business location with a substantial added value. Being located on the HTC should help firms in carrying out open innovation and thereby offer them a location advantage not available at normal business parks. In the vision of the campus developers, open innovation can be stimulated by combining a number of conditions. The first condition is that innovative firms need to be located in geographical proximity with each other, and the firms should be active in related industrial sectors.

In line with the principle of related variety (see Chapter 2), the HTC campus management is selective about the firms it admits to the campus. The campus management has commissioned a research team to select a limited number of sectors that seem suitable for the HTC to concentrate on. These sectors have been selected as follows. First, any sector considered should be a coherent and recognisable field of high-tech development and production. Second, the region should have at least some existing expertise in these sectors or the clear ability to develop such expertise. Third, the sectors considered should have a well-developed market for their products, and this market should be sustainable in the long run. Finally, there should be a real potential that Eindhoven, and the HTC within it, will gain worldwide recognition as a cutting edge centre of this industrial sector. Based on this selection process, five sectors were selected for the HTC, namely high-tech systems, microsystems, embedded systems, life sciences, and infotainment. Besides these main sectors, a number of fields of technology application were selected, which draw on the five main sectors for their knowledge base. These sectors are not entirely fixed as, for example, after the initial selection process, the solar energy sector was added to the list.

These five sectors guide the acquisition strategy of the campus management. In each of these sectors, the global industry leaders were identified and have been offered a proposition for locating on the HTC. Moreover, 20 per cent of the land within the campus is left vacant to have space available in case a key firm in the five sectors wants to move there. While the pro-active acquisition strategy is very selective, the campus management is less selective in its reactive acquisition. When a firm spontaneously expresses interest in locating on the campus, this firm does not necessarily need to be from one of the five sectors. But a track record of innovation and a specialization in some high-tech activity are requirements for allowing the firm to locate on the campus.

When a suitable mix of firms has located on the campus, a second condition for facilitating open innovation is for knowledge workers in these firms to come in contact with each other. In order to achieve this, the campus offers a number of other facilities besides business space. In the middle of the campus, a complex called the Strip has been developed, which provides dining areas, meeting places, and sports facilities. The Strip has become a place where the knowledge workers of firms located on the HTC meet and expand their social networks. To make sure such meetings actually occur, the campus management has banned all private canteens on the campus, forcing workers of all firms to eat in the Strip rather than each in their own canteen. Besides this, the campus management also regularly organizes informal meetings and public lectures. A concrete example of this is the 'meet-and-greet' sessions organized by the campus management whenever a famous scholar or entrepreneur visits one of the firms located on the campus. Finally, the campus management has set up a Campus Business Club open to knowledge workers employed on the HTC.

The creation of start-ups and spin-off firms is a prominent feature of open innovation. The High-Tech Campus facilitates start-up firms by the provision of inexpensive and highly flexible (short-term renting contracts) business space for start-up firms. Start-ups are concentrated in one building in order to promote network formation and knowledge exchange between them. Moreover, the clean rooms that were formerly exclusively for use by Philips have been opened for use by other firms at a moderate price, allowing smaller firms and start-ups access to a cutting-edge research facility that would otherwise be out of reach for them.

Another important facilitator is the Holst Centre, a research institute for collaborative pre-competitive R&D, which is located on the campus as well. Its goal is to facilitate open innovation by developing pre-competitive technology that can be used by a range of high-tech firms in the region. It was co-founded (in 2005) by the IMEC research centre in Leuven (Belgium), which has strong connections to Philips, and TNO. Philips acted as the launching customer for the Holst Centre, and recently other local firms have started to make use of its services as well. In this type of open research centre, partners (which can range from young high-tech entrepreneurs to the researchers of large firms) together carry out an R&D project. Because the knowledge they develop is pre-competitive, firms that are in direct competition with each other can still cooperate through these open research centres in developing knowledge that benefits both of them.

A challenge for the further development of the start-up incubation function of the HTC is the lack of start-ups that succeed in growing into large firms, partly because of an inability to find sufficient venture capital funding. So far, the HTC has attracted three venture capital investors to locate permanently on the campus. The campus management aims to expand this number and organizes meetings between venture capital investors and start-ups on the HTC.

Even though the HTC has only started its development as an open campus quite recently, it has already become a reputable and financially healthy enterprise. According to a representative of the HTC in charge of acquisition of firms, the HTC has succeeded thanks to four success factors. First, the park received support from a leader firm, Philips, until it had sufficient facilities to attract firms by itself. Second, the HTC was the first of its kind in the Netherlands, giving it an edge over later attempts to create parks using a similar concept. Third, the park was opened in a time of economic growth, allowing it to gain just enough strength to weather the subsequent recession. And fourth, the HTC stuck to its concept of keeping control over the type of firm allowed to locate on the campus, even though it was tempting to relax these standards when economic recession made the acquisition of firms more difficult.

Limiting the range of industry sectors represented by the firms in the HTC has ensured that the park could relatively quickly achieve some critical mass in these sectors, while it also helped to establish a recognizable brand for the park. A study by Van der Borgh and colleagues (2012) concludes that one of the major benefits for firms of being located on the HTC is related to its brand name. Unknown or young firms often have difficulty in getting recognition from potential collaboration partners or corporate clients, especially abroad. Partly thanks to Philips, the HTC has an increasingly strong brand name, signalling the credibility of firms located on the campus even when these firms themselves have not built up a strong reputation yet.

Developing a new urban core

Another interesting strategy is the development of a new urban core at Strijp S. Turning this 'forbidden city' into a creative city has proven challenging, both due to the timing of the project (the credit crisis and following recession made it impossible to develop the amount of office space originally planned) and due to characteristics of the area itself. Strict Dutch rules on the redevelopment of heritage buildings have limited the ability of the developers to demolish or radically change the buildings. Moreover, changes that are allowed have proven very costly because the buildings were never intended for residential use. Initial investments in the main buildings of Strijp S were more costly than expected, and the developers had to deviate from the initial 'blueprint' plans to find more flexible and innovative ways to work around these problems.

The development concept behind Strijp S revolves around an urban, lively atmosphere and a young, creative character. This concept is applied to all aspects of the district's development. First, while the housing units at Strijp S are in principle open to any target group in terms of age, income, and household status, it is made clear to potential residents that they need to accept some level of traffic and noise if they are to live at Strijp S. In other words, residents have to make a conscious decision to live in a lively, mixed-use space and accept both the advantages and disadvantages this entails. For example, the exceptional level of freedom for combining working and living in the loft apartments at Anton and Gerard (see Box 3.6) means that residents have to accept some amount of activity and traffic next to their room. Similarly, Strijp S will remain the location for regular music and cultural events, some of them drawing a hundred thousand or more visitors to the area. Residents who prefer an urban, lively atmosphere will also appreciate the bustle and activity brought by the mixed-use, high-density, and frequent events at Strijp S, and in practice these are expected to be predominantly young singles and couples without children.

Box 3.6 Innovative living concepts in Strijp S

Because of the young and creative target group, and because of the need for a high level of flexibility in the development plans, Strijp S requires innovative designs and regulations for its living units. Two specific housing developments in Strijp S illustrate these innovative concepts.

The first housing units to be completed are the 'loft' houses in the buildings Anton and Gerard. Both buildings have six floors and, on top of that, a large rooftop garden, and each floor has a 4-meter-high ceiling. A loft is a spacious, adaptable apartment, often consisting of a single large room. Compared to an ordinary apartment consisting of several distinct rooms, a loft can be created relatively quickly and easily in a building that used to have a different function. The loft has become a common feature of redevelopment projects in which former warehouses and light industrial buildings are converted to (sometimes temporary) residential use. Trudo selected the loft as the key form of housing in existing buildings on Strijp S, which among others have been used for light electronics production in the past.

By the end of 2013 a total of 240 lofts have been opened to residents,, about half of them relatively small (50 m2) and the other half medium-sized apartments (80 m2). While the main corridor, elevators, and other key elements have been constructed in a permanent way, all inner walls in the buildings are constructed in such a way to make it possible to remove them quickly at low cost. Moreover, all 'wet' functions (toilet, shower, water access for washing machine, etc.) are concentrated in a 'wet cube' attached to one central access point for water and sewage. The wet cube is a separate container that can be disconnected and moved within about four hours. While this is already common in hotel rooms, the developer redesigned the wet cube with the help of a group of future residents to be customized to their needs (resulting, among others, in the possibility to place a bed on top of the wet cube). The flexible inner walls and wet cube together allow the developer to double or triple the size of loft apartments whenever there is market demand for larger lofts, which over time will result in a diversity of different-sized apartments evolving along with market demand.

Besides housing units, the buildings have ample public space. The ground floor is devoted to meeting places, such as large cafes in which residents and visitors are free to work, relax, and organize small gatherings even if they do not spend money in the cafe. The top floor will house other cafes and restaurants, besides small shops and art galleries. The rooftop will become an attractive public garden with full-sized trees.

The loft apartments will be especially attractive to young and creative residents because of the exceptionally free regulation. Residents are free to combine working and living within their loft, allowing not just office work but even the operation of, for example a barber shop, a small restaurant, or an art gallery. This is usually not allowed because of the traffic and resulting noise generated by such enterprises, but in Strijp, it is encouraged in order to enhance the vibrance and richness of activity in its buildings. The only work functions not allowed in Anton and Gerard are those that generate too much traffic (due to fire safety regulations) or extreme noise (e.g. manufacturing).

Another housing development in Strijp is the Condotoren, a 24-story building expected to be finished by 2016 and which was also planned to house a key museum named Volt devoted to new media. The tower will have small, fully furnished rental apartments that should feel like a comfortable hotel suites. While the small size of the apartments is suitable for its target group (singles or young couples without children) and also keeps the rental price limited, there is the risk of creating an impersonal 'hotel atmosphere'. In order to avoid this, large public spaces will be offered on the ground floor, and semi-public facilities are offered on each floor of the building.

These semi-public spaces include shared working and lounge spaces accessible only to residents of the Condo tower, but also guest rooms and separate rooms suitable for organizing a small party that can be rented on a daily basis by Condo tower residents. For example, if a researcher living in a Condo tower apartment wants to invite his parents for a few days, he can rent a guest room on the same floor of the building for about €20 per day, including cleaning and servicing. These services have been tailored to the needs of future residents, which are expected to include a large share of international knowledge workers. The semi-public spaces and rentable guest rooms were proposed by PhD researchers that took part in brainstorm sessions organized by Trudo.

In a similar way, housing corporation and developer Trudo is very selective about the entrepreneurs and retail firms it admits to Strijp S. While the emphasis is on housing start-ups and SMEs, large firms would be welcome at Strijp S if they contribute something to the atmosphere, the branding, and the dynamics of innovation and knowledge exchange in the district. Several large firms have already been turned down since they were only attracted to Strijp's central location but were not expected to make any major contribution to its development. An illustrative example of what Trudo wants to avoid is presented by the R&D facility of Bosch. When Bosch considered leaving the region, the Eindhoven city council decided to offer a building on Strijp S to the firm in order to preserve its employment. As this happened before the redevelopment of Strijp S got underway, Trudo had no say in the matter. However, in a district devoted to innovation in design, the Bosch facility for research in security technology seems out of place. The firm is unlikely to benefit from its proximity to the many design firms and institutions at Strijp S, and in the same way there is very little synergy to be expected for Strijp S from having Bosch located in its premises.

While Trudo is unable to change the current situation with Bosch, it is convinced to prevent similar developments in the future in order to safeguard its development concept. For the same reason, the developer has turned down several offers of traditional retail chain stores, choosing instead to admit only shops, hotels, and restaurants with an innovative formula that adds to the attractiveness and uniqueness of Strijp S. Examples of desired retail concepts are a farmer's market, a design hotel, and a café that functions as an attractive meeting or working place for creative workers.

Besides being selective about the kinds of residents and firms it admits to Strijp S, the developer is also careful to manage the district in such a way as to preserve its open and inclusive atmosphere, since this is a necessary condition for the successful development of a cluster of creative activity. This style of management is distinctly non-commercial, in line with the social mission of Trudo. A first aspect of this is the way the corporation plans to deal with the rents it charges young entrepreneurs. The developer aims to create a so-called 'Soho effect', in which a succession of target groups is attracted to the district, each making the district more attractive for the successive wave of residents that supplants the former. While Trudo wants to use this Soho effect in order to gradually develop and upgrade Strijp S, it will not allow all its pioneer users to be supplanted when later waves of residents bid up the rents and housing prices. It will retain ownership of part of the buildings at Strijp S and continue to offer affordable workspaces to artists and young entrepreneurs. Besides this, it expects that when rising rent levels push out some of the pioneers at Strijp S, the neighbouring Strijp T area (another former site of Philips) may be able to absorb them.

Similarly, Trudo manages the many events that take place at Strijp S with an emphasis on strengthening the branding and vibrancy of the district rather than focusing on short-term profit maximization. It refuses the common practice of selling the exclusive rights for selling food and drinks at the many events organized at Strijp S to a large firm, as this risks reducing the atmosphere of openness and experimentation at its events. Instead, Trudo decided to retain ownership of its event spaces and accepts events to focus on breaking even rather than making a profit. In this way, leading international events can be hosted side by side with very small local events and parties, providing an atmosphere of access and inclusiveness. In the first years since the start of the redevelopment, Strijp S has hosted a range of events from large international events such as Dutch Design Week (organized in cooperation with partners in Helsinki and drawing 180,000 visitors in 2011) and Flux S (an international art festival, including music, dance, and live performances, that typically draws up to 10,000 visitors), to very small events with a strong relation with the city of Eindhoven.

Considering the economic and cultural function of Strijp S, an important site is the Apparatenfabriek, which houses a cluster of creative firms and institutions, including the so-called Ontdekfabriek (discovery factory). The latter is an initiative of the Brainport Foundation together with the TU/E, a number of local firms, and local government institutions, who together organize activities for exposing children to technology and science through workshops, invention competitions, and events. The goal is to persuade more young talents to choose science and engineering majors in order to address the current shortage of technically skilled labour. Another relevant building is the former Philips physics laboratory NatLab, which is planned to house several cultural functions related to music, film and theatre, and new media. Moreover, it will provide space for apartments, offices for start-ups and a vocational school in design, event management, and media.

In order to promote the creative activity at Strijp S, Trudo has two other points of attention in its management of the district. First, it uses the design of the district and its buildings to foster meetings and network formation among the residents and tenants in the district. The ground floor of all main buildings, including the mainly residential Anton, Gerard, and Condotoren, will have a large, public cafe where residents and workers can lounge and meet each other. Trudo put a strong emphasis on this after it realized that in another building, it had neglected to create adequate meeting spaces visible at the entrance of the building, leading to complaints by the residents that the building had a cold and impersonal character. Moreover, the developer is actively organizing networking events for its residents, focusing especially on bringing different groups of residents and visitors of the district (e.g. entrepreneurs and high school-age skaters) into contact with each other.

Second, the developer facilitated the creation of Baltan Labs, which will offer working space for projects in which artists and engineers can do 'experiments' together such as creating digital art using state-of-the-art ICT technology. For Baltan Labs, Trudo cooperates with the TU/E, the Design Academy, and other educational partners, while Philips provides one of its researchers to take part in its projects. Finally, a project has been set up to turn Strijp S into a test bed or 'living lab' for high-tech firms in the Eindhoven region, allowing firms to apply their experimental technology in the public space of Strijp S. One example is to use innovative lighting techniques to increase the vibrancy of the district at night. However, while firms appreciate the opportunity to showcase their cutting-edge technologies in a real-life environment, few concrete initiatives have so far been set up, and it is unclear to what extent the test bed function of Strijp S will materialize.

In sum, under the management of Trudo, Strijp S is being developed according to a distinct development concept. Strijp S is fully focused on a limited number of related fields of creative activity, and it strictly implements its development concept. By being highly selective about the kinds of activities and inhabitants permitted in the district, Strijp S hopes to preserve its uniqueness and establish a strong, internationally recognized brand. The non-commercial nature of this concept seems very suitable for the goals of creating an anchor for the region's design sector and providing an attractive and inspiring urban environment for working and living, which Eindhoven has lacked so far. However, this non-commercial attitude also introduces risks to the prospects of Strijp S. For example, currently there is an annual budget available to support initiatives for organizing cultural events, provided by, among others, the city government and the Eindhoven regional government. But in times of economic recession, this is vulnerable to budget cuts, possibly threatening the continuation of some of the events that are to play a key role in maintaining the brand name and vibrancy of Strijp S.

Another point of uncertainty is to what extent Strijp S will be able to fulfil the high expectations of many stakeholders in the Brainport region. Firms and local government institutions have expressed their expectation that with Strijp S, Eindhoven will gain the urban atmosphere it has lacked so far and that it may need to be able to attract young knowledge workers to the region. Strijp S may certainly be able to provide such a living and working environment, but its limited scale (in 2020, about 3,000 housing units are expected, corresponding to about 6,000 inhabitants) makes it unlikely that Strijp S can deeply change the city of Eindhoven itself and solve the lack of urban atmosphere in the city as a whole.

Upgrading the university campus

In response to the developments at the High-Tech Campus and Strijp in the early 2000s, the Technical University of Eindhoven formulated a vision in 2006 to transform its campus into a Science Park by 2020. The development plan includes up to 700 permanent, high-quality studios and apartments for TU/E (international) students, PhDs, and postdocs. In order to give the campus a livelier atmosphere, a 'green strip' has been planned in the central axis of the campus terrain. This green space is exclusively open to pedestrians and cyclists, and it includes facilities that make it possible to organize large-scale outdoor events and festivals. On the green strip, a central meeting place is being constructed. While so far most TU/E facilities had very limited opening times, the central meeting place will be open in the evening and during weekends.

The overall structure of the Science Park will be based on a stronger separation of functions in different zones of the campus. The central area (with teaching and student facilities, including the dining hall, the library, and the central meeting place currently under construction) will be a high-density zone with a lively atmosphere. The green spaces centred around the Dommel River valley will be upgraded to strengthen their ecological value, and any research facilities still located in this zone will be removed. Finally, a significant part of the Science Park will be reserved as a business development zone. It will offer more business space for start-ups and the TU/E Innovation Lab, and firms with whom TU/E has strong cooperation bonds are invited to open subsidiaries in this zone. Moreover, the business zone houses other research organizations, of which the most important research centre, TNO, is already established there.

A unique selling point of the campus (compared to the other physical locations in Eindhoven) is its specialization in energy-related research and business. This choice was made not only to avoid direct competition with already established science parks in the region but also to assure that within the limited space of the TU/E campus, a cluster of firms can emerge that, in spite of its limited size, can still gain the necessary critical mass to establish an internationally recognized reputation.

Developing a campus for innovative manufacturing

In addition to the three hot spots discussed above, the Brainport Innovation Campus (BIC) will be developed as a campus for innovative manufacturing. While manufacturing creates more traffic and possibly more noise than research and development, the BIC is still intended to become a green and attractive working place. In the first tentative design plans, the core of the park will be a green area, while firms are located in a ring around this green core. In contrast to the HTC, the BIC will offer space for events, festivals, and expositions besides a broader range of eating and meeting places and will be open day and night, in contrast to the restricted opening hours of the HTC. The BIC is to become a lively place that is open to visitors, not only guests of the tenant firms but also to the general public.

The Brainport Innovation Campus will be owned and managed by a cooperation of which all tenants are members, including the cafés and restaurants located in the park. While the park is intended to become a profit-making enterprise not long after its completion, having it managed by a cooperation may result in lower rents and an inclusive, flexible management style. Besides the group of high-tech suppliers who are members of Brainport Industries, the campus will also be open to international partners who work together with or are customers of ASML or its supply firms.

Like the High-Tech Campus, the Brainport Innovation Campus is explicitly developed as a place where firms are enabled to practice open innovation. Firms with a related specialization are brought into geographical proximity in an attractive area in order to stimulate knowledge exchange and R&D cooperation. The campus manager selects firms by their collective membership in the same value chain, which may or may not overlap with industry sectors (for example, a high-tech systems developer like ASML has suppliers ranging from precision stone polishing to optometrics to ICT suppliers). It remains to be seen whether industry sector or value chain membership is a better predictor of the extent to which firms can learn from each other.

Moreover, the Brainport Innovation Campus will host facilities for start-up incubation. Sioux, a fast-growing ICT service provider and product developer, will take a leading role in setting up the BIC incubation centre. Sioux has a track record in setting up collaborative research and product development projects that have resulted in a number of successful start-up firms, while it also acts as a venture capital investor.

3.5 Overview and conclusions

This chapter has analysed the development and features of Eindhoven's innovation system. This region, with its strong specialization in high-tech systems and materials, design, lifetech, and the automotive industry, is one of the leading European regions in research and development. Its strong performance in innovation can be traced back to its historical development trajectory, with particular importance of the region's leader firms Philips (micro-electronics) and to a lesser extent DAF (automotive industry), which laid down much of the region's physical, human, and social capital and through spin-off created many of the currently dominant firms of the region. During the 1990s, the region had to deeply restructure itself during a crisis before reaching its current level of innovation performance. This restructuring process had an especially strong impact on the region's system of governance, triggering stakeholders to set up a strong regional government layer, eventually culminating in the creation of a public–private organization for economic development (Brainport Foundation).

Besides the deep historical roots of its innovation performance, we identified several key features that explain the region's performance and present challenges to safeguard its future growth prospects. They are summarized in a SWOT analysis in Table 3.2.

Table 3.2 SWOT analysis Eindhoven

Strengths	*Weaknesses*
• Embedded leader firms and strong supply chains • Pro-active regional governance • High-quality research infrastructure • Open innovation • Regional branding strategy	• Vulnerability due to overspecialization • Limited rate of new firm creation • Shortage of public R&D investment • Shortage of technical labour
Opportunities	*Threats*
• Design sector has potential for diversification • Attractive, open environment for attracting IKWs • Leader firms invest in their value chain	• Offshoring of R&D due to labour shortage • Downward trend in innovation performance • Risk of over-dependence on a few key leader firms

A major source of strength underpinning the innovation performance of the Eindhoven system is the fact that its key firms are strongly embedded in the region. They feel a strong attachment to the region and are willing to make a contribution to addressing challenges facing the region. Strong local embeddedness explains why Philips was willing to invest as deeply as it did in the region, as were young firms such as the semiconductor giant ASML. But also, for example, the fast-growing ICT firm Sioux aspires to become one of the new anchors of the regional economy. The key benefit of having strongly committed leader firms is their positive effect on the region's supply chain. Eindhoven OEMs are highly demanding but at the same time generous to their suppliers in terms of knowledge sharing and building healthy long-term relations rather than squeezing suppliers' profit margins for short-term cost advantage. In this way, they help their suppliers continually upgrade themselves and become able to carry out their own R&D. The development of the High-Tech Campus and the Brainport Innovation Campus, with key roles for Philips and ASML, respectively, illustrates another way leader firms can contribute to the strengthening of the regional value chain. However, the kind of region building Philips used to engage in is now a thing of the past, and an over-reliance on a few key leader firms could turn this source of strength into a threat to the sustainability of the region's competitiveness.

Second, the effort to rejuvenate the regional economy in the 1990s left the region with a strong governance network of pro-active public and private stakeholders. Through their regional cooperation organization (SRE) and the public–private organization for regional development (Brainport Foundation), a wide network of local actors has developed effective ways to collectively address the region's challenges. This public–private governance model seems very suitable to cope with the complex and fast-changing opportunities and threats facing urban innovation systems. The working style of Brainport Foundation illustrates the need to set up such intermediary organizations with care, providing sufficient funds and legitimacy to be an effective partner for local firms and research institutions but without making it too independent (with an overly generous budget) or dominant (with too far-reaching a mandate).

Third, a strong research infrastructure is an essential asset of the innovation system, first and foremost as a source of new talent. The region's technical university, TU/E, is especially strong in cooperation with local industry, a crucial task many universities in other regions still struggle to perform well. But historically, its bonds with local industry have been so strong that it made the TU/E overly dependent on a few key private partners for funding and direction. Its recent development strategy, illustrated by the redevelopment of the TU/E Science Park, is an interesting case in how a university can reform itself into a more independent and central actor in the system while keeping its traditionally close bonds with industry. Moreover, the TNO and Holst Centre are interesting cases in public–private cooperation in research and development.

A fourth source of strength for the Eindhoven system is the widespread adoption of open innovation among its firms and other stakeholders. This umbrella of innovation strategies promises to enable the system to sustain its high innovation performance even if firms are no longer able to fund the kind of large internal R&D labs like the NatLab that first brought the Eindhoven system to prominence. But the successful application of open innovation puts high requirements on a system, most notably the ability of local actors to carry out R&D cooperation based on trust rather than contracts, and the ability to quickly establish and nurture start-up and spin-off firms. The Eindhoven region shows an exceptional ability for the former but performs relatively weakly on new firm creation.

Finally, the Eindhoven system has benefited from an effective regional branding strategy, which is the fifth source of strength identified for its innovation performance. It went from a relatively obscure and underestimated region to a globally recognized one in just a decade, presenting itself to the world with a focused brand image (rather than trying to be perceived as 'good at everything') agreed on by a wide coalition of local stakeholders. While this strong branding is a relatively recent asset for the Eindhoven region, it can help attract more leading firms to the region and strengthen its position in the global network of innovative regions.

Besides these five sources of strength of the region, four key challenges face the region's stakeholders if they are to sustain their competitiveness in the future. The first and most urgent challenge that Eindhoven faces is in addressing its shortage of skilled technical labour, making it an interesting case for any innovative region facing the need to attract substantial numbers of international knowledge workers. The Eindhoven region benefits from its attractive environment and open character and above all from the cutting-edge research opportunities at its firms and research institutions, which form the most important attraction factor for international knowledge workers. Innovative living concepts at Strijp S also form an interesting potential element in a strategy for attracting international knowledge workers.

Second, the region is over-specialized in the high-tech systems and materials sector, which is highly innovative but also very vulnerable to cyclical ups and downs. Moreover, this sector has a tendency to produce a small number of large firms at the top of extensive value chains, increasing the vulnerability of the region. If any of these leader firms were to offshore their R&D or relocate out of the region altogether, the repercussions of this would ripple through the region's value chains and potentially create a new crisis like the one the region faced in the 1990s. The rapid emergence of the design sector holds promise to help the region diversify into a more recession-proof industry, and the Strijp S redevelopment project may play a key role in this. Also, the leader firms themselves are strengthening their position in sectors such as healthcare, energy, and mobility, which are likely to enjoy steady demand in the near future owing to, among others, trends of population ageing and the need for energy transition.

The third challenge facing Eindhoven is its relative weakness in new firm creation. Since this challenge seems to be caused by both a paucity of entrepreneurial spirit and skills among the region's knowledge workers and a weakly developed network of venture capital investors, an integrated solution is needed to address this weakness. Start-up and spin-off incubation is a generally accepted policy instrument for providing such an integrated solution, and nearly all hot spots we analysed include such initiatives. While both examples of success and failure have been identified, start-up incubation remains a complex challenge to the many Eindhoven stakeholders involved in it.

And finally, the region faced the challenge of a shortage of public investment in R&D, making the region's research infrastructure highly dependent on the willingness of local firms to make increased investments. In general, a dependence of private rather than public R&D does not have to be a weakness for an urban innovation system, but at turning points in its development (such as the breakthrough of ASML in the case of Eindhoven), a lack of public funding sources can threaten the sustainability of its innovation performance.

Governing the innovation system

This analysis underlines the path dependence of urban innovation systems: as in any region, the strengths and performance of Eindhoven have deep roots in the region's history, its economic, social, and political development. Evidently, this is true for any region. But where Eindhoven seems to stand out is in its ability to actively steer and govern the system very adequately and to develop innovative response mechanisms.

In Eindhoven, this 'innovation system governance competence' can be found on three interrelated levels: the micro level (individual firms and organisations), the meso level (the very active management of specific areas, like the HTC and Strijp S), and the regional level (the way regional public and private actors collaborate).

On the micro level, there are several key organisations with an explicit vision that in a global economy, collaboration/open innovation with partners in the region is important and can add to the firm's competitiveness. Philips and ASML are key examples, but there are many more. Especially Philips's explicit move to open innovation was significant. A recent example is the development of the Brainport Innovation Campus: it was conceived after a number of high-tech suppliers in the Eindhoven region, most of them suppliers of the semiconductor systems builder ASML, expressed an interest in co-locating in a new business park. The strong commitment at the micro level lays the basis for innovation system governance at the two other levels, meso and regional.

On the meso level, Eindhoven shows some remarkable practices of governing innovation. The most striking examples are found at the knowledge hot spots HTC and Strijp S. Both sites have adopted a conceptual and managerial approach with the aim to promote innovation. For each area, there is a management organisation that not only develops the hardware (master plans, buildings, infrastructure) but also explicitly takes the 'soft sides' of innovation governance into account. Some of the key features are:

- *Strict and sustained tenant selection.* At both Strijp S and HTC, tenant selection is used to increase the chance that complementary firms are located together, which may result in innovation synergies. Also, in difficult times, the rules apply. A prime example is HTC's persistent focus on a limited number of sectors, in which it aims for a mix of industry leaders and start-ups. HTC's acquisition strategy is carefully tuned to these targets. In both locations, the tenant selection criteria are not only based on the potential of the location but rather take the characteristics and strengths of the entire region into account.

- *Creating facilities to support the identity and cohesion of the hot spot.* HTC created the Strip, a concentration of restaurants, shops, and conference rooms used by all tenants, as a means to increase coherence and facilitate unplanned encounters; Strijp S only admits the type of restaurants and retail stores that fit its progressive, cultural, and creative profile.
- *The use of events to underline the image and reputation of the area.* The former 'forbidden city' of Strijp S managed to draw creative audiences by programming specific events, thus establishing a new image.
- *Deliberately creating and sustaining platforms where people and firms meet (planned or unplanned).* At HTC, the 'meet and greet' sessions are a platform for new, promising encounters.
- *Deliberate flexibility.* There is a deep realisation that not everything can be planned: there must be sufficient flexibility to host and respond to unplanned events or changing tastes. The HTC leaves 20 per cent of its space vacant to be able to host promising newcomers outside its core sectors. In Strijp S, apartments are designed in a very flexible way: they easily can be changed in size and style if the tenants want to.

On the regional level, finally, actors in the region share an understanding that regional collaboration between public and private sector is a necessity to thrive. This ambition is translated into Eindhoven's unique governance model, which is an international reference. It works as follows: the regional innovation/knowledge strategy is made by a foundation in which the three parts of the triple helix are present: four members are mayors from local governments in the region, four are leaders of knowledge institutes, and the remaining four are leading businesspeople. The president is the mayor of Eindhoven. The strategy is developed in close consultation with all the relevant actors, and after its completion, all the actors are committed to it. The partners have agreed on a common agenda, with a long 'wish list' in each block, and action points. The action points are to be taken up by the partners in the triple helix. The strategy serves to guide regional actions but also works as an effective lobby agenda towards the national government and the EU.

Thus, unlike in many other regions, the strategy is not only a piece of paper: it is shared and consistently implemented. For this, the region set up a powerful cooperation organisation named Brainport Foundation, with 50 people in its development company Brainport Development. This organisation organizes a wide variety of actions: it runs business parks, it kick-starts projects, it provides support for funding and subsidies, it markets and promotes the region at home and abroad, and it supports the strategy-building process. Normally, it does not run projects for a longer time: the policy principle is that actors in the triple helix must develop and fund their own actions. The Brainport Foundation is owned and funded by a large number of municipalities in the Eindhoven region, and it enjoys a high level of trust. The effect is a depolitisation of knowledge policies and a more long-term approach.

In sum, Eindhoven has a fine grid of 'innovation system governance' organisations and structures, operating within an overarching strategic regional framework that is shared and co-developed by the main actors. Individual companies and institutes operate in this framework, and most see that it makes them all stronger. The governance and management practices are embedded in a culture of trust and connectedness. Importantly, over time, the region has been able to renew itself, to adapt to changing – and at times very difficult – circumstances.

Notes

1 Also see a report of Brainport Development (2011) that states that R&D investments by the government in the Eindhoven region are very low compared to those in other innovative regions.
2 Values greater than 1 indicate a level of specialization that is higher than the national average.
3 While Woonbedrijf is focused on developing residential units, Trudo is responsible both for residential development and the area's iconic buildings that are to house, among others, museums, galleries, and retail. Being a social housing corporation, Trudo is not profit oriented but has the mission to provide affordable housing and contribute to the development of the city of Eindhoven.
4 Seventy-one per cent of the publications were written in cooperation with Dutch partners, but co-operation with international firms was growing faster than with domestic firms.
5 Named after the province of Noord-Brabant, in which Eindhoven is located.

Sources

Beckers, T. (2008) Het waren toch de mensen, in L. van den Berg and T. Beckers, *Stille Krachten: 25 jr sociaal-economische ontwikkeling in de regio Eindhoven,* Eindhoven: NV REDE.

Van den Berg, L., Van der Meer, J. and W. Van Winden (2008) Van industrieregio tot technologie hotspot; de ontwikkeling van de Eindhovense regio tussen 1983 en 2008, in L. van den Berg and T. Beckers, *Stille Krachten: 25 jr sociaal-economische ontwikkeling in de regio Eindhoven,* Eindhoven: NV REDE.

Bits and Chips (2011) *3TU-federatie: succesvolle samenwerking, maar verder niks bijzonders,* available at: www.bits-chips.nl

Van der Borgh, M., Cloodt, M. and A. Romme (2012) Value creation by knowledge-based ecosystems: evidence from a field study, *R&D Management* Vol. 42.2, pp. 150–169.

Brainport Development (2011) *Brainport 2020: top economy, smart society,* Eindhoven: Brainport Development.

Brouwers, J., Van Duivenboden, H. and M. Thaens (2009) *The triple helix triangle: stimulating ICT-driven innovation at regional level,* paper prepared for the 2009 Annual Conference of EGPA in St. Julian (Malta).

Buck Consultants (2010) *Op weg naar een Brainport campussenstrategie,* Nijmegen: Buck Consultants International.

CBS (2012) CBS Statline, available online at http://statline.cbs.nl, extracted 17-06-2012.

CBS-CIS (2008) *Regionale innovatie in Nederland, Community Innovation Survey 2004, 2006, 2008*, Heerlen: CBS.

Chesbrough, H. (2003) *Open innovation: the new imperative for creating and profiting from technology,* Boston: Harvard Business School Press.
Eurostat (2008) *Patent applications to the EPO by priority year and NUTS 3 regions*, available online at http://epp.eurostat.ec.europa.eu, extracted on 15-06-2012.
Frenken, K. (2012) Een economische verkenning van de Nederlandse ontwerpsector, *ESB Ondernemerschap & Innovatie*, Vol. 97.3, 77–79.
Heerding, A. (1989) Philips, Gerard Leonard Frederik (1858–1942), in *Biografisch Woordenboek van Nederland* 3, Den Haag: Instituut voor Nederlandse Geschiedenis.
Janssen, J. (2011) Glanzende scherven in een zee van groen, *Stedenbouw en Ruimtelijke Ordening,* Vol. 92.6, pp. 14–21.
Otten, A. (1995) Anton Frederik Philips (1874–1951), in Van Oudheusden, J., Cuijpers, T., Van der Heijden, M., Roosenboom, H. and A. Van Vliet (Ed.), *Brabantse biografieën. Levensbeschrijvingen van bekende en onbekende Noordbrabanders. Deel 3* Uitgeverij Boom en Stichting Brabantse Regionale Geschiedbeoefening, Amsterdam/Meppel: Boom.
Philips (2012) *Geschiedenis van Philips,* available at: www.philips.nl
Research voor beleid (2009) *Creatieve industrie en design Eindhoven, Monitor 2009*, Zoetermeer: Research voor beleid bvTijssen, R., Van Leeuwen, T. and E. Van Wijk (2009) Benchmarking university-industry research cooperation worldwide: performance measurements and indicators based on co-authorship data for the world's largest universities, *Research Evaluation*, Vol. 18.1, 13–24.
TNO (2011) *Topsectoren en TNO – position papers 2011,* Eindhoven: TNO.
Van Hooff, J. (2008) Duurzame bedrijvigheid en bestendige welvaart voor de regio, in Lintsen, H. and Thoben, P., *De Canon van Eindhoven,* Uitg. Adr. Heinen, 's-Hertogenbosch: Heinen.

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4 Kista, Stockholm

4.1 Introduction

In this chapter, we discuss the development of Kista, one the major knowledge locations in Stockholm. As the home base of ICT giant Ericsson and other cutting-edge firms and universities, this science park has been the home of the world's leading cluster in wireless ICT for more than two decades. It is a key component of Stockholm's successful urban innovation system with a relatively high level of specialization. Particularly interesting are its fast emergence from scratch in the decade after its founding in 1976, and – more recently – its (foreseen) transformation into a science city.

Location

The Kista ICT cluster is located in the northwest quadrant of Stockholm, just within the borders of the municipality and about 15 km from the Stockholm city center. Together with the adjacent residential neighbourhood Ärvinge, it forms one of a series of suburban new towns planned as part of the Million Programme, a massive urbanization programme of the Swedish government. Kista (including Ärvinge) and the neighbouring residential areas Husby and Akalla together form one suburban core connected by a subway line, which until 2007 constituted the Kista District (Swedish: stadsdelsområde). Kista borders a nature park to its southeast (Kymlinge) and southwest (Järvafältet). Located on the southeast across the nature park is another former district (Rinkeby District) consisting mostly of residential area, including Rinkeby, Tensta, and Hjulsta. The two former districts were integrated in 2007 to form the Rinkeby-Kista District.

The region of Rinkeby-Kista District and its neighbouring areas is also referred to as Järva, the name of a former military zone encompassing this region. Policies for the development of Kista Science City have, over time, expanded to include not just Kista itself but the entire Järva area, referring to it as the Kista Region or Kista Science City region. Northwest of Rinkeby-Kista District is the town of Järfälla, which includes the former Barkarby Airport that was closed in 2010. Northeast of Rinkeby-Kista and directly bordering the Kista ICT cluster is the town of Sollentuna. Finally, the small town of Sundbyberg is located to the south-east, almost directly bordering Kista.

Although Kista has a rather remote location relative to the Stockholm city center, it is well connected to the city center with a fast and frequent subway and commuter train. International accessibility has so far been more problematic. Kista is located only 9 km away from Bromma Airport, but this relatively small airport mainly serves domestic and short-range international flights and its future is uncertain. Stockholm's major airport, Arlanda, is located about 30 km from Kista, but due to frequent traffic jams, the accessibility is sub-optimal. By the end of 2012, however, international accessibility was improved by the expansion of the commuter train between Stockholm and Kista to Arland. More investments in the road and railroad network infrastructure around Kista will be done in the near future.

Socio-cultural structure

The socio-cultural structure of the Järva region is one of deep segregation, being one of the places where the Stockholm riots in May 2013 took place. The great majority of inhabitants of Rinkeby-Kista are (children of) non–Western migrants. In 2011, 79 per cent of the residents of Rinkeby-Kista were either foreign born or had two foreign-born parents, compared to an average of 30 per cent in Stockholm. About 26 per cent of Rinkeby-Kista residents did not have the Swedish nationality, compared to an average of 10 percent in Stockholm as a whole (SCB/SWECO 2012). Because of the linguistic problems associated with recent migration and segregation, as well as a lower average education level, few of the inhabitants living in the area are able to work in the ICT cluster. In 2002, only 9 per cent of the people working in Kista actually lived in Kista or its immediate surroundings (Barinaga & Famfelt 2004), and the percentage for knowledge workers is likely to be lower still.

4.2 Development trajectory

With a history of almost four decades, the Kista ICT cluster may be regarded as a mature but still highly dynamic cluster. Originally conceived of as one of several industrial zones to create jobs for Stockholm's sprawling suburbs, its development into a world-leading ICT cluster was not anticipated by its planners. When a fully developed vision for Kista as a science city finally emerged around the turn of the millennium, the cluster had already experienced three decades of tumultuous development since the first ICT firms moved into Kista in 1976. What are the circumstances among which Kista emerged? And what development path did it take to become one of the world's leading innovation systems?

Swedish excellence in communication technology as well as its ability to produce world-leading innovative firms is deeply rooted in its industrial past. By the end of the 19th century, Stockholm was already home to a substantial number of innovative industrial companies, with products ranging from advanced steel products for agricultural mechanization, refrigerators, and explosives to telephones. Some of these products had been invented in Stockholm, while products like the telephone had been invented elsewhere but were quickly identified as market opportunities and developed into practical and attractive products by local entrepreneurial engineers. Three characteristics of the Swedish market that are still relevant today caused such enterprises to grow into world-leading firms. First, from the 19th century up to this day, the Swedish domestic market has been exceptionally fast in adopting new products. Both big early adopters such as state-owned transportation and public utilities companies as well as a consumer market eager to try out new products and put them to use together helped new inventions to quickly move from ideas into tried-and-tested products that are ready for export.

Second, while the Swedish market is a fruitful test bed of new technologies, it is also a very small market, with 5 million inhabitants around 1900 and less than double this number one century later. This forces firms to look beyond the domestic market and prepare for export from an early stage. Third, the Swedish market and the Scandinavian markets in general have been very open to foreign competition from the 19th century on, with the government resisting the level of protectionism and support for national champions that was still characteristic in most Western countries until recently. This strengthened the effect of the first two characteristics, since it allowed Swedish consumers and entrepreneurs to come into contact with cutting-edge products quickly after their invention, and it puts even more pressure on local firms to continually improve their products, keep prices low, and expand into international markets.

The most prominent leader firm to emerge from this dynamic market is ICT giant Ericsson. Founded in 1878, the firm started by imitating foreign telephone equipment from the United States and Germany but quickly moved on to develop its own knowledge base and vision for the telephone as an attractive, practical product with mass-market appeal. Most importantly, Ericsson became a world leader in switchboards and other networking technology. Before and during World War II, Ericsson widened its product range, among others to cope with wartime protectionism and to supply critical equipment to the Swedish army, but after the war it quickly returned to its core competence in telecommunication. In a mix of competition and cooperation with the government-owned telegraph and telephone operator Televerket (later Telia), Ericsson gave Sweden one of the most advanced telecommunication systems worldwide, as well as gaining a substantial share of the world market. The other key players in the early Swedish ICT sector, SRA (advanced radio and radar equipment) and Rifa (component supplier to the radio and later the wireless communication industry), were both co-founded and later fully acquired by Ericsson (Karlsson and Lugn 2009).

Being a magnet for young workers, graduates, and entrepreneurs as well as a major center of Swedish industry, Stockholm has faced high land prices and shortage of housing from the early 20th century into the 21st. Most industrial firms moved out of the city center but stayed close to Stockholm's labour pool and consumer market. Ericsson was the last major industrial firm to move out of the city center in 1940, moving to its new complex at Telefonplan just south of central Stockholm, where it concentrated its decision-making and R&D. While the firm expanded with production and R&D facilities in Sweden and abroad, it would remain very much a Stockholm company to this day.

Urban development

With a seemingly unstoppable flow of inhabitants and economic activity into Stockholm, the need for urban expansion became clear. But the municipal government responded slowly, and it would take until the 1960s before the Swedish national government decided to take action to address the by then urgent housing and land shortages through the Million Programme. This massive urbanization programme involved the construction of a million homes all over Sweden between 1965 and 1974, with a substantial number of those built in the form of suburbs around Stockholm. Some of the largest of these new suburbs were built to the northwest of Stockholm in the Järva area, housing about 120,000 people. The design of the neighbourhoods focused on apartment towers up to nine stories high in order to preserve large green areas in between the neighbourhoods. The residential area next to the Kista industry cluster, Ärvinge, was completed after the Million Programme, and with lower apartment buildings and semi-detached houses, it was aimed at a higher price range.

However, when construction of the new suburbs was finished, their further development did not go as planned. The oil crisis starting in 1973 and the ensuing economic recession in Sweden reversed the flow of Swedes moving to Stockholm as employment opportunities in the city plummeted. Demand for housing dropped sharply, and parts of the newly finished neighbourhoods remained vacant. By coincidence, around the same time, the first wave of refugees was admitted into Sweden, and since there was substantial vacancy in Järva, it was a logical choice to house many of them in the new suburbs there. The result, however, was a high level of ethnic segregation, with about half of the residents of the Kista District and up to 90 per cent of the residents of neighbouring Rinkeby having a foreign background (predominantly African, Middle Eastern, or Pakistani). This lead to a concentration of inhabitants who, due to linguistic and cultural barriers, are relatively far removed from the Swedish labour market, let alone the knowledge-intensive labour market that would develop in the Kista cluster (Barinaga and Ramfelt 2004).

Emergence of Kista

The new suburbs of Järva were planned according to the ABC (Arbete-Bostad-Centrum) concept, which means that every new neighbourhood should function as a self-contained city in which people not only live but also work, shop, and enjoy public services. To realize this goal, several industrial zones were planned in the Järva area, one of which was Kista. The current location of Kista had been used as a military practice area from 1905 until the army left in 1970. Because of its status as a restricted military zone, it retained an open and natural character, so when construction of the industrial park started, Kista offered an exceptionally attractive environment. However, due to the economic downturn, the industrial development of Kista had a slow start, and hardly any development had occurred when the neighbouring residential areas were already finished.

But while the economy was still in recession, Kista quite suddenly started its rapid emergence into the ICT cluster it is today. Perhaps as a result of personal discussions between Ericsson's CEO Marcus Wallenberg (one of the most prominent and well-connected citizens of Stockholm at that time) and the mayor of Stockholm, the two large Ericsson subsidiaries SRA and Rifa decided to move to Kista. Shortly afterwards, IBM Sweden, which at that time had plans for deep cooperation with Ericsson, also moved to Kista. So between 1976 and 1978, Kista went from empty land to the location of three prominent players in the ICT sector. These three firms together employed about 3,000 workers (most of them engineers) at the time they entered Kista. The size and reputation of these three anchor tenants set off a chain reaction, quickly giving Kista the image of a high-tech engineering hub and making it an attractive location for other electronics firms and their suppliers.

With the sudden surge of interest in Kista, the municipal land development organization in charge of Kista could afford to select tenants rather than welcome any type of firm. It decided to exclude polluting industry from Kista and focus instead on clean industry, with a preference for electronics. However, by the early 1980s there was no precise vision nor a timetable for Kista's future development yet, and the concept of ICT itself had not yet been specifically defined. Many of the tenants moving in following IBM, SRA, and Rifa were related to what would later be called ICT, but also included were, for example, the Swedish postage stamp printing facility and an elevator factory.

As part of the Million Programme, the Kista subway station and an adjacent shopping center had been constructed. But other infrastructure was still very limited and Kista was perceived as a rather remote location. Moreover, there was no detailed plan for the layout of Kista, and this only emerged gradually from negotiations between Kista tenants and the municipal land development agency. As the number of tenants grew rapidly, the development of infrastructure did not keep up with the demand, and early tenants complained about low service quality and cramped conditions in part of the industry park. Kista's early tenants also faced difficulty in hiring top-level engineers. Hardly any engineers were willing to live in the new suburbs surrounding Kista, and workers from other parts of Stockholm perceived Kista as remote, desolate, and empty. In the mid-1980s, Kista was still a rather quiet place, especially outside of office hours. But even during the day, Kista felt empty because workers hardly left their offices. To attract workers, some Kista–based firms offered luxury facilities such as swimming pools inside their office buildings, but there was little effort to create an attractive public space outside of these 'self-contained islands' (Bengtsson *et al.* 2011:149).

Breakthrough in ICT

Kista reached a new milestone in the second part of the 1980s, partly thanks to an innovation breakthrough at Ericsson and partly as a result of an ambitious national research project culminating in the development of Kista into an ICT campus. Ericsson's daughter company SRA had developed advanced wireless communication technology at its Kista R&D labs, but for almost a decade this breakthrough was ignored by the Ericsson head office at Telefonplan. Mobile telephony was considered an unimportant side product, at best relevant for business travelers and public agencies (hospitals were a launching customer, equipping their ambulances with mobile telephones). The Ericsson top management never visited Kista and repeatedly tried to cut off SRA's funding. The Kista research team gained a reputation as 'cowboy engineers' chasing their vision for wireless communication, operating as a 'skunkworks' ignored by the head office and at times having to improvise their own funding. The remoteness of Kista created a 'splendid isolation', giving the Kista research team freedom to work undisturbed and create its own subculture of 'a bunch of cowboys who worked night and day and spurred each other on' (Karlsson and Lugn 2009). It was only when Ericsson was obviously falling behind foreign competitors and SRA had reached commercial success on its own strength that Ericsson finally gave mobile telephony full priority. SRA was integrated into Ericsson's core business and expanded, and the center of gravity of Ericsson shifted to Kista. Where Ericsson's head office was convinced of the potential of mobile ICT, the Swedish banks were not, and it was only thanks to a large loan from the national government that Ericsson's wireless ICT could make its breakthrough in the mid-1980s (Karlsson and Lugn 2009).

While Ericsson was still struggling to move from wired to wireless ICT and from analog to digital technology, a major diplomatic scandal took place that would trigger the Swedish government to throw its weight behind the takeoff of the Kista ICT cluster. After the Swedish firm Datasaab was caught selling sensitive American military technology to the Soviet Union, the United States refused technical cooperation with the Swedish Army between 1979 and 1982. This made the Swedish government realize how dependent and technologically backward they had become, especially in digital technology. The Swedish government called together the army, industry, and universities and set up the National Microelectronics Programme, the biggest technology investment in Swedish history, to fund their coordinated research effort. The programme resulted in the creation of the Institute for Microelectronics at Kista, in which Ericsson and its subsidiaries were key partners.

The Kista ICT cluster quickly faced the problem of a lack of specialized engineers, and it became clear to industry and government that Stockholm's universities (the famous KTH and the smaller but growing Stockholm University) had to modernize and expand. Because of the large economic and military interests involved, the two universities were offered extensive funds and modernized facilities but on the condition that they would relocate to Kista to work more closely together with industry and the military. When KTH refused to relocate, great pressure was exerted by the government, the military, and industry, and a compromise was reached in which KTH and Stockholm University only moved their electronics and ICT-related departments. In exchange, they received state-of-the-art computers (donated by industry), labs, and teaching facilities, and when a lack of teachers held back the universities' expansion, Ericsson sent some of its researchers to help with teaching.

The iconic Electrum Building was constructed to house the university departments, the Institute for Microelectronics, and other research institutes funded by government and/or industry. This center for research and education was intended to foster cooperation among the various universities and research institutes, with the goal of enabling them to better serve the needs of industry. The strengthened knowledge base would help Kista's firms and institutes to become world leading in ICT, and it helped Ericsson to develop groundbreaking products such as the GSM mobile phone with roaming ability at its Kista research labs.

Ericsson also attempted in the 1980s to enter the then emerging computer industry and challenge the giant IBM in its core market. Ericsson tried to recreate the 'skunkworks' atmosphere by renting an anonymous garage at an industrial park nearby Kista, Veddesta (at that time sometimes called 'Silicon Hill'), and giving a team of developers a few months to develop a working Ericsson PC (Computer Sweden 2003). However, the Ericsson computer division was plagued by setbacks, largely because its local suppliers were unable to keep up with the demands in this highly dynamic sector and competition from IBM proved too tough. In 1988, the division was sold to Nokia, which also gave up on the sector in 1991.

When Ericsson had secured its leading position in wireless ICT and at the same time given up on its attempts to expand into the computer industry, Kista's specialization in wireless ICT was firmly established. Kista continued growing and specializing through the recession in the early 1990s, and growth accelerated as the ICT boom changed into a bubble around 1998 and 1999. Venture capital became abundant and large numbers of start-ups sprang up, though more in the Stockholm city center than in Kista. Ambitions for Kista also rose during the bubble, and several plans were proposed to build iconic high-rise buildings in Kista. The municipal aesthetic commission rejected all except one of these proposals, allowing the Kista Science Tower to be built as an icon for the Kista cluster.

When the ICT bubble popped in 2000 to 2001, it was the Stockholm city center that was hit most strongly, while Kista was less affected. However, the disastrous GSM bandwidth auctions throughout Europe[1] did have serious consequences for Kista's ICT firms. Between 2001 and 2005, Ericsson, threatened with bankruptcy, laid off more than half of its global workforce, including 12,000 of its 40,000 Swedish workers (Karlsson and Lugn 2009). But the Kista ICT sector returned to growth and continued to be a world-leading wireless ICT cluster in the second half of the 2000s and beyond. With the move of its headquarters from Telefonplan to Kista in 2003 (after having briefly relocated to London in the early 2000s), Ericsson reaffirmed its commitment to Stockholm and to Kista, and it continued to carry out its key R&D and decision making within the cluster (Bengtsson *et al.* 2011).

From science park to science city

By 1999, Kista had developed into a well-known and prestigious area of industry, research, and education, marketed under the name Kista Science Park. Its available land had mostly filled up with ICT-related firms, and the original developers of Kista concluded that the park was more or less finished with no opportunities for expansion. But as the dotcom bubble was still picking up momentum, demand for land at Kista kept increasing and land prices reached unprecedented levels. Pressure for further expansion of Kista increased, if not by physical expansion then at least through intensification of land use. By that time, Kista had developed piece by piece for two decades, but there had never been a long-term strategy or specific development plan for Kista. The Stockholm planning agency and the Kista stakeholders in Electrum Foundation came together to think about what direction they wanted Kista to take, culminating in the 'Future Vision for Kista' project (Bengtsson *et al.* 2011).

In 2000, these discussions resulted in a clear and ambitious vision. Rather than a fully developed science park, Kista was reconceptualized as an emerging science city. The 'Future Vision Kista Science City' planning document was created and Kista Science City AB was formed as a planning and networking organization by Electrum Foundation (but focusing on inspiring rather than planning, see Box 4.1). In 2007, the City of Stockholm also formulated its *Järvalyftet* to upgrade the Järva area (elaborated in 2009 in the Vision Järva 2030 document), in which Kista is conceptualized as the core of a science city encompassing the entire Järva area. Besides spatially expanding the Kista Science City concept, its ambitions now also came to include social goals. Turning Järva into a science city centred on Kista is expected to help solve its segregated character and improve the career and educational opportunities for its currently largely disadvantaged population, while at the same time addressing public safety issues, improving the attractiveness of the area, and upgrading its image. This bundling of policy ambitions means that Kista Science City is now backed up by extensive government funds and attention.

4.3 Current profile

In this section, we briefly introduce Stockholm and its innovation performance, focussing on the role of Kista but also paying attention to other important innovation hot spots in the region.

Stockholm

Stockholm is one of the most innovative regions in Europe. Its performance can be measured, for example, by looking at the absolute number of granted patents, which gives Stockholm third place among European regions (in 2008), just behind Eindhoven and Munich (Eurostat 2008). Another important indicator is the amount of money spent on R&D (see Figure 4.1): with investments that accumulate to 4 per cent of the GDP, the region receives twice as much R&D investments as the average European region (Eurostat 2008).

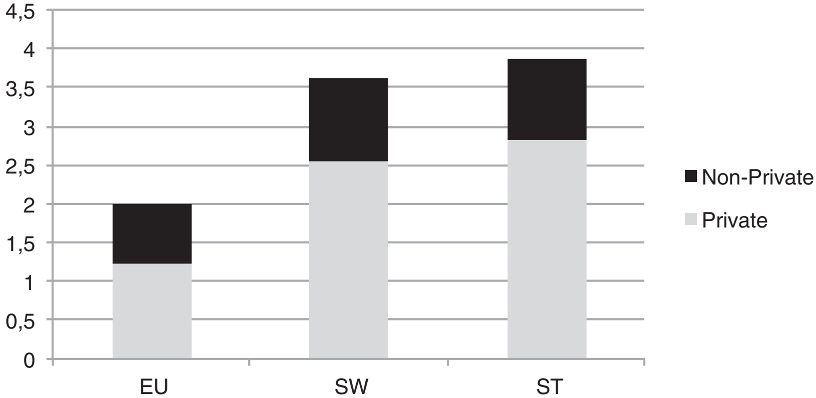

Figure 4.1 Public and private R&D investment in Stockholm (ST) and the EU average (EU27) as percentage of GDP, 2003–2009

(Source: SCB, accessed on 13-7-2012)

The ICT sector is well represented in the Stockholm economy. The computer programming and consultancy sector stands out as the most dominant part of the ICT industry, with employment reaching 40,000 workers in 2010; this sector is still growing. The computer, electronics, and optics industry employed about half as many workers and has decreased in size somewhat since 2008. The telecommunication sector, of high importance to Kista, takes a third position with a fairly stable level of employment around 11,000, while information services takes a relatively minor share of employment in the municipality. Location quotients based on the share of employment compared to the Swedish average (see Table 4.1) confirm that Stockholm is specialized in ICT (Statistics Sweden 2010).

Kista: hard ICT

As we have seen, Kista has become the undisputed center of Swedish ICT, with education, research, and industry in ICT being centred in the area. In 2012, Kista

Table 4.1 Relative specialization of Stockholm in the ICT industry based on share of employment, compared to the Swedish average (location quotients), 2007–2010

	2007	*2010*
Computer, electronics, and optics industry	1.11	1.09
Telecommunication	1.69	1.76
Computer programming and consultancy	1.86	1.78
Information services	2.18	2.45

(Source: SCB, accessed on 13-7-2012)

was home to almost 9,987 firms, of which 1,168 firms (11.7 per cent) were in the ICT sector. In terms of employment, the ICT sector is substantially more dominant: in 2011, ICT firms employed 23,973 of the 72,346 workers (33.1 per cent)[2]. These ICT firms are relatively large: 65 per cent of the employees in the ICT sector work within the 13 major companies of Kista[3] (Kista Science City 2011).

Ericsson is still a dominant player in Kista, with its head office and much of its R&D facilities located there. Many of the other firms at Kista are suppliers who want to be close to Ericsson to be able to fit into its value chain. What has changed over the past decade is the atmosphere at Kista. While it used to be a place of skunkworks and free-wheeling innovation, the dominant atmosphere is now more professional and business minded. This may partly be the result of a change of corporate culture within Ericsson, but the wireless ICT sector in general has also become more mature. Besides Kista, several other knowledge hot spots can be identified in the Stockholm region, some of which may have taken over the rough edge that used to characterize Kista.

Kista is focused on what may be called 'hard ICT', that is, the hardware and business services that work on the background to keep an ICT system running rather than eye-catching consumer products and software apps. This leaves a large part of the ICT sector for which Kista is far less attractive. In 'soft ICT' sectors such as consumer software, games, and app development, small firms are more common and the rate of firm creation and attrition is higher. Moreover, creative design is relatively important for these firms, while knowledge spillovers from laboratory R&D are expected to be far more limited. Firms in 'soft ICT' tend to prefer different locations: inner-city locations in which interaction with other entrepreneurs and with (potential) users happens more spontaneously. Being overall smaller firms, they tend to prefer smaller and more attractive real estate or collective firm housing.

Soft ICT clusters

In Stockholm, two areas in the city center have become kernels of soft ICT clusters. In a relatively small area in Södermalm (a few city blocks), a concentration of game developers has sprung up, while in central Stockholm (just north of the old town), pockets of app designers, web entrepreneurs, and new media have gathered in the vicinity of a few popular coffee houses. These coffee houses function both as meeting places and also working places for those entrepreneurs, who prefer to work in vibrant and lively surroundings rather than in their own offices. The City of Stockholm aims to support these hot spots of entrepreneurship, but at first it had difficulty reaching them. In contrast to Kista ICT firms, which are used to taking part in collaboration projects with government and academic institutes, the municipality found that small soft ICT firms were less interested and open to assistance in the form of business incubation and shared R&D projects. But the municipality eventually found a way to support its soft ICT in the form of 'company hotels'. Small, affordable, and flexible office spaces are offered to entrepreneurs in the form of work–life communities (or communes). For example, an unused church building was converted into office spaces for one or two dozen small firms, with plenty of communal space and shared facilities.

Other hot spots

Another noteworthy innovation hot spot in Stockholm is the medical cluster that is currently emerging around the Karolinksa Institutet just northwest of the old city center. This medical university and its associated university hospital is the leading medical university in Sweden and one of the most prestigious in its field worldwide, with more than 11,000 students and academic staff. The hospital will move to a new location further from the city center in 2015 because of a lack of space for expansion. Besides the space freed up with the relocation of the hospital, a lot of other space is available because an adjacent obsolete railway station has been assigned for redevelopment and new buildings are planned on top of another adjacent roadway. In total, the redevelopment is planned to create 36,000 new workplaces in the cluster.

An innovation hot spot that is still in the planning phase is the cleantech cluster that will be developed at the soon-to-be vacant Royal Seaports, less than 2 km west of the city center. The Royal Seaports are planned to become a cluster for green technology by 2025, with high-end facilities and a smartgrid system for energy saving. The area will be developed along the example of the Hammerby Sjöstad eco-town just south of Stockholm, which is a best practice of combining eco-friendly technology with a high quality of life (e.g. Notaras 2010).

Finally, the Uppsala Science Park is of some relevance for Kista. Uppsala is a medium-sized city about 70 km northwest of Stockholm and at 55 km from Kista (about 1 hour travel time). Uppsala University and its academic hospital have a strong reputation for medical sciences. Around the academic institutes, a cluster of innovative firms has emerged, and the Uppsala Science Park has been created to facilitate the further growth of this cluster. In 2007, the park was renamed Stockholm-Uppsala Life Science to emphasize its proximity to Stockholm, mostly aiming at foreign investors who are familiar with Stockholm but not with the smaller city of Uppsala. Kista is located between Uppsala and Stockholm, and this is being emphasized in Kista's marketing strategy. So far Kista has been only barely within commuting distance from Uppsala, but since December 2012, travel times have been reduced by an extension of Kista's commuter train to Arlanda Airport and continuing to Uppsala. However, since Kista is specialized in a different industry sector, the benefit of its relative proximity to Uppsala may remain limited.

4.4 Key features of the urban innovation system

Having discussed the historical background of Kista and its position in the Stockholm ecosystem, this section explores the sources of Kista's strength as an urban innovation system as well as the challenges it faces.

Specialization and identity

The most prominent feature of Kista as an urban innovation system is its strong specialization and clear identity. It has an unusually strong focus on a small range of interrelated industry sectors, centred around Ericsson's specialty of wireless communication systems. Within the ICT sector, Kista is identified with 'hard' ICT, while firms in the 'soft' ICT sector are primarily located in Stockholm's city center.

Kista's specialization emerged spontaneously and was not foreseen by the original developers of Kista. By a lucky coincidence, Kista was ready for the first tenants to move in just when a number of big ICT firms were looking for expansion space, and this set off a self-sustaining process of accumulation of knowledge-intensive ICT firms that benefit from their co-location in Kista. In recent years, Stockholm has started to discourage the development of new manufacturing facilities in Kista as opposed to headquarters and R&D facilities, but besides that there are no rules aimed to steer the tenant mix.

Similarly, the organizations active in the marketing of Kista (Kista Science City AB and Stockholm Business Region Development) have no formal policy of specifically targeting firms in certain sectors. So the strong focus on ICT was at first the result of coincidence and consequently became a market-driven rather than a policy-driven process. Interview respondents indicate that to them, the price of land and real estate at Kista is quite high, and it only makes sense for firms to be willing to pay these high prices if they benefit from being close to major wireless ICT firms like Ericsson.

This strong specialization brings two types of advantages. First, it offers increased scope for inter-firm and university–industry cooperation and knowledge spillovers. An important finding in recent research on innovative clusters is that firms and organizations with a related sector specialization benefit more from co-location. At Kista, not only is a large fraction of its firms focused on ICT, but also the university branches at Kista (KTH and Stockholm University) carry out research and education almost exclusively in ICT. Respondents from Kista–based firms indicate that being located at Kista gives them better access to university research that is relevant and useful for them. Also, they indicate that being located close to important firms in their own industry sector provides advantages in terms of, for example, recruitment tips and information about which industry events to visit.

Second, being highly specialized in one set of related industry sectors helped Kista achieve a critical mass early on, giving it a strong reputation. While Kista is not an especially large innovation cluster, it does offer a substantial pool of specialized skilled workers in ICT. If Kista had developed as a more diverse cluster, its limited size may have limited these advantages. As a result of this critical mass of firms and workers and their innovation performance, Kista has a strong reputation widely known in Europe, the United States, and beyond. And rather than being known as a high-tech region in general, Kista is widely known for its specific focus on wireless ICT.

This strong and specific reputation was found to be especially beneficial for start-up firms. Start-ups in general and those in newly emerging sectors such as

ICT in particular face the problem of lacking a track record that they can point at in order to win the trust of investors and customers. Respondents indicate that having their start-up firm locate in Kista early in their development process immediately gives them a basic level of credibility despite a lack of track record, increasing their access to VC investors and customers. This may explain the fact that 'a non-negligible share of the firms with addresses in Kista is not actively operating any business in the area. They are rather using the address as a branding element' (Johansson *et al.* 2007:11).

However, in innovative industries, the reputation of a cluster is highly dynamic and depends strongly on the performance of its leader firm. In the business media, the perception of Ericsson has shifted several times from a visionary innovation leader to a conservative and backward firm, affecting the reputation of Kista. A strong and consistent performance of Kista's university departments may stabilize its reputation and make it less dependent on Ericsson's ups and downs.

Kista's high level of specialization also has its drawbacks. Respondents identify Kista as professional and competent but also boring and nerdy. Firms that are active in 'soft' ICT such as games and app developers strongly prefer more vibrant areas such as the Stockholm city center. This will make it harder for Kista to diversify into other sectors, so it will likely remain dependent on the highly dynamic ICT sector with its frequent cycles of boom and bust. Moreover, Kista's nerdy image may also prove a hindrance in the effort to transform it from a science park into a real city. Most of the respondents, especially relatively young entrepreneurs and knowledge workers, indicate that they would not consider living in Kista but strongly prefer the vibrance and atmosphere of the Stockholm city center.

Institutional environment

A second factor that helps to explain Kista's strong innovation performance is its institutional environment – the written and unwritten rules prevailing in Swedish society in general and in Kista in particular that can either stimulate or obstruct innovation.

At the scale of Swedish society in general, the most salient characteristic is a strong and broadly shared interest in new technology. As described in more detail in section 4.2, Swedish firms, public institutions, and consumers have been remarkable early adopters of technologies from the GSM phone and its precursors to high-capacity wireless Internet access. Large sections of the Swedish consumers are willing and able to try out new technology, and the Swedish government is eager to stimulate and facilitate this. In this way, Swedish society as a whole has functioned as a test bed for ICT innovations, and it continues to be well ahead of most advanced industrial countries in adapting to the latest technologies. Currently, nearly 100 per cent of Swedish homes have access to fibre-optic Internet access, and ICT systems both at the office and at home are of a high quality at a relatively low price compared to other countries (for example, see United Minds 2011). Moreover, Stockholm was the first city in the world to roll out 4G wireless technology, 2 years before the first developments began in the United States.

An example of the importance of this openness to new technology is the story of Appear Networks, a successful SME (20 employees) founded in 2001 and located at Kista. A crucial step for any start-up is to find its first customer so it can build up credibility and track record and at the same time speed up its product development by having a chance to try out beta versions of its products and getting useful feedback. Appear develops systems for relatively big customers (e.g. public transportation companies and government institutions), which tend to be risk averse and uncomfortable working with small start-ups without a track record. But in Sweden, such agencies are open to experimenting with new technological approaches and more willing to give small firms a chance than their counterparts in other countries. An assignment from the operator of the Stockholm metro system gave Appear its crucial first customer, which helped the firm to relatively quickly outgrow the start-up phase.

Sweden is not only a test bed of innovative technology but also a small, open, and crowded market. For example, early on there were several mobile telephony operators competing for Sweden's less than 10 million consumers, and Sweden was one of the first countries to accept foreign firms to operate its telephone networks. The low appetite for protectionism forces firms to innovate to remain competitive and attempt to become exporters from an early stage rather than aiming to dominate the domestic market.

A major drawback of Sweden's institutional environment is its tax situation. While corporate tax is not exceptionally high, income tax is high and strongly progressive. This makes it more difficult for firms to attract top-level managers from the international talent pool. Ericsson's short-lived relocation of its head office to London was partly driven by this difficulty in attracting international top managers (Karlsson and Lugn 2009). More problematic is the very high tax on income from stock options, making it very unattractive to give shares to employees or managers as an incentive for their commitment to the firm. Start-ups tend to use stock options to reward risk-taking investors and employees rather than having to draw cash out of the firm to pay high wages or bonuses.

Besides the national institutional environment, Kista's innovation system has also developed some local institutional features. As mentioned in section 4.2, the nascent digital ICT cluster in Stockholm in the 1980s was a curious blend of conservative corporatism and rebellious 'cowboys'. While Ericsson's managers at the Telefonplan headquarters were for a long time a reactionary force trying to discourage R&D on digital wireless ICT, its researchers at Kista tended to ignore this scepticism and went ahead with their research with or without formal backing. Kista quickly gained the image of a place for free-thinking researchers focused on long-term visions rather than short-term profits. Many of the crucial breakthroughs in wireless ICT emerged from 'skunkworks', research projects ignored or discarded by the head office but continued by stubborn researchers who refused to give up their vision.

However, it is very symbolic that when Ericsson moved its head office from Telefonplan to Kista in 2003, this more or less coincided with a change in the firm's corporate governance emphasizing cost control and discipline and ending the 'Wild West' freedom previously enjoyed by Kista–based researchers. Nowadays it is difficult to find evidence of cowboy researchers engaging in cutting-edge skunkworks, although this may still take place in secret. Instead, Kista has developed into a space of respectable and professional R&D with an increasing focus on business services rather than eye-catching inventions. This transformation may partly be explained by the maturation of the ICT sector in general.

The openness to new technology in Swedish society in general can also be identified at the local scale within Kista. The key example is the Kista Galleria, a large shopping mall in the center of Kista. In 2007, when smartphones with wireless Internet access were still a relative novelty, the Galleria mall became a living lab for context-aware mobile services. In one of the first demonstration projects worldwide, shops and restaurant set up a live stream of information to give visitors to the mall up-to-date information on product offerings and opening times accessible by smartphone. Similarly, security personnel and maintenance workers were given access to live, context-aware information streams. Another example of a living lab in Kista is the work at the Mobile Life Center, described in Box 4.3.

A final dimension of the openness of the local institutional environment at Kista is the openness for new firms, domestic and foreign, to settle there. While from the start Kista was essentially dominated by Ericsson (through its daughter companies SRA and Rifa), competitors such as IBM were allowed to set up R&D facilities and even regional headquarters in the area. Ericsson tolerates co-location not only with firms it already has an established relationship with but also with more controversial firms such as the Chinese ICT giant Huawei (which is reputed to have close ties with the Chinese military). The prevailing attitude that emerges from the interviews is that while Ericsson and other key Kista–based firms may not always benefit from co-location with (foreign) competitors and in some cases may even run a risk by sharing the location of their most sensitive R&D operations, it is important to maintain the open atmosphere of Kista and keep a healthy sense of competition and rivalry.

Governance

A third building block of Kista's innovation performance is its governance structure. The actors that take part in Kista's governance are a peculiar mix of a relatively powerful municipal planning office and a network of public–private actors brought together in the Electrum Foundation and Kista Science City AB.

Sweden has a strong urban planning tradition. Kista's development from the 1970s on was originally the outcome of the ambitious, state-directed Million Programme (see section 4.3). This programme involved massive top-down blueprint planning, aiming to build homes but also commercial centers and industry zones from scratch. The residential areas neighbouring Kista were largely constructed as planned, but planners soon found out that setting up an industrial zone from a blueprint design is much more difficult due to the unpredictability of economic development and the strategic decisions of firms. Planners found that they had to learn to adapt to the circumstances of the time and give more space to the free market, allowing more bottom-up initiative than may have been expected in the Swedish context at that time.

Moreover, top-down planning was complicated by the fragmented nature of local government in the Järva area. While Kista itself belongs to the Stockholm Municipality, it directly borders two other municipalities, so expansion would require their support. Traditionally, there are tensions between these neighbouring municipalities and the city of Stockholm,[4] which at times is perceived as arrogant and condescending and only recently has started to take a more modest approach to interaction with smaller neighbouring municipalities.

So while Kista developed in the context of a powerful top-down planning system, the actual local governance structure is more complex and allows more initiative by non-government actors. Currently the City of Stockholm owns all of the land and half of the housing stock in the Kista area, and it enjoys planning monopoly. When real estate developers want to develop a plot in Kista, the municipality typically negotiates with them to also develop something that helps the municipality achieve its social planning objectives (e.g. you can build an office park, but you should also provide sufficient green space; you can develop a residential area, but it should include student housing).

In some cases, the municipal government depends primarily on its ability to inspire and convince private actors to realise its plans. For example, as part of the Järvalyftet programme (see section 4.6), the municipality seeks help from Kista–based firms to provide internships and organize activities with local schools. To convince these firms to take part, the municipality needs to align its goals with the CSR (corporate social responsibility) objectives of the firms themselves. Another example is the Sustainable Järva project in which the municipality had to convince energy utility companies and housing corporations to join forces and together invest in improving the energy efficiency of the housing stock of Järva.

Besides the local government, the other important player in the local governance of Kista is the Electrum Foundation and its subsidiary Kista Science City AB. Electrum Foundation was founded in the 1980s to help Kista expand its knowledge base by attracting university departments to locate there, which was needed for the Stockholm ICT cluster to make the leap from analog to digital technology and achieve excellence in wireless ICT. Electrum also played a key role to create the vision for transforming Kista from an industry park into a science city, as we will discuss further on. Box 4.1 describes in detail how Electrum Foundation and Kista Science City AB work.

In sum, Kista developed in the context of a powerful planning system with a decisive role for local government, but over time, the City of Stockholm learned to provide more space for the initiatives of private actors. However, transforming Kista into a real city requires some substantial investments in infrastructure and facilities, for which the tradition of government planning will come in handy.

Box 4.1 Electrum Foundation

Electrum Foundation is a public–private partnership. Its board members include the Mayor of Stockholm, the President of the KTH University, and CEOs of large Kista firms such as Ericsson, IBM-Sweden, and real estate developer Atrium Ljungberg. Ericsson traditionally provides the chairman of the board, an unwritten rule that still holds today. The mission of Electrum is to promote the development of Kista and bring together the three Triple Helix actors – industry, academia, and government – to jointly address any issues and challenges faced by Kista's tenants and other stakeholders.

Electrum has five councils that each cover one aspect of Kista (higher education, innovation, infrastructure, marketing, and research). These councils operate as think tanks and organize meetings and other events. While Electrum's employees set up these meetings, representatives from industry and academia are in charge of running them and setting the agenda. When these councils identify a shared problem (e.g. a lack of specialized knowledge workers or the need for improvements in infrastructure and accessibility), they set up a team to find concrete solutions and spearhead their implementation. This often involves passing on a request to the Stockholm local government, either directly during the meetings (the mayor of Stockholm is a member) or in the form of a formal letter signed by the members of Electrum.

Electrum Foundation owns two subsidiaries to help it implement its goals: the STING business incubator (see Box 4.4) and Kista Science City AB (KSC). KSC is a small organization with eight employees that acts as a facilitator between the Triple Helix actors. For example, it can facilitate negotiations between the city and real estate developers with development plans in Kista, and it receives potential investors in Kista. KSC is not a decision-making actor but instead aims to elaborate Electrum's vision for Kista as a science city and use it to inspire the Triple Helix actors that make the actual decisions. Besides its eight employees, KSC does not have regular members, but its meetings are open to all Kista stakeholders.

Comparing Kista Science City AB with Brainport Development in the Eindhoven region (see Box 3.1) provides some useful insights. First, their parent foundations (Electrum Foundation and Brainport Foundation) have quite similar membership structures, with the head of the region's leader firm (Ericsson, Philips) as chairman of a board that includes representatives from all of the Triple Helix actors. But while Brainport Development has 50 employees and 28 part-time project leaders, Kista Science City AB is clearly a much smaller organization with only 8 employees, depending more on voluntary than part-time paid workers.

Moreover, while both organizations are tasked with formulating a vision for their respective innovation clusters, Brainport Development produces more detailed policy documents that come close to the kind of documents usually produced only by local government agencies. However, the key similarity between the organizations is that they are intended as light organizations that organize, network, and inspire but do not have the budget to take the role of planning and implementing their vision by themselves. This means that Electrum Foundation and its subsidiary Kista Science City AB, like their colleagues at Eindhoven, are forced to keep very close contact with their public and private partners, preventing them from becoming too independent from the actors they are tasked to serve. But again, like their colleagues at Brainport Foundation, Electrum also faces the challenge of making sure that the voices of smaller firms receive enough attention vis-a-vis the region's leader firm.

An ongoing challenge is the cooperation between the City of Stockholm and its neighbouring municipalities. While this has been problematic in the past, at least in the case of Kista, a consensus seems to have developed that regional-scale coordination and heavy investments are needed. Neighbouring municipalities have become eager to associate themselves with the economic success of Kista and share in the wealth, jobs, and international visibility that Kista has generated over the years.

A more structural solution to the challenge of coordination with neighbouring municipalities would be the establishment of an effective regional-scale cooperation organization. However, while a Stockholm Region organization has been created, the City of Stockholm is not eager to let it become powerful and let it grow into a government layer with its own source of funding and a clearly defined role in the policy-making process. More still needs to be done before regional actors can rally around their shared interests in Kista.

R&D and human resources

The knowledge base is a fourth building block of Kista's innovation performance. Over the past decades, R&D labs in Kista have been the source of many breakthrough technologies in wireless ICT. Even if the time of skunkworks and cowboy researchers is now mostly over, the possibilities for cutting-edge R&D at Kista are still the main reason leading ICT firms are willing to pay relatively high rents to be located there. Respondents indicate that even if at some point they may outsource basic programming and product development to low-cost locations outside of Sweden, they are not planning to move their key R&D out of Kista.

The availability of rare and highly specialized human resources is another key location factor for Kista–based firms. The dense concentration of ICT firms in Kista has created a vibrant local labor market, which, due to its high level of specialization, offers excellent job opportunities to specialized engineers. But the supply of human resources has not kept up with demand, leading to shortages and rising wages. Addressing these shortages is a challenge for Kista's universities as well as for the municipalities' housing policy.

In the early 1980s, Kista started as an industrial zone without any academic institutions. The Stockholm region by then already had a century-long tradition in analog communication systems but lacked the knowledge base and human resource pool necessary to also succeed in the upcoming digital ICT sector. In response to the urgent need for a major knowledge upgrade, the Electrum Foundation was set up to attract and settle university departments and research institutes. With support of the local and national government, Electrum spearheaded the development of the Electrum Building, a large and eye-catching building located in the center of Kista and intended as a meeting place for education, research, and industry. It went on to house several ICT firms, besides parts of KTH's and Stockholm University's ICT departments and several research institutes on ICT and other high-tech fields. Box 4.2 describes the Electrum Building in more detail.

Box 4.2 The Electrum Building

In order to develop a strategy for a knowledge upgrade of the Kista cluster, Electrum Foundation and its stakeholders sent a delegation to the United States in 1983 to study five cases of successful science parks, including, for example, Stanford in Silicon Valley and MIT in Boston. Their main finding was that academic research and education institutes tended to be the core of successful science parks, around which large MNCs and spin-off firms would concentrate. They realized that Kista was attempting to do the opposite, by first developing as an industry cluster (with limited spin-off formation) and only later adding academic institutes to it. Therefore it was crucial to develop sizable academic institutes and strongly integrate them with the local institutions.

Moreover, the team picked up a number of design features that seemed to promote the development of American science parks. These parks tended to consist of low-rise buildings with extensive public space, designed (probably by coincidence) in such a way that engineers had to regularly cross some distance to move between laboratories, offices, eating places, and teaching facilities (Bengtsson *et al.* 2011). Because of these regular daily movements and the attractiveness of the public space, vibrant meeting places emerged that enhanced not only the attractiveness of the campus atmosphere but also the knowledge development through spontaneous knowledge exchange. Kista at that time was a very quiet place with offices that functioned like self-contained islands rather than an integrated community, and except for the summer, climate conditions were not suitable for the kind of picnics that are characteristic of American campus life.

In order to quickly integrate academic institutes into the Kista cluster and at the same time implement the design features learned from the American case studies, the Electrum Building was conceived. The Electrum Building is designed as an open gallery six floors high, located roughly in between the campus of KTH and Stockholm University on one side and the Ericsson complex and other firms on the other side. Its main entrance is on the central axis through Kista (Kistagången). The ground floor is designed as an open corridor (almost an indoor street) planned to contain restaurants and shops, and the other floors contain a mix of academic institutes, firms, and R&D labs with their entrances towards the gallery and linked by elevated walkways (facilities are spaced apart in such a way as to invite users to frequently cross through the gallery). Walls are predominantly made of glass to emphasize its open and interactive character.

The first tenants started to move in by 1987, and the building was officially opened in 1988 in a media spectacle, with much of the business and governmental elite of Sweden taking part. It became an iconic center of Kista and currently houses parts of KTH, Stockholm University, and the EIT-ICT co-location center besides research centers including MLC and SICS, and about a dozen small and medium-sized firms. Its eating and shopping facilities are, however, very limited, since few tenants moved in and some went bankrupt because of high rental prices and insufficient customers. Not all tenants were comfortable with the open character of the building, and several moved to a more private location or blocked the glass windows with curtains (Bengtsson 2011). Visitor traffic on the ground floor appears to be limited, although it frequently fills with visitors when events and exhibitions are organized there. One issue that may reduce visitor traffic is that from the outside, the building does not appear to have a very open character, and its high, open gallery is entirely invisible from the street. It is doubtful whether the goal of promoting spontaneous meetings ('interaction planning') is met. The setup of the facilities in the building (and the elevated walkways connecting its floors) may promote a regular flow of workers through the building, but the public space offers few places that invite them to stop and stand or sit down.

Over the past two decades, KTH and Stockholm University have fully taken root in Kista. After deciding that only their ICT and microelectronics departments would relocate to Kista, it became easier to strongly integrate their education and research, since having a similar specialization meant that the departments could perceive clear benefits from cooperation. At first there was even a plan for merging the ICT departments to create a 'Kista University' or 'ICT University', but because especially KTH and to some extent Stockholm University have a strong established reputation, they decided not drop their original names. Instead, the two universities put their logos side by side at Kista, emphasizing their strong cooperation.

Collaborative R&D

In 2012, a third player was added to the Kista academic landscape, namely the ICT department of the newly created European Institute of Technology. The EIT is an EU project that aims to be a catalyst for existing research and education at firms and universities, promoting their interaction and the growth of fully functional innovation systems. EIT-ICT Labs is a distributed organization with nodes in six European cities and its head office at Kista. It does not function as a self-contained academic institution but provides funds and space for students and researchers from existing firms and universities to meet. In its first year, the Kista office will host 25 students who will be offered courses in Kista and in the other nodes and are stimulated to work in collaboration with local firms. Moreover, the EIT-ICT node in Kista has contacts with start-up incubator STING to help it accomplish its other key goal of generating spin-off firms. Students from the other EIT-ICT nodes will also be invited to spend time at the Kista location, and some of them will live at the Kista campus. An interesting aspect of the Kista node of EIT-ICT is its co-location center located in the Electrum Building. It is a meeting place for EIT-ICT students but also open to other students, researchers, and employees of Kista firms. It is intended as a neutral meeting place for events and exhibitions but also spontaneous meetings among Kista's industry and academic institutes. Kista hosts a total of 7,000 students (from KTH, Stockholm University, and the new EIT-ICT), which constitutes 90 per cent of the total number of ICT students of KTH and Stockholm University (Bengtsson 2011).

With the Electrum Building and the new EIT-ICT node, Kista has an elaborate infrastructure in place for fostering university–industry cooperation. One concrete example of this is the use of shared R&D facilities: for example, the cleanrooms in the Electrum Building are used by both university and industry researchers.

The Swedish innovation investment agency VINNOVA also co-funds the research institutes SICS (Swedish Institute for Computer Science) and the Mobile Life Centre (see Box 4.3), both of which have the goal of enriching the knowledge base of Kista firms besides generating spin-off companies. SICS started in 1985 and has since produced 13 major spin-off firms that have produced commercial products or have been acquired by other ICT firms, and its research is widely appreciated by Kista firms.

Box 4.3 Mobile Life Centre

The Mobile Life Centre (MLC) is a collaborative research institute that was opened in Kista in 2007. It is a joint venture of several large MNCs (including Ericsson, Microsoft, Nokia, and IKEA) and the universities KTH and Stockholm University. It is funded by the state research investment agency VINNOVA (33 per cent) and its industrial members (the remaining 67 per cent). The concept for the centre was inspired on the Equator project in Nottingham (for more information, see Mixed Reality Lab 2012), but while Equator is a university–university collaboration, MLC is mainly a university–industry collaborative institute. A challenge faced by many such collaborative research institutes is that only large firms can afford to contribute funding, leaving out SMEs that might have benefited strongly from taking part. In the case of the MLC, this problem was solved by allowing SMEs to become joint venture partners, contributing in kind (mostly by sending their employees to take part in research on a part-time basis) rather than in money, and so far two SMEs have joined.

The Mobile Life Centre offers internships to its members and organizes workshops for firms to consult them on concrete product development issues. But its main mission is to carry out pre-competitive research on the use of mobile technologies in daily life. In 2012, it had 10 projects running, focusing on topics such as the implications of the emergence of the Internet-of-things and the ways people play with mobile technology. Research questions such as the latter are studied ethnographically, turning the research center into a living lab in which experimental technologies can be tried by real users. The joint venture partners of MLC give its researchers freedom to do long-term, visionary research rather than instructing them to solve specific problems or produce short-term results. But still there is some tension between the needs and interests of industry on the one hand and the academic researchers employed by MLC on the other. When the centre's research becomes too visionary, its industry partners try to steer it closer to their day-to-day needs, for example, by giving feedback during workshops.

Even though many joint venture partners are rivals competing in similar product markets, they are able to work together in a relaxed atmosphere in the context of the centre. Research is by and large pre-competitive, providing input into the long-term R&D efforts of all partners involved but not usually leading to immediate applications, which firms prefer to develop in house. When research does lead to practical intellectual property rights (IPR), complicated negotiations about the ownership of these rights are avoided with the simple rule that all partners have equal rights to all IPR resulting from the research. While helpful for preventing legal complexities, this rule has a substantial drawback. The centre is, in theory, a very open institute ready to accept new members, but in practice this is complex because new members immediately get ownership over all IPR previously developed by MLC even if they did not contribute to its funding. So long-term members of MLC resent seeing their IPR ownership become diluted when new members are admitted.

Another mission of the Mobile Life Centre is to generate spin-offs. Whenever research results in a marketable application, the researcher involved is stimulated to develop it in a start-up firm, receiving guidance from STING. At the time of our visit (August 2012), the centre was guiding two spin-off projects that were being prepared to enter the market, and it had one more in the pipeline. But in its first 5 years, MLC has not produced any spin-offs yet that have finished the entire process from preparation to market entry and commercial success. This is partly because its research is not focused on developing practical applications and partly because a spin-off needs permission of all industry partners before being able to use the centre's IPR.

The case of the Mobile Life Centre (MLC) illustrates that the collaboration between industry and academia, under the auspices of the government, can be very fruitful but also raises the problem of different expectations. Industry and academia differ in the type of research results they value, and as co-funder the government adds a somewhat unreasonable expectation of spin-off generation to MLC's mission. Another weakness is that while industry has so far been willing to carry most of the financial burden for the centre, government funding is still essential for its survival. MLC is running on a 10-year grant that is unlikely to be extended. The collaborative research institute SICS, which has a similar structure to that od MLC but carries out more practical research projects, is also co-funded by VINNOVA, and its grant expired in 2012. Even though its research has immediate use for industry and it has a strong reputation, SICS (currently running on a 6-year grant) seems fated to disappear, as industry appears unwilling to take over full funding when the government pulls out. If industry is not even willing to fund the practical research at SICS, it is even less likely to fund the more visionary MLC research projects.

The cases of SICS and MLC reveal the difficulty in creating sustainable industry–university collaboration that can thrive independent of government funding. VINNOVA's funding principle is to provide temporary financial support and seek industrial co-funding. When the funding period expires, industry is expected to take over full funding for the R&D centers. If industry is unwilling to do this, this is assumed to indicate that the R&D centre's research is not in fact valuable enough for industry to support and therefore can be terminated. While not unreasonably, the consequence of this strategy is that just when collaborated research centers are fully operational and have started to generate intellectual property rights (IPR) and spin-off firms, they face closure and may lose the capabilities that were created. Perhaps the role of industry in this process is most curious, since firms seem to be willing to take part in co-funding (which usually involves a majority funding by industry, e.g. 67 per cent) but abandon the projects when they are asked to also contribute the remaining part (e.g. 33 per cent) of funding.

Human resources

At the beginning of the twenty-first century, Kista was world leading in its human resources, as some very specialized skills (e.g. engineers who combine expertise in networking and software development) could be found almost exclusively in Kista. But respondents indicate that Kista's attractiveness is starting to fall behind as other ICT clusters are catching up. Kista's human resources are still leading in quality but insufficient in quantity, as the cluster has seen rising shortages of specialized labour. This results in rising wages and, more problematically for Kista–based firms, an increasing risk that scarce workers are hired away by competing firms. Local human resource shortages are most strongly felt by smaller firms and start-ups since they need to hire locally. In contrast, the large multinational companies in Kista are usually able to recruit internally by transferring staff from another subsidiary to Kista.

The origins of the human resources shortages are partly demographic but also stem from a worrying decrease in interest in ICT majors among Swedish high school graduates. The Higher Education Council of Electrum Foundation identified this problem and took the initiative of organizing 'Future Friday', an event for promoting ICT majors to prospective students. The yearly event draws about a thousand visitors and has been organized for the past 5 years.

Another initiative to address this issue is the increased interaction between Kista–based firms and local secondary schools in the Järva area. Engineers and entrepreneurs from Kista agreed to make regular visits to schools to talk with students and organize activities, including visits to the laboratories at Kista. The goal is to inspire these students to choose ICT majors and impart to them the ambition to work at Kista later. The current inhabitants of the Järva area, many of whom are recent immigrants to Sweden, have a low education level on average. But it is expected that the second generation will reach an education level sufficient to work at Kista–based firms. In addition to this, a new secondary school will be opened in Kista that emphasizes innovation and entrepreneurship and that will have strong bonds with Kista–based firms.

Besides raising awareness of ICT and job opportunities at Kista among prospective students, Kista's university branches are also planning to expand to fill the demand for ICT engineers. They plan to triple their number of students over the coming 10 years, and many of these additional students will have to be attracted from abroad. Sweden used to have a unique attraction for foreign students in the form of completely free tuition, but since 2011, this is limited to EU students only, with a limited number of scholarships offered to the brightest non–EU students. But so far this change in policy has not had a noticeable effect on the number of enrolments, and in the case of Kista students are more likely to be attracted by world-class education and job opportunities.

A significant challenge for expanding Kista's university branches is the lack of affordable student housing. While students strongly prefer to live in the Stockholm city center, many are desperate to find any suitable room and would gladly accept living at Kista if rooms were available. A vigorous expansion of student housing at Kista would support the growth ambitions of its universities and at the same time help Kista overcome a more general weakness, namely the lack of a campus atmosphere and urban vibrancy in general. Moreover, the student community of Kista could be strengthened to increase its attraction and especially to enhance the integration of foreign students in the local community. Kista has a relatively well-developed student union (it is unique in Sweden to have an autonomous local student union branch, which is normally reserved for locations with an independent university) and a small but lively student community centred on a bar at Kista. But the union has so far not succeeded in integrating foreign students into this community. While nearly all Swedish students join up, almost no foreign students join and instead organize their own meetings, largely along ethnic lines.

Most foreign graduates who decide to stay in Kista do so because of the employment opportunities and the excitement of being part of the cutting edge in their specialty. As long as Kista remains a leading ICT cluster, it will have little trouble retaining most of its foreign graduates, but some bottlenecks remain to be solved. Besides somewhat strict immigration laws, the housing market is the main issue for foreign workers. A large part of the Stockholm housing stock is government-owned rental housing, which is inaccessible to foreign workers or impractical due to long waiting lists. Private housing is also available in the Järva area that includes Kista, but the quality of the housing stock and the living environment is too low to be acceptable for most workers. The Stockholm city center, on the other hand, is highly attractive, offering a high quality of life and urban vibrancy. But prices of private rental units are too high to be affordable for starting knowledge workers. Some firms, even smaller start-ups, have resorted to buying apartments and renting them out to their international workers. A more structural solution to the housing problem would help especially the smaller firms to attract the international talent they increasingly rely on.

Entrepreneurship

The case of Kista illustrates that at crucial moments in the innovation process, an innovation system depends on the ability of engineers to defy skepticism and carry out their research in a spirit of independence and experimentation. Kista played this role when the difficult switch from analog to digital and wireless telecommunication was spearheaded by ‘cowboy engineers’ that defied the lack of trust or even hostility from their headquarters and went ahead with their skunkworks. But while such ‘cowboy engineers’ would typically work as independent start-up and spin-off entrepreneurs in the United States, they predominantly operate within big corporations in Sweden. Even when SRA made dramatic breakthroughs in wireless ICT at Kista and Ericsson’s head office at Telefonplan tried repeatedly to cut off funding and discourage their efforts, very few of the workers at SRA were triggered by this to start their own firms. So historically, Kista showed a lot of examples of intrapreneurship (workers taking initiative and carrying out innovation within the boundaries of the firm) but relatively few examples of entrepreneurship.

But recently a vibrant start-up community emerged in the Stockholm city center, mostly in app development, web design, and other ‘soft’ ICT. An impressive range of successful firms emerged from this community, ranging from online communication provider Skype and the online music service provider Spotify to the recent gaming start-up Minecraft. There now appears to be substantial interest for entrepreneurship among young Swedes, and the barrier to attempting to start a firm is lowered by the fact that Sweden has a very strong social safety net. This allows Swedes time to grow their start-up firm and in the meantime live off social benefits, and in case of failure the consequences are limited. Moreover, a broad spectrum of seed funds is available for start-ups, and with start-up incubator STING, Kista has a prominent place in the start-up incubation environment. Box 4.4 describes STING and its incubation strategy.

Box 4.4 STING

Stockholm Innovation and Growth (STING) is one of the leading incubators in Sweden, with a focus on start-ups in the larger Stockholm region. It was founded in 2002 as a wholly owned subsidiary of Electrum Foundation and has the mission to generate 12 start-ups with export potential per year. In practice, it takes a recruitment of about 15 start-ups per year to graduate between 10 and 12. Attrition of unsuccessful start-ups is limited due to the strict recruitment process, with an admission rate of only around 9 per cent of applicants. Between 2002 and 2010, STING accepted 80 firms into its incubation programme, of which only 8 have been discontinued. The turnover of firms 'graduated' from the programme was €29 million (70 per cent from export) in 2010, and they employed 463 workers (STING 2011). Of the entrepreneurs accepted into the programme, about 70 per cent already have a background in business. The remaining 30 per cent come from academia, typically PhD researchers who want to apply their research findings in a commercial venture.

STING's incubation model can be characterized as highly selective but generous to those entrepreneurs selected into the programme. Candidates for the incubation programme are asked to identify potential customers that have expressed their interest in the product to be developed by the start-up firm, and these potential customers are then contacted to check this. Moreover, entrepreneurs must first assemble a good team, since conflict within start-up teams is the major reason for failure. Candidates that get through this strict selection procedure are then offered a trajectory that can last between 6 months and 2 years, in which they receive intensive guidance from experienced entrepreneurs and training courses on topics from pitching to investors, product branding, IPR protection, and exporting to networking skills. Moreover, office facilities are offered at STING's Growhouse at Kista, free of charge for the first 6 months of the start-up phase and then at an affordable rent. In exchange for these and other services, the incubator receives stock options in the start-ups it guides.

Besides this, STING also helps start-ups gain access to financing. In the earliest phase, start-ups are helped to apply for soft money, which does not need to be repaid in case the start-up fails. The main contributor of early-stage seed funding is STING Capital, a fund co-founded by STING and funded by public and private investors. As soon as the start-up is deemed ready, it is introduced to the incubator's network of private angel investors as it moves from soft money to normal financing.

A number of research institutes at Kista also have the mission to generate start-ups, including SICS, MLC, and EIT-ICT described previously. However, not all these institutes are equally suitable for achieving this mission. For example, research centres like the Mobile Life Centre, which focuses on long-term exploratory research rather than applied research expected to lead to short-term outcomes, may not be able to fulfil its role as spin-off generator. Moreover, spin-off generation by academic institutes is held back by a lack of flexibility. Currently, university staff who want to start their own firm are expected to give up their academic position without any certainty that they can get back their old position after completion of the start-up project (e.g. because the start-up failed or because it was acquired by another firm). If barriers between university employment and entrepreneurship were lowered, more staff might be willing to attempt a start-up project.

Finally interview respondents indicate that the venture capital community of Kista and Stockholm in general needs to be strengthened. Earlier in the development of the Kista ICT cluster, for example, when the GSM mobile phone was ready to be launched, Stockholm's banks perceived it as too risky and refused to fund it (Karlsson and Lugn 2009). After a short spike of activity during the ICT bubble, Stockholm's venture investors again have a very limited appetite for risk taking today. An idea that was raised to have the Stockholm municipal government set up a VC fund for Internet start-ups was abandoned after fierce resistance from the local banks. However, a key Wall Street technology VC recently opened a branch in Stockholm, and general interest among American investors in Kista has increased after the success of such start-ups as Spotify and Skype. If more investors follow, the initial success stories of Stockholm entrepreneurs may have acted as a trigger to raise awareness for investment opportunities, attracting foreign investors to enhance the still limited domestic VC community.

Place marketing

When IBM, SRA, and Rifa moved into Kista between 1976 and 1978, the area quickly gained a reputation for high tech and innovation. This was partly thanks to the size of these firms (about 3,000 workers, many of them engineers) and partly because of the novelty of the digital wireless products that would soon come out of Kista. The construction of the iconic Electrum Building in Kista between 1988 and 1992, and again the Kista Science Tower in 2002, strengthened the image of the Kista cluster, but it can be argued that these iconic buildings followed rather than caused its reputation. Moreover, while service quality, accessibility, and the attractiveness of the environment were quite limited in its early years (Bengtsson 2011) and the university departments had not yet moved to Kista, the strong image of Kista seems to have been the main force attracting large numbers of firms to the cluster.

The precise loading of the brand 'Kista' has evolved over time. In the 1980s and early 1990s, it was commonly known as Kiselsta (roughly corresponding to the words for 'silicon' and city' in Swedish; *Wired* 1998) or Chipsta, since at that time it still housed Ericsson's state-of-the-art semiconductor factories besides Ericsson's computer division (both closed in the 1990s). As mobile telephony became more dominant in Kista, its image shifted to Wireless Valley or Kista ICT. In 1998, Electrum Foundation created the brand name Kista Science Park to use in its marketing strategy. This name was picked up in an article in the famous American magazine *Wired*, which proclaimed Kista Science Park as the second most important ICT cluster in the world after Silicon Valley. One year later, Kista was again the center of attention when Stockholm, largely thanks to Kista, was selected as European Region of Excellence for that year. As of 2000, the Electrum Foundation is marketing Kista as Kista Science City and created Kista Science City AB to further develop and market its vision for Kista as a true city rather than a science park.

At the municipal level, the City of Stockholm developed a marketing strategy in which Kista plays in important role. Stockholm Business Region Development (SBRD) evolved from Stockholm Land and Localization Company (SML), the municipal agency that, among others, was tasked with finding tenants for Kista. SBRD has about 18 employees divided into teams that focus on the industry sectors most important for Stockholm (ICT, life science, automation, and cleantech). Their task is to promote investment in Stockholm and provide information and practical assistance to potential investors visiting Stockholm. Because Stockholm and especially Kista are already well known as investment locations, SBRD does not advertise Stockholm in general. Instead, it focuses on establishing relations with specific firms and investors and helps them get in contact with a portfolio of potential partners or investment opportunities.

For example, when their ICT team visits an international ICT event, it contacts firms and investors visiting the event in advance and meets them one on one rather than simply opening an information booth at the event. In its contacts with the media, SBRD also does not rely on sending out press releases and instead builds up relations with specific newspapers and magazines and helps them with, for example, data collection. When *Wired* magazine contacted SBRD for assistance on a special issue on entrepreneurship, SBRD organized an event to bring *Wired*'s writers into contact with the Stockholm start-up community. Because Kista and Stockholm in general are already well known and attractive investment locations, SBRD does not offer incentives to attract investors. When firms are interested specifically in Kista, they are brought into contact with Kista Science City AB.

Two other organizations play an important role at the municipal level. First, Stockholm Business Alliance acts as a shared marketing organization for 50 municipalities that have opted to brand themselves as part of the Stockholm Region. While some of these municipalities are located at a considerable distance from Stockholm, they nevertheless found that for international investors, these distances are less relevant, and the name Stockholm is by far the most recognizable in Sweden (to a domestic audience, these municipalities would not associate themselves with the Stockholm Region). For the international branding of the Stockholm Region, the brand 'Stockholm, capital of Scandinavia' was developed. Finally, Stockholm IT Region is a municipal organization involved in the marketing of the ICT sector of Stockholm. But Stockholm IT Region is more than a marketing organization, as it also acts as a network for government, industry, and academia to deal with shared issues such as labor shortages.

The reputation of Kista as a world-leading 'Wireless Valley' constitutes a strong attraction factor for hard IT and conveys a sense of professionalism, 'seriousness', and a business-like mentality. As long as Ericsson remains a world-leading ICT firm, this reputation is likely to retain its power. However, it is uncertain whether Kista's reputation would remain strong if at some point in the future Ericsson relocates or loses its leading position in ICT. Possibly the reputation of its university departments, of which especially KTH (known in English as the Royal Institute of Technology) is well known abroad, might be strong enough to carry on the reputation of Kista. A bigger challenge is the marketing of Kista as a science city. While foreign observers might be persuaded that Kista and its surrounding region constitute an integrated region, the facts on the ground currently do not support this view. Only when the high level of segregation is addressed and Kista becomes a more urban and lively area with attractive housing and facilities would it actually be possible for visitors to experience it as a true city. This brings us to the following key feature, analysed below.

Attractive city

The main goal for the Kista cluster itself is to increase its attractiveness as a place of work, study, and living and give it a vibrant urban atmosphere. In 1999, Kista was still described by a student as 'incredibly sad, cultural and entertainment offerings are zero and regimentation is total' (translated from Swedish; original quote in Swedish in Bengtsson 2011:114). Since then, a number of initiatives have been started to improve the situation. First, the Kista Science Theater started in 2009 with a mission to explore the intersection of technology, culture, and society. It is an initiative of Stockholm University and several art colleges that work together in the Centre for Design and will also involve schools in the Järva area. For example, it organized a project involving 1,000 schoolchildren from Järva in which art was used to make the process of innovation visible. In another project, together with the Mobile Life Center, a game on a smartphone was developed to raise awareness of artistic and cultural events at Kista. Another interesting initiative is the Digital Art Center (Box 4.5).

Finally, in 2008, the Kista World Music Festival was launched as a celebration of the diversity of cultures in the Järva area, and Art in Kista is being set up as an outdoor meeting place between art and technology taking place in the public spaces at Kista. So far, the cultural initiatives at Kista appear to be somewhat fragmented, and awareness for them was limited among the respondents interviewed for this research. But around 2014 to 2015, a new iconic building called NOD (Swedish for 'node') will be opened at Kista, which will bring many of the cultural initiatives together and raise their visibility. Plans for the NOD are still at an early stage, but two key occupants are already known. First, the Digital Art

Box 4.5 Digital Art Center

The Digital Art Center (DAC) was established in 2010 as a collaborative project between, among others, Stockholm University, the Interactive Institute (a research institute focused on the interplay between experimental IT applications and design, headquartered at Kista), the Stockholm Library, and a number of Triple Helix partners including Kista Science City and real-estate developer Atrium Ljungberg. Inspired by the Electronic Art Center in Linz, Austria, it is an interactive space for exhibitions, meetings, and workspaces in which artists, researchers, and firms, from both Kista and elsewhere, can showcase their work.

In this way, the technology and research results developed at Kista can be made visible to a wider audience in an accessible and inspiring way. The centre's target groups are schoolchildren and engineers, but also, for example, tourists who want to get a feeling for what happens behind the closed doors of Kista R&D labs (in line with the emerging concept of 'industrial tourism' – e.g. see Otgaar et al., 2010 – or 'innovation tourism'). DAC expositions focus on interactive objects such as educational games but can also include non-interactive art or consumer products developed by Kista firms. Moreover, firms are welcome to organize their product launches and other events at DAC.

Examples of interactive art on display at the Digital Art Center are the Mindball game, in which visitors play by wearing an EEG scanner that records their brain activity, and the DigiWall game that combines a physical climbing wall with computer software that guides the player through light and sound to climb on the wall. So far, most funding comes from real estate developer Atrium-Ljungberg, and the centre is still in negotiations with Kista-based firms for co-funding, for example, as part of these firms' corporate social responsibility programmes. Additional funding may also be collected by charging an entrance fee, although free entrance fits better with its open and public character. In 2014 to 2015, the Center will move from its temporary location to the newly built NOD building.

Center (DAC) will take up a highly visible location near the entrance of the NOD building, and second, the Stockholm Science and Innovation School will be located there. The latter is a school for secondary education (high school) that will be set up with the aim of inspiring children for entrepreneurship and innovation. Children will be selected based more on creativity and independent thinking than on IQ scores and will be given ample opportunity to come into contact with the research and cultural institutes of Kista (including the DAC) but also Kista–based firms. A unique feature of this school is that already at high school level students, will be encouraged to take part in international internships organized by MNCs like Ericsson, which will place students in its overseas subsidiaries. Moreover, students from the other Järva schools will be involved in projects on the principle that all high school students should come into contact with entrepreneurship and innovation.

Another key strategy is to make the main walking routes through Kista more lively and attractive. The main axis through Kista, Kistagången, is planned to become lined with bars and restaurants, attracting visitors not only during work hours but also in the evening. This axis is marked by the Kista Science Tower and Kista Galleria shopping mall on the southwest side and the newly built Kistamässen conference center and Victoria Tower on the northeast side. When the NOD building is finished, this central axis will be extended into a triangle of lively public space with the Electrum Building in the middle. And eventually the layout of Kista will be enhanced by building iconic buildings ('gates') on three sides of the park, leading visitors into three squares. One of these squares, Stenbeck Square opposite the Kista Galleria mall, is expected to become a commercial and cultural hub with intense visitor traffic due to the nearby public transport access (Bengtsson 2011).

Besides cultural facilities and lively public spaces, another element of turning Kista into a real city is by enhancing its housing function. This is done in two ways. First, the strict separation of functions that was a key element in the original ABC city planning principle governing the Järva area will be fully abandoned. Already some student housing has been developed on top of the Kista Galleria, and more student housing will follow. Moreover, 3,000 new apartments will be built within or adjacent to the Kista cluster. The population of the Järva area as a whole is planned to rise from 120,000 (in 2012) to 170,000 in the near future.

Second, the existing housing stock of Järva, mostly consisting of the original houses built as part of the Million Programme, will see a considerable upgrade. Although only part of the housing stock consists of somewhat monotonous apartment towers, the image of the Järva neighbourhoods is that of grey concrete buildings. To counter this image, part of the towers will be transformed into terraced apartment buildings, creating diversity and a more modern image. Moreover, the Sustainable Järva project, involving energy companies and housing corporations, will result in more energy-efficient and better-insulated homes. The green space running through Järva on an east-west axis (which is the largest recreation park of Stockholm) will be made more accessible to residents by expanding walking paths and bicycle lanes connecting it to the surrounding neighbourhoods and the Kista cluster.

Finally, heavy investments have been committed to improve the accessibility of Kista and the wider Kista Science City area. Focus areas are the connection between Kista and the Arlanda airport, public transport connections between the Kista cluster and the surrounding residential neighbourhoods, and improvement of the currently often jammed highway connections to Kista. Interview respondents from Kista–based firms indicate that nearly all of their workers live outside of Kista, and commuting times are sometimes longer than is acceptable to (Swedish) workers. In some cases, firms lost key personnel for the only reason that they were unwilling to accept the length of the daily commute but also unwilling to live in the neighbourhoods near Kista. Improved accessibility can therefore provide very real benefits not only for Kista's workers but also for their employers.

As the housing and infrastructure investments have not been carried out yet, it is difficult to assess their expected outcomes. The largely negative image of the residential areas around Kista (with a possible exception for the smaller and more high-end Ärvinge neighbourhood adjacent to Kista) is deeply rooted and will require a sustained effort to overcome. Students are likely to be easiest to attract to Kista, partly because of the current lack of student housing. Moreover, the high-end apartments planned inside Kista will be some of the most attractive in the Järva region and may also be popular, especially for foreign workers in search of short- to medium-term housing after being recruited by Kista-based firms.

However, a true integration of the Kista cluster and Järva neighbourhoods will be more difficult to achieve, since the current workers of the Kista Cluster have a very strong preference for living in the highly attractive Stockholm city center, while at the same time the current residents of the Järva neighbourhoods on average have a large gap in terms of linguistic and technical skills to overcome before being able to work at Kista. Projects like the Stockholm Science and Innovation School may help the next generation of Järva residents to bridge this gap and become the next generation of engineers at Kista. Finally, the effects of the infrastructure investments are also difficult to foresee. On the one hand, living at Kista will be made more attractive when improved accessibility reduces the sense of remoteness of Kista. But on the other hand, improved accessibility also makes it easier to work at Kista and commute from a home elsewhere in Stockholm, possibly reducing the demand for housing at Kista.

4.5 Conclusions

This chapter has dealt with the case of Kista. We have analyzed the development, innovation performance, and the management of this highly specialised ICT cluster that has been the world´s leading cluster in wireless ICT for more than two decades.

The leading position of this cluster is intrinsically linked with the presence of the prominent leader firm Ericsson. The nascence of Kista as an ICT hot spot can be attributed to the decision of Ericsson in the mid 1970s to locate two of its subsidiaries (SRA and Rifa) in the newly planned industrial zone that used to be a restrictive military zone. In its Kista laboratories, SRA has developed the advanced wireless communication technology that was the basis for Ericsson’s ground-breaking products, such as the GSM mobile phone with roaming ability. After that location decision, more ICT companies followed and kick-started the development of the ICT cluster, and it is no surprise that eventually Ericsson’s headquarters also moved to Kista in 2003. Sometimes Kista is nicknamed as ‘Ericsson’s land’ because of the strong presence of the ICT giant in the area. Today, Ericsson’s role is still strong, but this nickname does not reflect the rapid development of Kista into a specialised wireless ICT cluster with many other companies (including Ericsson’s competitor Huawei), university departments from KTH and Stockholm University, and other research institutes. An important role in the development process of the cluster is played by the Electrum Foundation – a top-level public–private partnership aiming to promote the development of Kista and bring industry, academia, and government together. They launched the Kista Science City vision in 2000 that includes the main ambition to develop a science park into a science city.

In this case study, we identify several strengths and weaknesses of the Kista innovation system affecting the performance of Kista. They are summarized in a SWOT analysis in Table 4.2.

Evidently, the innovation performance of Kista is strongly influenced by the strongly embedded leader firm Ericsson. Its track record as an innovator in wireless communications is known all over the world. The leader firm confirmed its commitment to the area when it moved its headquarters to Kista Science City in 2003. The firm's strategic decision making as well as its most important R&D activities take place in the cluster. In addition, Ericsson is involved in most of the important public–private research projects both financially and with its employees, and the chair of the Electrum Foundation is traditionally a top executive from Ericsson. It is also supporting the strategy to transform the science park into a science city.

Another strong point of Kista Science City is the high level of specialisation, which makes it the world's leading location for wireless ICT. Kista's clear specialisation and hence its clear identity as a top location for this specialisation makes it a very attractive place for companies in this field, as they can find a well-developed knowledge infrastructure supported by very good research institutes – and for a long time, Kista was one of the few places companies could find dedicated engineers that bring together expertise in networking and software development. In sum, Kista provides abundant agglomeration economies for the specialised firms located there.

A crucial strength of Kista Science City is the high-level public–private partnership at the very top level through the Electrum Foundation, including the mayor of Stockholm, the president of KTH University, and the CEOs of large Kista firms

Table 4.2 SWOT analysis of Kista

Strengths	*Weaknesses*
• Embedded leader firm Ericsson • Strong specialization and clear identity • High-level public–private cooperation at top level • Sweden is a fruitful test bed for innovative technology. • Strong Kista Science City Brand in wireless ICT sector	• Vulnerability due to specialization in one sector • Kista is seen as 'uncool' and nerdy; soft ICT firms prefer other locations. • Underdeveloped venture capital supply • Huge gap between Kista and the rest of Järva area.
Opportunities	*Threats*
• The broad support for the Kista Science City vision • The newly planned NOD as a icon and 'visitors' centre' of Kista • Strong and reinforced commitment of Ericsson • The Kista university departments are becoming a new anchor for Kista.	• Losing the edge of specialised human resources • Weak image of Kista among Stockholm residents as a place to live

such as Ericsson. This partnership has been around since the 1980s, when firms in Kista wanted to attract the universities to the area to strengthen its knowledge base. The Electrum Foundation has been a driving force behind the initiatives to promote the development of Kista and produced the vision for Kista Science City that has been the leading document for the development since the start of the new millennium.

Sweden proved to be a fruitful test bed for innovative technology. Generally speaking, the Swedes are open to new technology and are often early adopters of new technology. This applies to the consumers in the competitive but small Swedish market (only 10 million inhabitants) but also to the willingness of large firms and public institutions to experiment with new technology and give small firms a chance, as illustrated by the example of the SME Appear that got its break through an assignment from the operator of the Stockholm metro system and now operates internationally.

Finally, the good reputation of Kista in the ICT community is a major strength. After the move of Ericsson and some of the early followers, the location had become really attractive for other companies in that sector. This has been partly a self-reinforcing mechanism through which more interested firms led to higher attractiveness and again more interested companies. Kista Science City has developed into one of the leading brands around the world. The success of the area was very important for building the Kista Science City brand, but the efforts of the various marketing organisations have also been important in spreading the story of Kista Science City among relevant target audiences across the globe. This is mostly done by participating in the right meetings and events and establishing contacts with opinion makers, prospective firms, and specialised media (see the example of *Wired*). Traditional brand communication through advertisement has not been very important in this respect.

Besides these strengths, there are also weaknesses of the cluster that present a challenge to Kista's future development. The first is that a very strong specialisation can be a weakness in times of economic problems. It is highly innovative but at the same time very much exposed to cyclical ups and downs. Both the wireless ICT sector and leader firm Ericsson have had their ups and downs in the past decades. For example, after the burst of the dotcom bubble around 2000 to 2001, both Ericsson and Kista were in crisis and the Kista Science Tower struggled a number of years with low occupancy rates.

This strong specialisation in a highly competitive and volatile market calls for diversification of the cluster to dampen the effect of the economic cycles. This is easier said than done for Kista, as a second challenge is the relatively 'uncool' and nerdy image of Kista among workers from other ICT sectors. Companies in the soft ICT sector (such as app development) prefer locations such as Södermalm or other locations in the centre of Stockholm.

A third challenge is that the supply of venture capital is not as well developed as one might expect from such a successful cluster. The Kista stakeholders are aware of this problem and, for example, the local government attempted to set up a local VC fund but failed due to opposition by the local banks. The good news is that US VCs are now discovering Stockholm because of the success of such start-ups as Spotify and Skype, and recently a key Wall Street technology VC opened a branch in Stockholm.

A fourth challenge has to do with the big gap between Kista and its surrounding neighbourhoods in the Järva area. For historical reasons, those areas have very high concentrations of poor immigrants with relatively low qualifications that are in sharp contrast to the high-level ICT cluster in Kista. Some of these areas have really gained a bad reputation. The proximity of Kista to one of the most notorious neighbourhoods such as Rinkeby means that many Stockholm residents avoid the area altogether.

Governing the Kista Science City system

The case of Kista has showed that it takes a few innovative firms to lay the foundations for the development of an ICT cluster. There is the element of chance involved, as the emergence of an ICT cluster was not what the urban planners were aiming at back in the 1970s. The decision of Ericsson was the first step, and Ericsson's presence attracted other firms to the location, setting the path for the cluster's development. An important part of the development of the cluster can be characterised as 'organic', as the growth of the cluster has kept going because of new companies coming in and wanting to be co-located with Ericsson and the other firms in the area.

However, this does not mean that there was no governance of the innovation system. On the level of the Kista area, the Electrum Foundation has been instrumental in strengthening the cluster's competitiveness through the cooperation of its members in the foundation. On several occasions, the foundation acted when necessary, with the lobby for the co-location of KTH University and Stockholm University and the vision for Kista Science City as examples. The Electrum Foundation also owns the STING business incubator that has gained a good reputation. The Electrum Foundation is supported by five specialised councils (for higher education, innovation, infrastructure, marketing, and research) to identify challenges for Kista, put them on the agenda of relevant stakeholders, work on solutions, and organize their implementation. In many cases, this means the involvement of the Stockholm local government, as they are very powerful in the Swedish planning system. The top-level contacts in the board of Electrum Foundation are very helpful in this respect. The five councils have proved to be effective in putting challenges to Kista on the agenda, such as the threat that Kista is losing its leading edge of a stable supply of highly qualified engineers that can work for the firms in Kista.

Another subsidiary of the Electrum Foundation is Kista Science City AB. This organisation facilitates the interaction among the stakeholders in the Triple Helix[5], it consequently promotes the Kista Science City vision, and it is investing a lot of time in building the Kista Science City brand by conveying the Kista story to relevant audiences and media. It understands that building a brand for a science city cannot be done by simply labelling the area Kista Science City but by letting the world know what Kista achieved and raise awareness of its ambitions.

The ambition to transform the science park to a science city is a formidable challenge for all stakeholders involved. At the time of writing, Kista has moved gradually away from being a 'dead' science park and added facilities to make the area more lively (e.g. the new hotel), but it is by no means a sparkling science city yet. It is still lacking critical mass in terms of residents and amenities and the uncool image among hip and trendy people working in soft ICT. The problematic association of Kista with nearby areas such as Rinkeby, for Stockholm residents, does not help either.

Having said that, public and private stakeholders are working together on a step-by-step transformation by the creation of pedestrian-friendly walking routes, adding more cultural facilities, and promoting more housing in the area. One of the possible engines of the transformation is the planned NOD, which should be a spectacular building open to the public demonstrating the merits of technology and design. One of the tenants will be the Digital Arts Centre, which should make it worthwhile to visit the NOD on a regular basis. The NOD could function as a visitor centre, helping change the perception of Kista to be more attractive. Today the NOD is still a plan, but it has the potential to contribute to the desired transformation.

Another promising and innovative initiative is the establishment of the Stockholm Science and Innovation School. It will be set up within the new NOD building with the aim of making youngsters enthusiastic about entrepreneurship and innovation. This school will admit its pupils not only on the basis of their cognitive capacity but also on their creativity and ability to think independently. This shows that working with educational institutes can start long before the university level. Several large firms have already promised to open their international networks for international internships for these talented youngsters.

Finally, on the level of the city of Stockholm, there are plans to develop a new medical cluster and a cleantech cluster in former port area. The question arises of what this means for Kista and the Järva area. The threat could be that the municipality will give less priority to the transformation of Kista into a science city because of these ambitious and prestigious new projects. At the moment, this is not an issue, as the importance of Kista is on the mental map of decision makers, but once these new projects really take off, they could be competing with Kista for the scarce resources and attention of the Stockholm local government.

Notes

1 Mobile telephony operators bid up prices to extraordinary levels, causing a long-term dearth of investment capital among mobile operators and even some bankruptcies.

2 Source: http://en.kista.com/for-your-business/statistics/ accessed 11-6-2013

3 Firms employing more than 250 individuals.

4 For example, in the 1980s, a conflict with the small Sundbyberg Municipality southeast of Kista lead to the large and prestigious office park development Kymlinge, championed by Stockholm Municipality, being cancelled after the subway infrastructure had already been constructed.

5 The Triple Helix refers to academic institutes, the business community and (local) government. For more information see e.g. Etzkowitz and Leydesdorff, 1995.

Sources

Barinaga, E. and Ramfelt, L. (2004), Kista – The two sides of the Network Society. *Networks and communication studies,* Vol. 18: 3/4, pp. 225–244.

Bengtsson, I., Anjou, A. and Å. Waldton (2011), *Från runor till radiovågor – historien om kista science city,* Anna Ma Mdedia: Stockholm.

Computer Sweden (2003), *Datavägen leder uppåt,* Stockholm, Sweden: IDG Sweden.

Etzkowitz, H., and Leydesdorff, L. (1995) The Triple Helix---university-industry-government relations: A laboratory for knowledge-based economic development. *EASST Review 14*, pp. 14–19.

Eurostat (2008) *Patent applications to the EPO by priority year and NUTS 3 regions*, available online at http://epp.eurostat.ec.europa.eu, extracted on 15-06-2012.

Johansson, B., Lööf, H., Baltzopoulos, A. and Andersson, M. (2011), Intellectual Capital Report for the Kista Cluster, RICARDA, available at www.difu.de

Karlsson, S. and Lugn, A. (2009), *Att förändra världen: en berättelse om Lars Magnus Ericsson och hans efterföljare,* Stockholm: Sellin & Partner.

Kista Science City (2011), *Kista Science City 2010 Trend Report,* Stockholm: Author.

Mixed Reality Lab (2012), University of Nottingham: Nottingham, accessed 31 October 2012 at www.mrl.nott.ac.uk

Notaras, M. (2010), *Sweden's gold medal winning eco-town,* UNU – Our World 2.0, available at http://ourworld.unu.edu/en/hammarby-swedens-gold-medal-winning-eco-town/

Otgaar, A., Van den Berg, L., Berger, C. and R. Feng (2010), *Industrial tourism: opportunities for city and enterprise,* Ashgate: Aldershot.

SCB/SWECO (2012), Statistik om Stockholm, available at www.statistik.sweco.se/

STING (2011), *The first 10 years – annual report for Stockholm Innovation and Growth,* Stockholm: Author.

United Minds (2011) *How much do businesses pay for a bandwidth of 100 Mbit/s? A comparative study between 11 cities*, Stockholm: United Minds.

Wired (1998), *Special issue on Siliconia, Wired* Magazine September 1998, pp. 136–137.

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5 Suzhou Industrial Park

5.1 Introduction

In this chapter, we study one of the most prominent science parks in China: Suzhou Industrial Park (SIP). As recently as 1994, the location of SIP was still a sparsely populated agricultural area near the city of Suzhou. But in 18 years it has grown into a 'science city' with 20,000 firms, 23 university departments, and a population of about 700,000 residents, of whom about 20,000 are foreigners, around 2012. SIP provides one of the best examples of a science city built from scratch in a relatively short time. Moreover, SIP is a unique example of an innovative development strategy in which a foreign government, Singapore, was given a prominent role as developer and advisor. This approach has helped speed up the development process, but it also led to conflicts that caused stagnation in its development around the year 1999. This institutional setting and the fact that SIP is located in an emerging economy rather than a high-income country make SIP an interesting case to study the influence of the institutional context on the development of an innovation system.

5.2 Location

Suzhou is located in the Yangtze River Delta, one of the richest and most industrialized parts of China with a population of more than 100 million inhabitants. It is one of the three regions in China that attract most high-tech and international firms, the others being the Bohai region near Beijing and the Pearl River Delta around Guangzhou and Shenzhen in south China. More than a third of international firms coming to China end up in the Yangtze River Delta. Respondents describe the region as well balanced, with a relatively well-developed human capital stock, a wealthy hinterland (it is one of the most important consumer markets in China), and a reputation for business-friendly governance. Suzhou is one of a string of cities that forms the core area of the Yangtze River Delta, stretching from Shanghai (22.3 million inhabitants) to the capital of Jiangsu Province, Nanjing (6.8 million inhabitants). With a population of about 4 million, Suzhou is considered a medium-sized city in China. As a prefecture-level city, Suzhou also administers four nearby cities, of which the largest is Kunshan at 1.6 million inhabitants, bringing the total population of this metropolitan area to 10.5 million. Suzhou borders Kunshan to the east and the city of Wuxi (3.5 million inhabitants) to the west.

Suzhou is one of the richest cities in China with a GDP per capita of around $15,800 in 2011, surpassed only by the economic powerhouse Shenzhen near Hong Kong and a number of oil-producing cities. The city and its hinterland are home to a bewildering number of special economic zones and industrial parks, differing strongly in size and level of economic development. In fact, the Suzhou city centre borders industrial parks on all four sides. The largest of these is Suzhou Industrial Park (SIP) to the east of the old town, followed by Suzhou New District (SND) to the west. Two smaller but still substantial industrial parks are Wuzhong, bordering the old town to the south, and Wujiang, about 15 km further south. And lastly, an industrial park is being developed north of Suzhou in the Xiangcheng district. Moreover, the neighbouring city of Wuxi is home to, among others, the Wuxi-Singapore Industrial Park located between Wuxi and Suzhou. Finally, the city of Kunshan is home to a cluster of ICT firms centred on the Kunshan New & High-Tech Industrial Development Zone.

While most of these industrial parks are home to high-tech and international firms, SIP stands out as the largest and most influential industry cluster in the Suzhou region. Moreover, it is one of the leading parks in China. Somewhat confusingly, Suzhou Industrial Park refers to both a city district and an industrial park. This distinction has lost most of its meaning over time as the industry park has grown to dominate the entire SIP city district, but it is important for interpreting statistical data. The SIP city district has an area of 288 square km, which includes the Jinji Lake (10 km^2), three small pre-existing towns (total population 165,000 in 1994, at the start of SIP development), and a commercial centre adjacent to the Suzhou city centre. Of this area, 80 square km are devoted to science and industry and are officially called China-Singapore Suzhou Industrial Park (CSSIP). This report studies SIP as a whole rather than the CSSIP industrial core, recognizing that SIP is well on its way to becoming a science city rather than an industry park.

In contrast to the other industry parks mentioned, SIP also hosts several universities and offers extensive residential, retail, and cultural facilities. To a large extent, it functions as an independent city. Administratively, SIP is not a city but rather a district under the authority of the Suzhou city government. But in practice, SIP's administrative committee (SIPAC) does enjoy significant influence over its planning and development. As elsewhere in China, the land is owned by the government, but it can be leased for a longer period, directly or via a developer acting as intermediary.

SIP is directly adjacent to the Suzhou city centre, which in large part consists of a well-preserved historic city known as one of China's greatest tourist attractions. To the north, SIP borders the attractive Yangcheng Lake, and to its south and east it borders small areas of remaining agricultural land. To the east, only about 5 km of agricultural land separates SIP from Kunshan. SIP is connected to Kunshan and Shanghai by train and to the Suzhou city centre and Suzhou New District by subway. However, because of the size of SIP (roughly 19 km by 8 km), travel times within the park are substantial, making a daily commute from Shanghai, Kunshan, or the Suzhou city centre somewhat inconvenient. Moreover, frequent traffic jams make a commute by car equally time consuming. Nevertheless, many of the workers employed at SIP still make the daily commute from as far away as Shanghai.

Within China, the accessibility of SIP by air is excellent. The closest airports are Wuxi Airport and Shanghai Hongqiao Airport, both accessible by train within about half an hour. These airports service mostly domestic lines with also a few East Asian destinations. For other international and intercontinental flights, people can travel via Shanghai Pudong Airport, which is, however, considerably less easy to reach from SIP. Currently there is no direct train connection from SIP to Pudong Airport, and by car or bus, one risks traffic jams and hence long and unpredictable travel times. The limited intercontinental accessibility of SIP is especially problematic for employees of large multinational firms, while SMEs, which tend to focus on the domestic market, are less affected.

5.3 Development trajectory

While the location of SIP was still farmland as recently as 1994, Suzhou has a long history of commerce and entrepreneurship that has an impact on the character of the city to this day. The Jiangnan region, which roughly corresponds with the Yangtze River Delta and includes besides Suzhou also Shanghai, Nanjing, and Hangzhou, was the main centre of commerce and manufacturing in pre-industrial China. Suzhou itself was the second largest city of China in the 19th century and formed the node of a canal system linking it to other cities in the region. However, by the early 20th century, Shanghai, with its sea harbour and international settlements, had taken the place of Suzhou as economic centre, and landlocked Suzhou was reduced to the status of a second-tier city. During the Maoist era, Suzhou's economic position further weakened as development of inland China was given priority over the coastal zone, which was seen as vulnerable to enemy attack. This left Suzhou devoid of investment capital, and the city saw limited population growth and little industrialization well into the 1980s.

But when China adopted its reform and opening-up policy from 1978 onwards, the Jiangnan area returned to the forefront of development. Because of its long history of private enterprise, entrepreneurs from this region were among the first to make use of the possibility to start private enterprises. While the cities were still dominated by powerful state-owned enterprises (two thirds of Suzhou's output was provided by SOEs in 1980), the countryside became a place for experimentation with private enterprise in the form of town and village enterprises (TVEs). The countryside around Suzhou became the main destination for investment and young entrepreneurs from nearby Shanghai, leading to a decade-long boom of small-scale private firms targeting the domestic market. However, by the end of the 1980s, this development model ran into difficulties of inefficiency, inability to upgrade quality, and production technology – and, in some cases, mismanagement and corruption. The Suzhou local government recognized that it needed to upgrade its development model and changed its focus to international firms and investors (Wei *et al.* 2009).

When in 1985 Suzhou was opened for foreign investment by the national government, Special Economic Zones in Southern China had already been developing for 5 years. Moreover, large numbers of cities and development zones had opened to Foreign Direct Investment (FDI) at the same time as Suzhou, so the city of Suzhou knew it would lack prime-mover advantage and would face tough competition in attracting foreign investors. The nearby city of Kunshan had already started to attract Taiwanese ICT firms, and when in 1985 the Kunshan local government opened an industry park to facilitate the inflow of Taiwanese firms, the small town quickly grew into a major ICT cluster nicknamed 'Little Taiwan'. In 1986, the City of Suzhou, taking into account lessons learned from Kunshan, approved an urban development plan that included the Suzhou New District (SND). This industry park would be open to international investors and developed adjacent to the city centre. SND would focus on high-tech industry and also include commercial and entertainment functions to relieve development pressure on the Suzhou city centre, allowing the centre to be developed into a heritage site and tourist attraction. Its attraction next to the scenic lake Tai was expected to increase the attractiveness of the location and open opportunities for developing a tourism function at SND. The park opened in 1990 and the large Taiwanese multinational ICT firm BenQ was attracted as an anchor tenant. BenQ went on to attract many of its suppliers to locate in SND as well, and the SND administration worked closely with BenQ to plan the park's infrastructure and set up effective regulations (Wang and Lee 2007).

Singapore's regionalization strategy

As China and other emerging economies started to attract increasing amounts of foreign investment, Singapore was one of the countries hurt by this process. During the 1960s and 1970s, Singapore had itself been highly successful at attracting FDI, thanks to a low wage level (compared to Western countries) and a reputation for transparent and efficient government. By the 1980s, it became clear that increasing wages and lack of space in the small island-state made it less attractive for foreign investors, and Singaporean firms also started looking at opportunities for relocation to emerging economies. Singapore developed the 'regionalization strategy' to deal with this challenge. In short, the strategy involves facilitating the flow of FDI from Singapore to nearby emerging economies rather than attempting to stem the flow by engaging in a 'race to the bottom' of offering incentives and restricting wage increase.

The core of the strategy is the Regional Industry Parks initiative. Singaporean real estate developers created industry parks in China, Vietnam, Indonesia, and other emerging East Asian economies to attract the flow of firms and investment from Singapore and other advanced economies. The Singapore government supported these parks with investment money and by using its strong reputation and diplomatic goodwill to secure support and preferential treatment of the host governments. Moreover, many Singaporean government agencies were involved in training local administrators and setting up customs and other institutions of Singapore quality. The goal was to build 'mini-Singapores' that recreate Singaporean rule of law and efficient, corruption-free governance with the low wage levels and plentiful development space of the host country. The industry parks were not only expected to generate profits but also to help Singaporean firms succeed abroad in difficult institutional environments, giving them a first-mover advantage. Moreover, the parks were meant to bolster Singapore's reputation as an economic node in East Asia, and the Singapore government expected that these heavy investments in the economic development of neighbouring countries would bring them political goodwill (Pereira 2007).

After a pilot project in Indonesia (Batamindo Industrial Park), Singapore set its sights on China. The combination of very low wages and an unstable institutional environment made China a very promising location for a Singapore industrial park. Moreover, with a population consisting of more than 75 per cent of ethnic Chinese, linguistic and cultural differences between Singapore and China would appear limited. When in 1992 China's paramount leader Deng Xiaoping declared Singapore a model for social and economic development, preparations were made for the creation of a 'mini-Singapore' in China. This Chinese park would be the jewel of the Regional Industry Parks strategy and would surpass the other parks in size, scope (e.g. including extensive and high-end residential areas), and political importance.

Singapore's Prime Minister Lee Kuan Yew was personally involved in the selection of a location for the new industry park and was impressed by the professional and business-minded attitude he found in Suzhou. As Suzhou had just opened its SND industry park and gained national recognition for the park in 1992 (which brings priority treatment and special economic status), it offered Singapore to develop its industry park inside SND. However, while Singapore did choose Suzhou as the location for its new park, it rejected the offer to collaborate with the SND park and asked for a greenfield location instead. To satisfy this demand, a new city district of Suzhou was created to the east of the city under the name Suzhou Industrial Park, which included three small pre-existing towns with a population of about 165,000 when development of SIP began in 1994. Of the city district's total area, 70 square km (later increased to 80 square km) was planned as business development area, of which 8 square km was to be developed in the first 5 years.

High-end location for low-cost manufacturing

Following the Regional Industrial Parks strategy, SIP was initially planned as a location for low-cost manufacturing, focusing on multinational corporations from high-income countries. In order to distinguish itself from the many industry parks that had already been established in the area, most notably SND within Suzhou itself, SIP consciously positioned itself in the high end of the market. In exchange for relatively high rents (about 25 per cent higher than SND and other industry parks in the region), tenants were offered a manufacturing location with the highest quality of both hardware and software. In terms of hardware, SIP set up independent power-supply and water-treatment facilities, with guaranteed quality and dependability. This reduced the risks of power failure or water contamination, which would be especially harmful to, for example, chemical and pharmaceutical manufacturers. Moreover, transportation and communication infrastructure was built to a high standard, and an environmental protection agency was set up for SIP to safeguard the safety and attractiveness of the living and working environment at SIP.

Safety and attractiveness were also a focus of attention in the physical design of SIP. A zoning plan was made that separates residential, commercial, and industrial functions, and in contrast to most Chinese industry parks (which tended to develop in an ad hoc fashion), this zoning plan was actually implemented strictly. The separate zones were positioned like onion rings with commercial and entertainment functions located around the scenic Jinji Lake, followed by a second ring consisting of residential areas, a third ring of relatively clean and silent industry facilities, and an outer ring of heavier manufacturing. Besides offering empty plots, SIP also set up high-quality ready-built factories, which had proven to be highly attractive to MNCs in Singapore. Ready-built factories enabled firms to move in and start production quickly, and about half of the tenants chose this option in the early years of SIP's development.

Besides high-quality hardware, the developers of SIP also paid close attention to the software of the park. They set up the so-called 'software transfer' programme to ensure that the management of the park, carried out by its Administrative Committee (SIPAC), would be as efficient, transparent, and corruption free as one would expect from a 'mini-Singapore'. In Singapore, business registration and other administrative functions are carried out by the Economic Development Board, which services firms through the 'one-stop-shop' model. All government branches that firms need to interact with for registration, tax payment, resolution of conflicts, and other tasks set up a service desk in the same building. In this way, entrepreneurs do not need to go from one government office to the next, and problems in the registration process are easily identified and dealt with. The Economic Development Board was tasked to help set up a similar system in SIP.

Moreover, it not only provided the organizational structure of the business registration of SIP but also ensured that the staff working in this SIP one-stop-shop gained the right mind-set and internalized the values of transparency, efficiency, and customer care. Hundreds of administrative personnel recruited to work at SIP were sent to Singapore for short courses organized by the Economic Development Board and involving the staff of Singapore's state ministries, urban planning authority, and other government bodies at the highest level. Moreover, specific training courses were offered to selected SIP personnel on customs clearance, environment protection, resolution of labour disputes, and many other topics. Finally, substantial numbers of Singaporean government staff were brought to SIP to work alongside their Chinese colleagues for a period of time to allow the

SIP staff to observe and learn their working style in practice. While the software transfer program met some setbacks (Singaporean officials complained that their SIP counterparts were mostly interested in learning about technology and urban design and paid less attention to Singapore's administrative expertise), it has led to visible results. By 1999, the entire registration process of a foreign firm took about 3 months in SIP – compared to about 1 year in other locations in China – without 'entertainment costs', 'hurry-up costs', or the need for outright bribing (Pereira 2004).

Another selling point of SIP, besides high-quality hardware and software, stems from the high level of political priority of the project. Since SIP enjoys support directly from the Chinese and Singaporean national governments, it received a special economic status that went beyond what most other industry parks could offer. While China at that time was still a relatively closed country without well-established regulations for private enterprise, the SIP Administrative Committee was given the authority to approve foreign investment projects independently from the national government. Moreover, it could approve incoming and outgoing business travel applications (at a time when it was still very hard for Chinese nationals to get approval for overseas travel) and offered its tenants faster and simplified customs clearance. Besides this, tenants were offered tax incentives, including exemption from import and export duties, and in selected industry sectors also a refund of corporate and personal tax (Wei *et al.* 2009).

The early growth phase: 1994 to 2000

SIP was opened in 1994 and showed promising growth rates in the first 3 years. In addition to the mostly domestic firms already present in the pre-existing towns in the SIP city district, the newly developed business area started to attract multinational firms. The first tenants were mostly American and European firms, including branches of Philips, AMD, and semiconductor firm Fairchild. Some of these firms had been active in Singapore before and were attracted by the prospect of a Singapore-style business environment in SIP. They were followed by a number of major Japanese (e.g. Hitachi) and Taiwanese firms, and the Korean electronics giant Samsung became an important anchor tenant for the park. Most early tenants first established manufacturing facilities and later added basic R&D facilities for product localization for the Chinese market (Walcott 2002). Especially Hitachi and Samsung also brought many of their supplier firms to SIP. However, already after 1996, the growth of SIP slowed down. Figure 5.1 shows the number of new foreign firms entering the CSSIP core area of SIP, which peaked in 1996 at 30 per year and then declined to an unexpectedly slow rate of about 20 per year up to 2001.

Investments in SIP similarly fell back after 1996 (see Figure 5.2), and it became clear that the early growth phase of the park would be very challenging. A first factor contributing to disappointing growth rates was the high price level of the park. While SIP's early tenants appreciated the high-quality infrastructure,

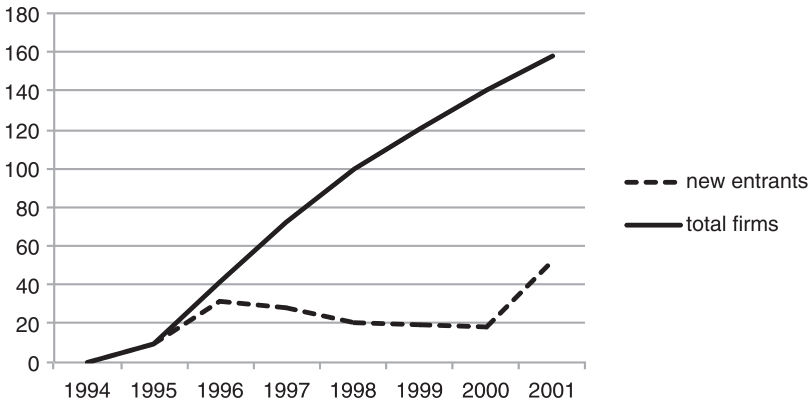

Figure 5.1 New foreign firms and cumulative total of foreign firms in SIP
(Source: SIPAC)

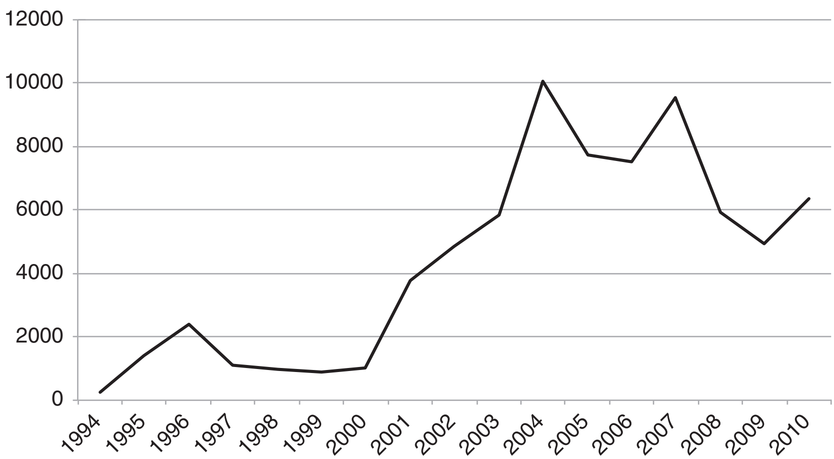

Figure 5.2 Investment in SIP, 1994–2010, in millions of dollars
(Source: SIPAC)

real estate, and utilities as well as the professional management of the park (with 'Singapore software'), the number of firms that were willing to pay high rents in exchange for premium services turned out to be lower than anticipated. In the early phase, SIP was not yet focused on science and innovation but on manufacturers who came to China in search of low-wage labour. Most of these firms focused more on price than on quality and opted for more affordable industry parks in the Suzhou region.

Second, the Singaporean founders of SIP encountered a more complex political environment than they had anticipated. The high-profile involvement of the

Singaporean and Chinese national governments in SIP was expected to guarantee a high level of political priority for the project. Both the prime minster of Singapore, Lee Kuan Yew, and the Chinese vice premier, Zhu Rongji, had committed to the success of SIP and could not afford to see it fail. However, the Suzhou local government was at first given a relatively minor role in the development of SIP. The park was owned 65 per cent by a Singaporean consortium and 35 per cent by a Chinese consortium, consisting mostly of Beijing–based state-owned enterprises. Besides having little financial interest in SIP, the Suzhou municipal government also felt neglected in the decision-making process, as its Singaporean partners tended to take issues to the national government over the heads of Suzhou local administrators (Pereira 2007). In contrast, the SND industry park, which Singapore had declined to cooperate with back in 1992, is wholly owned by the City of Suzhou and would provide significant returns for the municipality in case of a successful development. By 1997, Lee Kuan Yee and other members of the Singapore consortium began to raise complaints to the Chinese national government that the Suzhou local government was not providing the kind of support to SIP that was expected and that instead it was helping its own SND outcompete the struggling SIP.

Originally the Singapore consortium and the Suzhou Municipality agreed that SND would not compete in the same market segment as SIP. SND was to be a mostly domestic high-tech park, while high-end tenants and MNCs would be stimulated to locate in SIP instead. However, within years of the opening of SIP, SND had adopted many of the innovations that had been selling points for SIP, most notably the one-stop-shop concept and export processing facilities somewhat similar to those offered at SIP. Inkpen and Wang (2006) report, based on interviews with leading Singaporean officials involved with the development of SIP, that by 1997, the Suzhou local government was actively promoting the SND to potential investors considering to invest in SIP: 'For instance, when Japanese investors were invited by the Singapore [Economic Development Board] to visit SIP, they also received a free tour of SND, courtesy of Suzhou municipal authorities' (Inkpen and Wang 2006:799).

A change in ownership

By 1999, growth and investment in SIP reached a low point, and the Singaporean investors in SIP were facing mounting losses. The conflict about the alleged unfair competition by the Suzhou local government through SND deepened, and Lee Kuan Yew had taken his complaints against his Chinese partners to the press. As the conflict became public, investment dropped further amidst uncertainties about the park's future. To prevent further damage to the development of SIP and to limit diplomatic fallout between China and Singapore, a decision was reached in 1999 to reduce the role of Singapore and transfer the majority ownership of the park to the Chinese consortium by 2001. The ownership structure was flipped to 35 per cent for Singapore and 65 per cent for the Chinese consortium, of which 5 per cent went to the corporation in charge of SND. In return, the City of Suzhou reaffirmed that suitable tenants would be referred to SIP rather than SND and that disorderly competition would be prevented (Porter 1999). A Chinese management headed by the official previously in charge of SND was given control over SIP.

The ownership transfer proved to be a solution to SIP's growing pains. After 4 years of stagnation, the investments in SIP quadrupled between 2000 and 2001 and have remained at a high level since (see Figure 5.2). Moreover, in 2001, SIP made its first profits since the start of development in 1994. The new management lowered the rent level to make SIP more competitive and raised revenue by kick-starting the development of SIP's residential areas, selling housing to the first 20,000 inhabitants regardless of whether they worked in SIP (Dolven, 2001). As the rate of new firms entering SIP increased sharply, the first phase of development ($8\ km^2$) was finally completed in 2001, and development of the much larger Phase Two and Phase Three continued at a rapid speed.

Recent developments: 2001 to 2012

After 2001, SIP quickly became a successful industrial park, but it was still limited to manufacturing rather than innovation and product development and did not have the atmosphere of a real city. SIP was still a rather empty and remote area with very few amenities for its residents: 'Residents choose between two Kentucky Fried Chicken outlets, some small food courts, a few small restaurants or a trip into the centre of [Suzhou]' (Dolven 2001). In 2001, SIP had about 177,000 inhabitants, but of those, 85 per cent lived in the pre-existing towns incorporated into SIP in 1994 and only 25,000 residents had been attracted as part of the development of the park. However, as SIP attracted increasing numbers of new firms and residents, the pre-existing towns of the city district became increasingly less significant.[1] Figure 5.3 shows the rapid growth of the population and employment at SIP from 2001 onwards.

The data show a stagnant population level around 165,000 up to the year 2000, all of whom lived in the pre-existing towns in the SIP city district. The entire rise

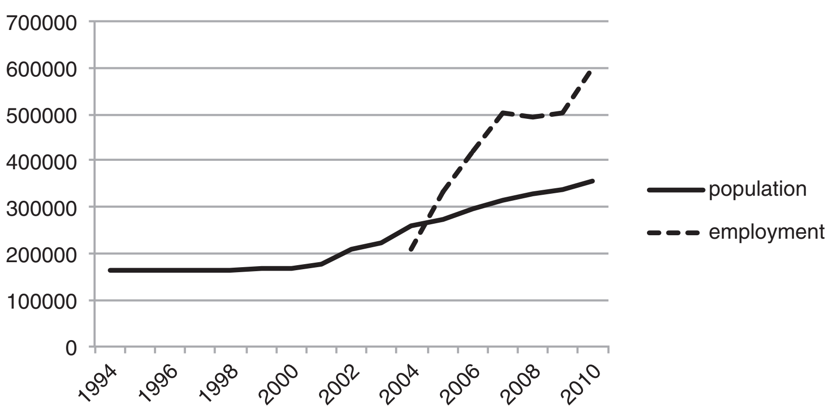

Figure 5.3 Registered population and employment of SIP
(Source: SIPAC)

in population after 2000 can be attributed to the growth of the residential areas as SIP started to develop into a real city. It should be noted that the available dataset only counts residents with an official household registration in SIP, while the true population is about twice as large. China still maintains a restrictive household registration system (*hukou*), which makes it difficult for rural-born urban residents to officially register at the city in which they live and work. As of 2012 SIP had an actual population size of 761,700 permanent residents (Suzhou Statistical Office, 2013). Clearly many more people live in SIP than are able to get a permanent registration there.

Figure 5.4 shows the growth of the number of firms in SIP after 2000. The data show that by 2000, SIP contained just under 4,000 firms, of which about 500 were foreign firms. At this point, a large share of the domestic firms in SIP belonged to the pre-existing towns incorporated in SIP, most of which are small and low tech. However, after 2001, the number of firms quickly rose to about 20,000 in 2010, including more than 4,200 foreign firms. During this decade, the share of low-tech firms in the pre-existing towns became less important. In 2010, the bulk of SIP firms consisted of foreign firms and more high-tech Chinese firms.

As the initial struggle to find tenants to fill the industrial park had been overcome, new challenges loomed for SIP. The park entered a second phase of development in which the focus shifted from growth to technology upgrading. Wages in China were rising quickly, especially in the Yangtze River Delta, which was losing its appeal to low-cost manufacturers. At the same time, unrestrained growth in the number and size of industry parks in the region was causing shortages of land and rising land prices. SIP's business area was rapidly filling up with tenants and the government made clear to SIP that, being a model industrial park, it would not be allowed to expand beyond its current borders and sprawl into the neighbouring agricultural land. The only way for SIP to continue developing would be to

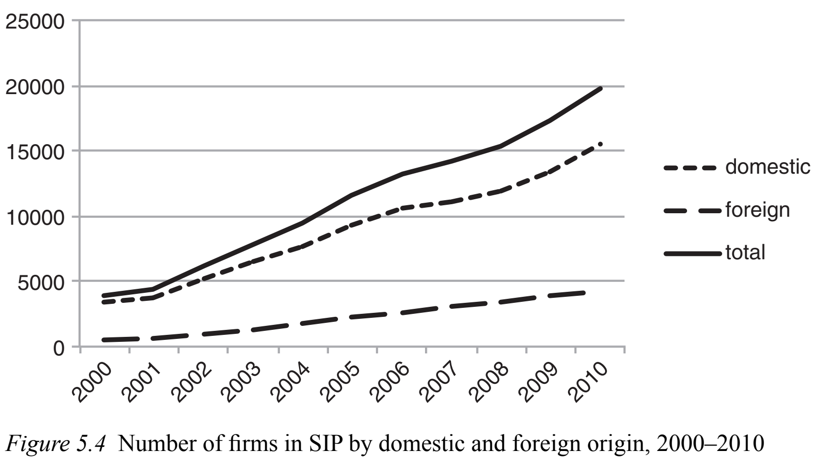

Figure 5.4 Number of firms in SIP by domestic and foreign origin, 2000–2010
(Source: SIPAC)

upgrade from manufacturing to R&D and innovative enterprise, using its scarce land for high-end rather than low-cost economic activity.

The original Singaporean planners of SIP had expected that at some point SIP might be ready to upgrade towards innovative activities, but it went faster than they had expected and with more local (Chinese) input than expected. Already in 2001, President Jiang Zemin asked SIP to upgrade into high-tech industry, as China could not continue to rely on low-cost manufacturing indefinitely. SIPAC set up a strategy for building up a knowledge base in SIP, focusing first on attracting knowledge workers from outside of SIP and nurturing them with high-quality facilities. At the same time, it started building up local university education so that in the future, the talents needed for SIP's upgrade would also graduate from within the park itself. In 2003, development started on the Dushu Higher Education Town, which was to add an academic heart to the industry park. This zone was planned to host several universities and branches of foreign universities and research institutes, as well as business incubators and student housing. The local Soochow University was the first to move in, and in 2006 the Chinese-British Xi'an Jiaotong-Liverpool University opened in the education zone. Based on the example of Biopolis in Singapore, the Biobay cluster for biotechnology was opened in the education zone in 2007, followed by the Nanopolis cluster for nanotechnology in 2010.

SIP, like SND, used to be purely a manufacturing location for foreign firms. As recently as 2003 to 2007, a survey of firms in the two parks (Wei *et al.* 2009:421) showed that in both parks, a majority of the firms were still production facilities of MNCs. About half of these production facilities produced for the Chinese market and the other half for the world market. In addition to production facilities, a substantial number of MNCs had transferred marketing for the Chinese market and some localization R&D to their branch firms. More knowledge-intensive functions such as R&D for the world market and basic research were still very rare, though, as MNCs still concentrated this in Shanghai and Beijing.

5.4 Current profile

In the present section, we discuss the innovation performance of SIP and the current process of upgrading and diversification.

Innovation performance

A good indicator of SIP's innovation performance is the number of patents granted. As illustrated by Figure 5.5, we can observe a rapid and sudden upward trend in the number of Chinese patents granted, with most of the increase happening between 2009 and 2010.[2] Moreover, the increase in the number of invention patents is faster than the increase in the total number of patents: in 2006, 6.0 per cent of patents granted were classified as invention patents, and by 2010, this had nearly doubled to 11.6 per cent. In 2011, SIP firms generated 200 international patents (and a cumulative total of 1,000 since the founding of SIP), which are likely to be

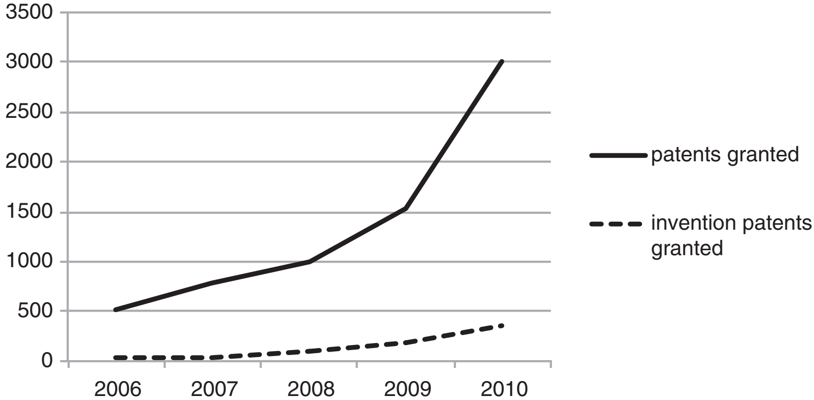

Figure 5.5 Number of patents granted to SIP firms; number of which are invention patents, 2006–2010

(Source: SIPAC)

of higher quality or inventiveness than those granted in China. This figure is also increasing rapidly, as evidenced by the fact that for more than half of the firms being granted a patent in 2011, this was their first patent (RightSite 2012).

Other relevant indicators are the number of start-ups, the number of venture capital investors, and expenses on R&D. By 2012, SIP reported about 3,000 start-up firms (Business Wire 2012). In the same year, about 200 venture capital investors were active in SIP, with a combined investment capital of around $5.5 billion.[3] As depicted in Figure 5.6, expenditure on R&D as a percentage of GDP grew from 2.9 per cent in 2006 to 4.4 per cent in 2010. SIPAC has committed itself to continuing this upward trend of expenditure on R&D to reach 6 per cent by 2024 (SIPAC 2010).

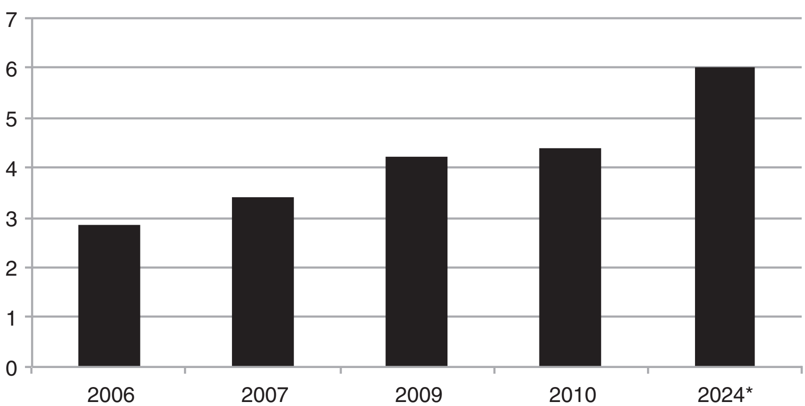

Figure 5.6 Expenditure on R&D as percentage of GDP in SIP, 2006–2010, with projection for 2024

(Source: SIPAC)

Upgrading and diversification

As of 2012, there were more signs that SIP is upgrading into knowledge intensive functions. For example, SIP has become the home base of a large number of companies that test chip sets and smartphone cameras, a function so far carried out mostly in Silicon Valley. Moreover, there is an influx of innovative SMEs developing new products. Most of them developed their business ideas in Silicon Valley or Singapore and subsequently moved to SIP to implement it. Another source of innovative SMEs is the China Mainland, notably from outside of Jiangsu province. Most of these firms were founded by researchers affiliated with the China Academy of Science and were attracted to one of the start-up incubation programs at SIP. While these firms are still small and their market potential unclear, some of these may grow into industry leaders and set SIP on the map as a location of innovation rather than manufacturing. However, in all these cases, the 'spark' of the innovation (the research or market discovery that led to the inception of the innovation) happened outside of SIP. In other words, SIP is developing into an incubation place of innovative firms but not yet a place where innovative ideas are born.

Besides upgrading its industry, SIP is also seeing a process of diversification. First, SIP is becoming more diverse in terms of the origins of its firms. While it used to be largely an enclave of foreign firms and their Chinese subsidiaries, it has developed a more balanced profile (Figure 5.7).

As of 2010, employment at SIP was distributed almost evenly between foreign and domestic firms, a marked change from an earlier dominance of foreign MNCs. Moreover, in terms of the number of firms, domestic firms even constituted a clear majority by 2010.

Second, the service sector has grown into a second pillar of economic activity in SIP besides industry. Over time, the share of the service sector has gradually

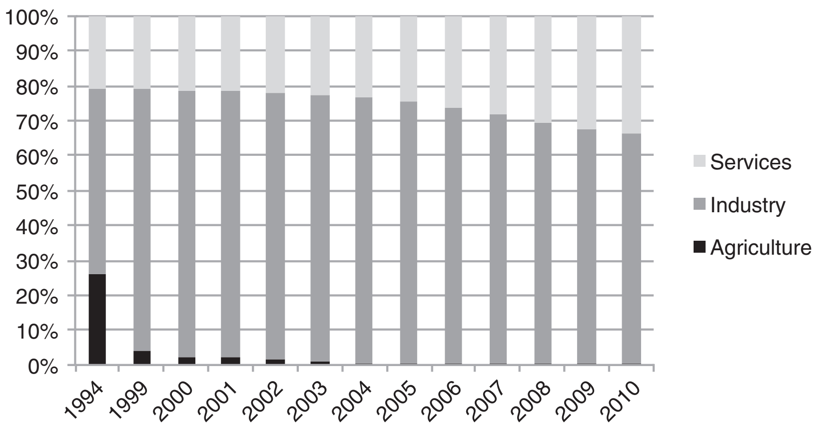

Figure 5.7 Value added by SIP firms, service, industry and agriculture
(Source: SIPAC)

grown to about a third of local value added in 2010, while the agricultural sector quickly disappeared (Figure 5.7).

Part of the rise of the service sector can be explained by the fact that as SIP's number of full-time residents is increasing, the park is growing into a real city with the retail, entertainment, and other service functions required by its residents. Moreover, SIP has a number of shopping malls and cultural centres (notably the Suzhou Culture and Arts Centre) that draw visitors from all parts of the city and beyond. But besides these consumer services, SIP is also seeing the development of a business services sector. SIPAC has made the further development of the service sector (especially business services) one of the focal points of development, with the goal that in 2024, the service sector will contribute 55 per cent of SIP's value added. However, Wei and colleagues (2009) add a word of caution on the potential for SIP's business services sector. A prerequisite for having a substantial business services sector is that SIP–based firms have command-and-control functions rather than just being subsidiaries without local decision-making power. So far this has not been the case, as SIP still hosts very few corporate headquarters. Moreover, its rival SND already hosts almost all of the headquarters of banks in Suzhou (Wei *et al.* 2009). So far SIP is mostly focusing on attracting firms in business services outsourcing (e.g. product localization and marketing outsourced to SIP by multinational firms).

Third, SIP is diversifying its profile by developing its tourism sector. Up to about 2004, tourism was not a big priority for SIP, as the park was still strongly focused on manufacturing and had few full-time residents. While there was some tourism development around Jinji Lake, this was aimed only at business travellers staying at nearby hotels, and much of the lake was not accessible to other kinds of tourists. From 2005 onwards, the tourism sector has been recognized as one of the key sectors of SIP, and a more comprehensive vision for SIP's tourism product has been developed.

Finally, some initiatives have been undertaken to stimulate the development of a creative industry cluster, focusing on animation and game design. For these sectors, the Creative Industrial Park has been set up, and the first firms moved in by 2010. The park includes a start-up incubator called Idea Pumping Station, aiming at a wide range of creative industries, including 'art, animation, games, [advertising], public media, publication, software design and IC design' (SISPARK 2012). As of 2010, the incubator hosted 31 firms, about half of them in advertisement and the other half in animation and game design.

From industrial park to science city

As we explained in section 5.3, SIP has developed from an industrial park into a science city with residential areas and facilities in education, research, retail, tourism, and culture. This city has reached a population of about 700,000 inhabitants, and it is projected to grow up to at least 1.2 million inhabitants in the near future. In the interviews, several inhabitants of SIP indicated that they already experience SIP as a real city. For dining, shopping, and other daily activities, they usually do not leave SIP, as within the boundaries of the park there is sufficient diversity and quality of these services. Moreover, frequent traffic jams between SIP and the Suzhou city centre make it impractical to visit the city centre daily. Also, the branding strategy of SIPAC has made a complete shift from presenting SIP as first and foremost an industry park to presenting SIP as a diverse and attractive city of science and technology.

While SIP already has a very substantial population and number of tenants, its large size (roughly 19 by 8 km) still makes it feel like a low-density and, in some places, rather empty place. Therefore, one way to further increase the sense of being in a real city is by concentrating people and firms in smaller sub-clusters within SIP, the ‘park-in-a-park’ clusters. These specialized sub-clusters have the additional benefit of creating tailor-made environments in which start-up entrepreneurs are surrounded by researchers, students, and incubation facilities all geared towards one industry sector. Firms are stimulated to locate in the sub-cluster that is most suitable for them given their industry specialization, but they are free to locate elsewhere in SIP if they wish. SIP’s investment promotion and branding strategy also uses the sub-clusters as key features of SIP and develops their names as brands in their own right. Below we introduce and briefly discuss four sub-clusters.[4]

Biobay

Biobay is a ‘park-in-a-park’ cluster with a size of 0.9 square km, planned as a zone within SIP that is tailor made for biotech firms and research institutes. Biobay was opened in 2007. Like Nanopolis and Creative Industrial Park, Biobay is located in Dushu Higher Education Town in close proximity to SIP’s universities and academic research institutes. Biobay is inspired by the Biopolis cluster in Singapore, which is designed as an attractive location for high-tech firms and hosts many subsidiaries of foreign biotech multinationals. In addition to this, Biobay also includes extensive start-up incubation facilities and hosted 275 start-up firms as of 2012. Most of these firms focus on doing only the first stage of drug development research and sell their IPR to large pharmaceutical firms when they reach their first milestone. However, the goal is for Biobay to produce at least one world-leading pharmaceutical company in the near future to establish the name of SIP and Biobay as places of cutting-edge biotech development. This is still very challenging, however, because of the enormous investments needed to conduct, for example, clinical trials.

Nanopolis

Nanopolis is a cluster similar to Biobay but aimed at the nanotech sector. Construction started in 2011, and when finished, Nanopolis will be a 1.5-square-km cluster that includes R&D facilities, small-scale production, and pilot-testing facilities and convention and exhibition facilities. Moreover, the cluster will offer business space for the headquarters of a limited number of nanotech companies and incubation space for start-ups in the nanotech sector. The nanotech sector is stimulated because it is seen as a multidisciplinary sector with the potential to support other related technologies and lead to the creation of niche markets on the boundaries of nanotech and other technology fields. However, just like the biotech sector, firms need to make deep investments to enter the nanotech sector and have a chance to become world leading in it.

Creative Industrial Park

The Creative Industrial Park is a 0.8-square-km cluster founded in 2006 and completed in 2011, dedicated to software (outsourcing), game development, advertisement, and animation design. By 2012, it had attracted 105 firms with a total of 5,500 workers. It has a younger image than the other clusters in SIP and aims to include creative design and art in addition to software and business services. Start-up incubation is a major focus of Creative Industrial Park. An incubation building named Idea Pumping Station is dedicated to housing and offering support facilities to start-ups. Firms are housed in lofts (flexible housing spaces) and interaction is stimulated in shared exhibition spaces. Currently this building houses 31 firms, about half of them in advertisement and the other half game development and animation design (including Snail Animation, China's first and most successful 3-D animation firm; SISPARK 2012).

Genway I-Park

I-Park, or Suzhou 2.5 Industrial Park, is a 0.6-square-km cluster currently under development in SIP, about 1 km northeast of Dushu Higher Education Town. Its developer, Genway, is a state-owned enterprise that builds and rents out many projects in SIP, including besides I-Park also, among others, residential developments and hotels. In contrast to the other specialized clusters within SIP, I-Park is aimed at the business services sector rather than ICT or natural sciences. This fits with the aim of SIP to diversify into the business services sector. To promote this sector, the Chinese government has selected SIP as a model for business services development. In the first years, firms in the business services sector were offered significant tax reductions at SIP. This special status only lasted for a limited time, but it gave I-Park an initial advantage to enter into this sector.

The first phase of the park opened in 2010 and houses firms and firm subsidiaries that carry out services such as product localization and marketing, which MNCs like IBM and Kraft Foods have outsourced to them. As I-Park has limited space, it does not accept manufacturing facilities and gives priority to R&D facilities and firm headquarters. A request to develop a data centre in I-Park is currently under debate. I-Park offers its tenants human resources services, a shared exhibition space, a manager club, and an industry forum. Moreover, as of 2013 residential facilities have been opened in I-Park. The two medium-sized apartment towers are especially aimed at short-stay facilities, since a large proportion of the R&D workers employed by I-Park firms (especially young or international workers) only stay there for a limited period of time. Most of these workers have received higher education and would not be attracted to live in a business park, but buying an apartment in the normal residential zones of SIP is also not convenient.

The solution is to offer them high-quality living space on the same campus as their workplace but to design this campus as an attractive campus rather than a standard business park. The design of the cluster is inspired by American university campuses, with attractive public buildings spread out in a park environment. Moreover, much of the green space is accessible for people to, for example, have picnics on them (as is common at university campuses), and it is hoped that in this way an informal atmosphere and unplanned meetings can be promoted. Another way to promote a sense of community at I-Park is by organizing regular meetings and celebrations for the people who work and live there. Moreover, inter-firm interactions are stimulated by organizing industry seminars and forums. Genway invites firms and experts in related industry sectors to these meetings, both from within I-Park and from elsewhere, with the aim that knowledge exchange occur between the firms.

5.5 Key features

Having discussed the background and development of Suzhou Industrial Park as well as its current profile, this section explores the sources of its strength as well as its challenges. These will be summarized in the form of four key features, namely the institutional environment, the education and human resources pool, the knowledge base and R&D performance, and the level of entrepreneurship.

Institutional environment

A unique feature of SIP is its institutional environment. While a reliable and supportive local administration is an important asset for any innovation system, it is the single most defining characteristic and key selling point of SIP. Previous studies (Wei *et al.* 2009; Pereira 2004) and interviews conducted for this book confirm that the governance and institutional environment of SIP are key reasons for them to choose to locate in the park.

The uncertainty and mixed reputation of China's institutional environment, combined with the attraction of China's low wages and massive consumer economy, created the *raison d'être* for SIP. It created an opportunity for SIP to attract investors by offering transparency, reliability, and a service-oriented administration. To instil these values, SIP's Singaporean founders have spared no expense to train all SIP administrative personnel in its 'software transfer' project, inviting hundreds for training courses at Singaporean state ministries and public institutions at the highest level. By the time Singapore reduced its stake in SIP, its institutional practices and values had become deeply ingrained and continue to characterize the park's institutional environment to this day.

The first aspect of SIP's 'Singapore software' is its business-friendly environment. A common problem in Chinese industry parks is the dominance of short-term thinking. Plenty of time and energy are spent to persuade a potential tenant to move into the park, but the moment the tenant has settled down, he is neglected. By contrast, interview respondents in SIP indicate that the park's management continues to nurture a strong bond with its tenants, not only with large anchor tenants but also with SMEs. Firms are assigned a liaison at SIPAC so that during and after relocation to SIP, they are serviced as much as possible by the same contact person. Moreover, a zero-tolerance policy against corruption is enforced at the park. All fees SIP tenants can legally be asked to pay have been publicly listed so that corruption or 'grey-area' transactions (such as expensive entertainment offered to administrators to hurry up a procedure) can more easily be identified.

An institutional innovation at SIP is the SME Service Center, which works according to the one-stop-shop concept. Adapted from similar models in Singapore, the SME Service Center brings together a broad range of services needed by SMEs. All relevant SIPAC and government departments have a window in the Service Center so that entrepreneurs only need to visit one place to take care of all legal duties (such as tax, business licenses, import and export licenses, etc.) and to benefit from additional services offered by SIPAC (see Box 5.1 for more information). Over time, other Chinese industry parks, notably SND, have adapted the one-stop-shop concept and set up similar services, but the SIP SME Service Center still offers the broadest range of services.

While it is aimed at SMEs, the service centre is also open to larger firms. Moreover, some workshops and other services offered at the Center are used by firms from outside SIP as well, including SND but also as far away as Shanghai. SND has its own service centre with largely parallel organizations, but there is no coordination between the SIP and SND centres.

A second aspect of SIP's strong institutional environment is its planning system. While a strictly enforced zoning plan and a top-down planning system are nothing new in a Western European context, these are rare and highly valued assets in the context of emerging East-Asian nations. At the start of the development of SIP in 1994, a zoning plan and development vision (prepared by a Chicago-based firm) were made, and these plans were carried out with only minor modifications. The advantage of this planning stability for investors is that the infrastructure and the features of the environment their investment project is located in (e.g. the number of nearby workers and residents, the quality of green space, etc.) are developed as promised and do not introduce unexpected challenges to the success of their project. Moreover, it promotes transparency, as it reduces the scope for secret dealings with firms to influence the development of the park: 'no is no', and the publicly available plan is the plan that will actually be carried out. The strictness of the planning system can also be seen in the SIP environmental protection agency. From the start, the policy was followed that before any development can be considered, the environmental protection agency first has to determine that it does not degrade the safety and quality of the park's water, air, and green spaces. Even when cancellation of a project is costly, SIPAC committed itself to following the binding advice of the environment bureau.

Box 5.1 The SME Service Center

The one-stop-shop concept of offering services to tenant firms has been a focal point from the birth of SIP in 1994. In 2006, the Science Leap Project was implemented in SIP with the aim of speeding up the development of high-tech start-ups. Based on the main challenges most often faced by SMEs, a range of services was selected to offer to firms free of charge, including help with filing patents, finding specialized human resources, and getting access to VC investors. To bring these additional services together with the usual services of administration and licensing, the SME Service Center was set up in the Dushu Higher Education Town area of SIP in 2009, near SIP's main start-up incubators. In 2012, it had 16 employees, which was expected to double in 2013.

SMEs in SIP were found to be hindered in their development by an inability to find their way in the Chinese VC community. This community is still strongly in flux, with great differences in experience and professionalism and with a strong role for government seed funds. International SMEs find it especially hard to identify suitable investors or get through the paperwork of applying for Chinese government funds, which exist at national, provincial, and local levels with different regulations and timetables. Another challenge is to find suitable talents with specialized skills. Many technical disciplines are still in an early stage of development in China, and graduates with this training can be hard to find. SMEs generally lack the time and funds to train specialists in house and depend on specialized workers that are ready to begin from day one. Through the SME Service Center, SIPAC helps SMEs find these talents through its network of headhunting firms.

Another important service offered through the center is patent registration. IPR protection is mentioned as the greatest worry of foreign firms at SIP. To address this, the SME Service Center helps firms file patents and advises on how to deal with patent infringements. However, here SIPAC is limited in what it can do; in the end, whether patents are truly protected or not depends on the Chinese legal system. Especially software patents offer only limited practical protection. A specific package of services is offered to overseas entrepreneurs who want to settle down in SIP, including guidance with finding housing and education. Moreover, workshops and cultural events for overseas entrepreneurs are organized from the center. Finally, a number of other SIPAC initiatives are housed in the SME Service Center, including an organization that brings universities and firms together to coordinate the education curriculum with the needs of the firms.

Human resources

SIP started as a location for low-cost manufacturing, requiring large numbers of disciplined low-wage workers who didn't need to have specialized training. However, during the 2000s, Chinese wages started to increase, while at the same time SIP-based firms started to require more specialized and better-educated workers. Interview respondents indicate that while the quality of workers available to work in SIP is generally sufficient, the size of the labour pool is starting to fall behind the demand. Both for higher- and lower-level engineers, the labour market has become somewhat tight, and this triggers especially lower-level engineers to job hop frequently in search of the best employment conditions. Moreover, substantial numbers of higher-level workers can only be recruited in nearby Shanghai, and they must make the long commute to SIP daily.

Another factor that has placed more stress on the local labour market is the shift in SIP from only big multinational firms to a higher proportion of small and medium-sized firms. SMEs generally lack the time and funds to (re-)train recruited workers to learn the specialized skills they require. Experienced workers with the right skills have to be available to start working from day one, or the SME faces a costly setback in its vulnerable early growth stage. The success of the shift to a more innovative, start-up-driven industry profile therefore depends on the upgrading of the local labour supply.

A number of approaches are taken to assure a sufficient quantity and quality of local human resources. The first approach is to attract suitable workers from other parts of China. In China, SIP is generally considered an attractive place for working and living. This is partly because of Suzhou's beautiful historical city centre, which is well preserved (in contrast to most other Chinese cities) thanks to the strategy of focusing urban development on the fringes rather than the heart of the city. Moreover, SIP benefits from its own heavy investments in high-quality infrastructure and environmental protection as part of its Singapore-inspired urban planning, which makes the park a very attractive living environment. Also, while housing prices have increased rapidly all over China and especially in cities like Shanghai (many even speak of a housing bubble), SIPAC enforced relatively strict controls over its housing supply to discourage investors from buying up houses (which drives up prices and leads to large numbers of empty homes owned by absentee investors). Young Chinese workers, who may have little chance to buy a house at the inflated prices of Shanghai, are able to settle down in SIP instead.

Another way to attract specialized human resources is through the 1,000 Talents Programme, a project initiated by the Chinese national government to attract Chinese who studied abroad and didn't return to China after graduation. These overseas Chinese are a large community especially in the United States, and, for example, many of the innovative firms at Silicon Valley were set up by Chinese founders. This program focuses on providing access to research funding and VC investment, which were found to be the things most desired by highly educated overseas Chinese (see the section on entrepreneurship and Box 5.3 for more information).

Besides attracting workers to SIP, another approach to improving the human resource pool at SIP is to expand local higher education. Chinese university applicants are highly mobile and have a tendency to settle down and look for work in the city where they graduate from university. A large and high-quality academic community in SIP would therefore help to solve the labour shortage. During its first decade, SIP didn't have any university-level education institutes, and its vocational education also built up only slowly. Suzhou as a whole had not been a major university centre since the foundation of the PRC, and the local Soochow University was not among China's best technical institutes.

From 2003 onwards, the Dushu Higher Education Town was developed within SIP. Soochow University opened a local campus and gradually upgraded its academic level. Afterwards, other university departments moved into the area in rapid succession, resulting in a total of 23 universities (mostly branches of other universities) by 2012. Starting in 2006 with Liverpool University (UK), several foreign universities have created joint-venture universities or independent colleges in SIP. Liverpool University was followed by National University of Singapore, besides University of Dayton, UC Berkeley, George Washington University, and University of Waterloo, all from the United States. The student population of SIP grew from 0 to 78,000 in less than a decade.

However, SIP's experience with attracting universities also illustrates some challenges and drawbacks. While SIP now hosts several high-quality education institutes, some of the 23 institutes are very small and a few departments are of low quality. SIP used financial incentives to convince institutes to move in, subsidizing the cost of building a new campus and allowing universities to use their new buildings for free during the first years. This attracted some universities that only set up some training courses or only offer an MBA, which is easier and more profitable than creating a full-blown university. Other universities only offer master-level education, which is also relatively profitable and easy to set up as an attachment to a research institute. Bachelor-level education is much more complex due to the relatively restrictive Chinese national education policy. Only Soochow University, Xi'an Jiaotong-Liverpool University, and Hong Kong University are able to grant bachelor's degrees in SIP. A different challenge is that while SIP is still mostly focused on science and technology (with animation and business services still in an early stage of development), most universities offer majors unrelated to science and technology and few really focus on the majors local industry needs most. Having reached a large student population, SIP has now become much more selective and only wants 'MITs', with expertise in applied engineering and other much-needed skills. Other universities may still be welcome as long as space is available, but they would not receive subsidies.

An issue that other industry parks face when they attempt to transform themselves into a science city is that they lack the urban vibrancy and amenities needed to become attractive for students to study and live there. SIP does have some of the amenities attractive to students, for example, a bar street with restaurants and karaoke bars at Harmony Times Square, illuminated at night by the iconic Skyscreen. But overall it is still rather silent and, due to its low-density planning, and the university campus area is not yet well connected to the entertainment area. However, in the Chinese context, these are not important considerations. For Chinese students, the quality of education and the ability of university professors to help them start their career through personal connections are decisive decision factors, and in contrast to most Western students, they cannot afford to base their choice of university on the attractiveness of the campus environment and entertainment facilities. However, if SIP also aims to attract international students, it may need to pay attention to the vibrancy of its campus environment.

The third focus area for improving the local human resources pool is in university–industry interaction. As mentioned earlier, SIP–based universities do not always provide the specialized graduates demanded by local industry. To address this, SIPAC organizes regular meetings between representatives from the universities and industry to better coordinate the range of majors offered to students and the specific curriculum of those majors. While still a challenge at university level, vocational colleges are already a step farther in this process. Box 5.2 describes the SIP Institute of Vocational Technology (SIPIVT), a vocational college with exceptionally strong bonds with local industry.

Box 5.2 University–industry cooperation at SIPIVT

SIPIVT is a college of vocational education with more than 10,000 students, founded in SIP in 1997. It has received extensive autonomy from the Chinese national education system, allowing it to experiment with several innovative policies. The aim of the college is to develop a new type of high-quality vocational education in which students are taught precisely the skills needed by industry so that employment can more or less be guaranteed. To ensure this, the curriculum is designed in cooperation with industry and is continually being updated as technological change demands new skills. Besides regular students, the school also focuses heavily on life-long learning for workers employed at SIP.

The concept behind SIPIVT was personally proposed by the former president of Singapore, Lee Kuan Yew, and the former president of China, Jiang Zemin, made it a high-profile project by paying a personal visit. Study visits to vocational schools in Germany, Singapore, and other developed countries were conducted to learn more about how to set up practical but high-quality education, with a focus on engineering. The first innovation of SIPIVT lies in its entrance examination system. Other Chinese colleges and universities accept students based on their score on the national *gaokao* exam at the end of high school. This examination is completely focused on standardized written tests that emphasize rote learning. SIPIVT, by contrast enrols, students based on oral examinations in which motivation and creativity are key criteria. Moreover, representatives from private firms take part in deciding which students are admitted to the college.

The education itself is also far less theoretical than at other Chinese institutes. The first reason for this is that 75 per cent of the college's teachers have working experience at a private firm and are familiar with the skills most valuable to the future employees of their students. Moreover, 62 per cent of the teachers have studied abroad. This too is a great asset for the students, since so far 80 per cent of graduates went on to work for foreign companies in Suzhou, which requires the ability to work with foreigners and understand the corporate culture of multinational firms.

SIPIVT has several cooperation partners in SIP, including Samsung, Bosch, and Philips, which offer internships and company visits to enrich the school's education. Whenever possible, students carry out their assignments as applied projects, solving real problems faced by local firms. Also, these firms provide the school with specialized equipment that few colleges can afford to buy at their own expense, such as lab space and tools used in the semiconductor industry. Training courses for current employees that the firms would otherwise have carried out in house are outsourced to SIPIVT, and engineers and students are trained in the same classes.

In some cases, industry involvement is taken a step further. When firms face a lack of engineers with a specific set of skills or they foresee a specific demand for labour in the near future, they can place an order at SIPIVT. The college then proceeds to educate students according to the specifications set by industry. While the advantages for industry of 'build-to-order' college education are obvious, it also has benefits for students in the form of good labour market prospects. Of the 25,000 alumni graduated by SIPIVT by 2011, 98.9 per cent have found employment (*China Youth Daily* 2011; *Suzhou Daily* 2011).

While deep cooperation with industry already caught on at the level of vocational colleges, with SIPIVT as the most extreme example, one may question how far reaching such university involvement could be at the university level. The risk is that students end up learning specific techniques at the expense of their general foundational training. For example, if a university-level IT major only learns how to apply specific programming languages but does not have a deep understanding of computer science in general, his skills may quickly become obsolete. Nevertheless, at Soochow University in SIP, not only industry partners but also the students put pressure on the university staff to offer a practical curriculum with immediate applications in industry to ensure good job prospects (DIMACS, 2007).

Research and development

As described in section 5.3, SIP only recently shifted its focus from manufacturing to research and development, and as recently as the early 2000s, few firms carried out R&D in the park. However, the shift to R&D is vital for safeguarding the sustainability of the park's development, and from 2003 onwards, deep investments have been made to develop universities and research facilities. As of 2012, there are clear signs of knowledge-intensive economic activity in SIP.

First, several of the MNC subsidiaries in SIP carry out increasingly more complex R&D challenges. For example, a SIP–based medical equipment firm with foreign headquarters is now tasked with not just the manufacture but also the development of a high-tech medical system. Basic research is still carried out in the foreign headquarters, but the engineering challenges involved in the design of the actual product and the scaling of manufacture are carried out by the SIP–based subsidiary, which leads to the generation of patents for process innovations. In other words, it is tasked with using the most advanced methods currently known and solving the practical challenges that come up when new methods are implemented for the first time. However, the development of new methods, associated with more radical innovations, still takes place at the headquarters outside of SIP where basic research is carried out.

A second source of knowledge-intensive activity and patents is innovative SMEs. This is exemplified by firms such as Magvention (miniaturized relay switches), Innolight (optical transmitters), and MXR (3-D augmented-reality software), with respectively 330 (after 4 years), 57 (after 3 years), and 27 employees (after 2 years). Magvention and Innolight were founded by overseas Chinese entrepreneurs who went to the United States for their master's and PhD studies. Through research and work experience in the United States, they developed an engineering invention, which they patented and now implement through a start-up firm in SIP. MXR has a Singaporean founder who moved to SIP after founding his firm. All three firms do things that have never been done before, either because of innovations in the product or in the production process. But their innovations can be described as incremental rather than radical, and in their R&D effort, the focus is more on development than on research. Moreover, in all three cases the initial 'spark' that set off the innovation process happened respectively in the United States and Singapore, not within SIP.

Innovative SMEs, and gradually more innovative MNC subsidiaries, have enabled SIP to reach a high and rapidly accelerating patent output focused on process innovations and incremental product innovations. However, the ambition of SIP is to also move into more radical innovations based on basic research. The main strategy for this is by nurturing strategic upcoming sectors such as biotech and nanotech. It is hoped that expertise in these broad, generic technological fields will support the rise of other subfields that depend on this knowledge base. However, the drawback of focusing on these cutting-edge industry sectors is that they require very heavy investments before any level of critical mass is built up, and even then the returns are uncertain. For example, developing a leading pharmaceutical company as an anchor to SIP's biotech sector requires very large investments, as a single clinical trial can already cost hundreds of millions of dollars before generating any returns. Because of this, some firms in SIP take a more gradual approach by carrying out drug-development research, and as soon as the first milestone is reached and expensive equipment or trials are needed to proceed, they sell their IPR to a large pharmaceutical firm. In this way, less investment capital is needed before returns are generated that can be plowed back into the next development project. This is a good first avenue into difficult, cutting-edge markets, and it allows small firms to do innovative and knowledge-intensive work without needing enormous investments. But it leaves SIP still quite far removed from the level of a world-leading cluster.

Somewhat similarly, SIP's ICT sector is making gradual process. So far, most leading Chinese ICT firms emerged by developing services for the Chinese domestic market. Firms such as Amazon, YouTube, Facebook, and eBay are reluctant or unable to enter the Chinese market, leaving a niche for Chinese firms to make localized versions of existing web services for the Chinese market. The Chinese market is large enough to spawn billion-dollar ICT-firms, creating an opportunity for SIP to build up critical mass in this sector. In addition to this, ICT outsourcing provides another avenue for building up critical mass in the ICT sector in SIP. But respondents think that SIP still has a long way to go before it could generate world-leading ICT firms, also because SIP faces tough competition in ICT from Beijing and Shenzhen in southern China.

One approach for SIP to further upgrade its R&D capability is by expanding university research within the park. Most entrepreneurs indicated in the interviews that they do not see SIP universities as research partners but solely as sources of human resources. Some SIP–based firms do carry out research cooperation with Chinese universities outside of SIP and would be interested in doing this with SIP universities if their research matched the knowledge needs of industry and if its quality was sufficient. But so far, few of SIP's 23 universities carry out a substantial R&D effort, mostly because it is far more expensive and less profitable than education. But because of the strong bond between Singapore and SIP, the National University of Singapore has become one of the first to make a substantial contribution in the form of its SIP subsidiary of the NUS Research Institute (NUSRI). It was founded in 2010 with an initial team of 30 Singaporean professors. In SIP, these professors are matched with Chinese PhD students to create research schools, and they receive generous research funding to make these budding research schools grow as quickly as possible. The Singaporean professors still have the duty to teach back at Singapore 30 per cent of their time, so they function as a bridge and vehicle of knowledge exchange between Singapore and SIP. NUSRI also cooperates with the SIP branches of the Chinese Wuhan and DongNan universities and is intended as a role model of knowledge transfer as well.

University–industry knowledge transfer mostly takes place by letting NUSRI researchers create start-up firms whenever their research findings create an opportunity for this. Other forms of knowledge transfer, such as R&D outsourcing by firms to academic research institutes or the sale of university IPR to private firms, are still not very developed at SIP. Multinational firms rarely do this in China, but among domestic Chinese firms, it is becoming more common. A few examples of foreign MNCs outsourcing R&D to Chinese universities were found, including a large SIP–based chemical firm that provided research funds on the order of half a million dollars to a Chinese university to carry out R&D.

Finally, no signs were found of open innovation, such as shared pre-competitive research. Interactions among local firms do not go much farther than sharing tips and business information, as opposed to organizing shared R&D projects. But shared research facilities are relatively common, since SIPAC provides these to SIP–based firms. In Biobay, Nanopolis, and other clusters, SIPAC develops facilities such as testing laboratories. These are then transferred to the foundations that manage the clusters and offered to local firms at a low price or, in some cases, free of charge.

However, a more pressing issue than the promotion of university–industry knowledge transfer and open innovation is IPR protection. Only when this issue is addressed can firms be expected to show greater interest in conducting R&D in SIP. IPR protection is especially a problem for big rather than small firms and for software- rather than hardware-related knowledge. While outright copying occurs in China, the main risk for firms is to lose strategic knowledge when their workers are hired by rivals. Western firms commonly have an understanding that workers hired from competitors should not be pushed to give up strategic information gained at their previous employer, and SIP–based firms indicate that they trust foreign MNCs at SIP to stick to this code of honour. However, they have less trust in the behaviour of local Chinese firms, which often do use the recruitment of employees as a way to gain access to trade secrets.

Entrepreneurship

SIP has adopted many of its key features from Singapore, including its institutional structure and the deep investments in making the park an attractive environment for working and living. And like Singapore, SIP became able to attract firms, especially multinational companies, and with them jobs and FDI. However, as successful Singapore is at attracting high-tech MNCs, it has not produced significant innovations. When SIPAC decided in the early 2000s that it had to upgrade itself from a manufacturing park to an innovation park, it realized that it had to go beyond the 'Singapore strategy' of attracting MNCs and instead nurture a culture of entrepreneurship. And since SIP could not use Singapore as a model for this, it had to widen its view and learn from other models as well.

The first step in this process was to attract innovative SMEs besides only attracting MNCs and to nurture these young firms within SIP to become the next generation of leader firms. SIP attracts entrepreneurs and their start-up firms from three main sources. Within China, SIP has created a partnership with the Chinese Academy of Sciences. When academic researchers affiliated with this academy decide to become entrepreneurs, SIP is one of the locations offered to them. In SIP, these academic start-ups are offered VC investments, and the academy contributed two of its workers to help set up SIP's investment funds. About 90 per cent of these start-ups are founded by PhDs, professors, or other academic staff.

A similar but so far much smaller source of start-ups is the Singapore–based NUS Research Institute, NUSRI. As described in the previous section, starting in 2010, a team of 30 Singaporean professors was selected to create research schools in SIP. A major goal of NUSRI is that the applied research of these research schools regularly leads to opportunities for start-up formation. NUSRI staff is stimulated to take part in the start-up firm itself and receive ownership of the IPR they need. Moreover, they are offered free housing in the NUSRI building for the first 3 years (which is actually financed by the Suzhou government rather than NUSRI). In return, NUSRI receives shares in the start-up. Singaporean academics are eager to join NUSRI because they receive larger research grants than back in Singapore. Equally important is the fact that China has many industry sectors the small Singapore economy lacks, which makes it easier to develop practical applications of research results than in Singapore.

Both the CAS–based Chinese entrepreneurs as the NUSRI-affiliated Singaporean entrepreneurs tend to retain a strong bond with their universities, and many keep their tenure while functioning as (part-time) entrepreneurs. This makes it easier to take the risk of trying to set up a start-up firm, and at the same time the ongoing bond with the universities is likely to promote ongoing knowledge transfers from university research to the start-up firm. But it also has drawbacks. Many of these start-ups are led by part-time entrepreneurs, who may not devote as much time and energy to the enterprise as would be optimal for its development. Moreover, their academic CEOs often lack experience in finance and marketing, which again introduces risks for the development of the start-ups. For the universities involved, there are also significant drawbacks. It is not uncommon for these academic entrepreneurs to invest their research time at the universities (paid by the government), and even the research time of the PhD students under their guidance, into their private enterprise. Many worry that this is at the expense of the quality of public education and research and hence not a sustainable entrepreneurship model.

For these reasons, another group of start-up entrepreneurs is vital for SIP, namely returning overseas Chinese. This community of researchers and entrepreneurs also consists mostly of university-educated experts, and many of them hold a PhD degree. But they typically also have working experience at Western high-tech firms, and some have already founded start-up firms abroad before coming to China. Moreover, having thoroughly integrated overseas innovation systems such as Silicon Valley, they return to China with knowledge of Western business practices and a network of academic and business contacts. After coming to SIP, they tend to be professional, full-time CEOs of their start-up enterprises with the ambition to grow into leader firms in their industry. The community of returning overseas Chinese in SIP is described in Box 5.3.

Box 5.3 The community of returned overseas Chinese in SIP

For more than a century, China has suffered from a brain drain as its most talented scientists and entrepreneurs migrate or stay abroad after graduating from an overseas university. Episodes of political turmoil have further strengthened this outflow of talent, with the most recent being the Cultural Revolution (1966–1976) and the Tian'anmen Protests of 1989. Overseas, and especially in the United States, these Chinese migrants have set up innovative enterprises and played a key role in the success of Silicon Valley (e.g. Joint Venture 2012). Over the past decade, a period of political stability and increasing openness of the economy has lead to a flow of return migration.

Because of its attractive environment and international character, SIP has become one of the magnets for returning overseas Chinese. While some of the returnees may choose SIP simply because their family roots lie in this region, most returnees interviewed for this book indicate that their family roots are elsewhere in China, and they chose SIP for its working and living environment. As of 2012, a community of about 1,500 returned overseas Chinese has developed in SIP. Most of the returnees move back to China on their own initiative, but recently the Chinese government has started programs to increase the number of return migrants.

Since 2008, the Recruitment Program of Global Experts or '1,000 Talents Programme' has been carried out by the Chinese government. It was planned to run for 10 years and aims to attract about 2,000 highly educated Chinese living abroad to return to China. They are offered relocation and housing subsidies, but most importantly they have access to extensive government VC investments. SIP is one of the main destinations for talents enrolled in this programme. While the number of returnees attracted through the 1,000 Talents Programme only represent a fraction of the total community of returnees in SIP, the programme helped add a number of leading experts to the returnee community and raised awareness among overseas Chinese for the option to move back.

Returnees typically come to SIP either to find research funding to set up a research team or to set up a start-up firm. Returnee entrepreneurs that we interviewed are each full-time entrepreneurs with business experience in the United States. They moved to China during the past 3 to 5 years, and for them the trigger to move was the difficulty of finding sufficient venture capital in the United States because of the recent economic recession. They indicate that being located in SIP gives them better access to public and private sources of seed funding, although for most funds it is not strictly necessary to be located within SIP. Equally important for them is the attractive living environment, including high-quality housing and education and transparent public administration. In addition to the one-stop-shop business services and other public services enjoyed by SIP tenants, SIPAC has set up a package of services offered through the SME Service Center that specifically target returning overseas Chinese. They include assistance in legal matters such as visa applications (many returnees only have a foreign passport, having given up their Chinese citizenship) and tax administration but also issues such as how to deal with healthcare insurance, which, being foreign nationals, they do not automatically have access to in China. Incentives such as the relocation subsidy offered through the 1,000 Talents Programme are not mentioned as important factors in their decision to return to China.

Having succeeded at attracting 1,500 returnees to SIP, the next challenge is to anchor them to the park by creating a local community they feel attached to. Besides practical services, SIPAC also organizes seminars and cultural events, for example, to celebrate Chinese New Year and other holidays. Respondents indicate that the returnee service desk of the SME Service Center functions like a social club, which is 'very lively' and 'really makes things work on the background'. Besides these more formal gatherings, there are also initiatives by returnees themselves to strengthen their community. For example, one returnee entrepreneur set up a club for overseas Chinese, and together they bought a restaurant to function as the club's meeting place.

A more challenging aspect of community building is found in the family situation of returned overseas Chinese. Most returnees are men (and a few women) who have come to SIP alone. While most of them do have a family, they did not bring them along with them to China. Younger children would face a strong 'culture shock' if they were suddenly moved from the United States to China, since especially the Chinese education system is radically different from any Western school experience. Moreover, respondents indicated that their wives also have high-level careers or own a firm back home in the United States and are unwilling to give this up by moving to SIP. International communities commonly start as 'bachelor societies' (consisting only of young men, without women and children), which was also typical of the earliest ethnic Chinese communities in the United States. Only when families are formed do these 'foreign outposts' grow into thriving and distinctive communities. SIP tends to attract somewhat older migrants who already have a family, but until their families settle in SIP, the returnee community will keep the character of an outpost that lacks local roots. International schools with an atmosphere closer to Western schools would help make the transition easier, but facilitating the overseas careers of wives is far more challenging. Even excellent international accessibility (improved access to Pudong Airport) would not be sufficient to enable an overseas career to continue, although some entrepreneurs try to do exactly that by traveling back and forth across the Pacific Ocean several times per month (see Saxenian 2006 for illustrations).

So SIP has been successful at attracting, besides Chinese entrepreneurs, also overseas Chinese and some Singaporean entrepreneurs. Moreover, these entrepreneurs have started to become embedded in SIP, perhaps because of its improving R&D capabilities or because of personal attachment to the place and community. In the early 2000s, start-up firms tended to stay in SIP only as long as incentives lasted (about 2 or 3 years), immediately moving to innovative clusters in Shanghai, Beijing, and Shenzhen afterwards. As of 2012, entrepreneurs that start up a firm in SIP tend to stay there. Much harder, though, is to also attract and retain Western entrepreneurs to SIP. The few Westerners in SIP are mostly CEOs of existing companies such as branches of multinational companies, not entrepreneurs of start-up firms. But a recent initiative of SIPAC may provide a first avenue for tapping into Western entrepreneurial talent, namely Israel SIP.

Israel SIP is a long-term cooperation program between SIPAC and Israeli firms and VC investors. SIPAC specifically focused on Israel as its first Western cooperation partner for entrepreneurship and investment because it believes Israel is a good role model of a start-up–based innovation system. Except for Silicon Valley and Israel, there are few innovation systems that really revolve around start-up entrepreneurship fuelled by VC investment as the major way for implementing innovations. Much more common are systems in which large firms use their financial clout to innovate and renew their knowledge base. Since SIP has the ambition to base its future development on start-up entrepreneurship, it decided it could benefit from cultivating close relations with Israel and use it as a development model.

Israel SIP is not a physical firm cluster but an organization that includes Israeli firms and investors who intend to cooperate with SIP in the long run. While the benefits for SIP are obvious, Israeli actors also benefit from this cooperation. Israel is a country with strong R&D capability and highly innovative industry. Moreover, through close contacts with Silicon Valley (Saxenian 2006), Israel has developed the institutions and infrastructure needed to generate and nurture start-up firms and spin-offs. Most importantly, it has an active community of VC investors able to identify and nurture start-ups with high potential. However, Israel faces chronic land and resources shortages, and international political tensions further limit its attractiveness as an R&D and manufacturing location. By creating strong bonds with SIP, Israeli firms gain the land and resources they need besides also gaining access to the growing Chinese market, while as a strategic partner of SIP they can also expect priority treatment. This resembles the interests small but highly developed Singapore had to establish its long-term bond with Suzhou in the 1990s.

The main thing SIP hopes to learn from Israel is VC investment. In the 1990s, China, still in the process of economic transition, had essentially no experience in VC investment. An important early model for capitalist economic structures was Taiwan. The 'godfather of Taiwanese VC', Wang Bai Yuan (director of the Taiwanese Venture Capital Association, TVCA), is originally from Suzhou and told Suzhou officials that he wanted to do something for his old hometown. They decided to set up a VC fund in SIP according to the model of TVCA named China-Singapore Suzhou Industrial Park Ventures Co. (CSVC). CSVC and TVCA did some VC projects together so that CSVC could learn the Taiwanese working style, and afterwards CSVC went on to set up more VC funds in Suzhou. In 2010, their expertise was used to set up the Guochuang Fund of Funds (FOF). This is a large (its starting capital was about $10 billion) fund that only invests in other funds, which then use their capital to make angel and VC investments in innovative start-ups. Guochuang FOF is registered in SIP and invests a significant part of its funds there, though its market encompasses all of China. Most of its money originates from the Chinese government or state-owned banks.

The Fund of Fund works by taking a 30 per cent position in other VC funds, leaving 70 per cent for private investors to contribute. Much of this 70 per cent is provided by cash-rich Chinese firms (e.g. Huawei) but also wealthy individuals, including some returned overseas Chinese. In case of losses, the FOF takes the first hit, creating a buffer to protect private investors. The goal is to convince private investors to join the relatively risky early-stage VC, thereby leveraging government funds and giving private investors a chance to learn and build up experience. The fund mostly invests in ICT, Biotech, and Nanotech start-ups. These firms tend to start from scratch rather than as spin-offs from an existing company, which means larger investments are needed and the risk level is higher. So far the government is still the only party willing to take the risk of angel VC, while the private VC community limits itself to second-round and later-stage VC. Some local angel investors have emerged, but they still lack professionalism. For example, they impose all sorts of conditions on the start-up firms they invest in ('if you do not launch your product within 1 year or become profitable within 3 years, all investments must be paid back immediately'), which is bad practice and hinders the development of start-ups. On the other hand, very large sums of money are available for (less-risky) later-stage investments, but so far too few investment opportunities are available, and what is really needed is angel investment and second-round VC. Currently angel and second-round VC still fully depend on government funds, but it is hoped that a VC community will emerge that will share this burden. A fund that already takes part in relatively risky VC is the Israel–based Infinity Investments, which is a member of Israel SIP. Infinity mostly invests in Israeli companies but also in other start-ups in SIP. Its funds originate partly from the Chinese government, but a majority is supplied by the international Jewish business community.

Besides organizing VC investment funds, SIPAC also tries to nurture start-up firms using its park-in-a-park clusters. It is common for science parks to create start-up incubators to add value to their start-up support policies, but the SIP park-in-a-park clusters are a very elaborate form of this. Within the Dushu Higher Education Town, clusters have been developed focusing on specific industry sectors, including Biobay for the biotech sector and Nanopolis for the nanotech sector. It is hoped that by housing start-up firms in incubators in close proximity to research and education institutes with a similar specialization, these start-up firms will benefit from knowledge spill-overs and have the first pick of graduates trained in their field. When start-ups that begin from scratch are facilitated in this way, the high risk of investing in them may be somewhat reduced.

5.6 Conclusions

In this chapter, Suzhou Industrial Park has been analysed as an upcoming urban innovation system. The development of SIP has been traced from its origins as an industrial park focused on manufacturing to its current status of a science city under development. It was found that SIP very recently made its shift to innovation and R&D but has already made significant progress in terms of patent output and other knowledge performance indicators.

Several key features have been identified that show both the strengths that underpin the increasing innovation performance of SIP as well as the challenges it still needs to overcome. The strengths and weaknesses of SIP, besides opportunities and threats for its future development, are summarized in Table 5.1.

The first key strength of SIP is its institutional environment. While reliable and supportive local administration is an important asset for any innovation system, it is the single most defining characteristic and key selling point of SIP. The uncertainty and mixed reputation of China's institutional environment created an opportunity for SIP to attract investors by offering transparency, reliability, and a service-oriented administration. To instil these values, SIP's Singaporean founders have spared no expense to train all SIP administrative personnel in its 'software transfer' project, inviting hundreds for training courses at Singaporean state ministries and public institutions at the highest level. Examples of SIP's institutional environment are planning stability (the park's zoning and design plans are strictly carried out), a transparent and corruption-free environment of 'Singapore quality', and a comprehensive SME Service Center in which tenants can complete all their administrative duties (registration, tax payment, etc.) in a 'one-stop shop', besides enjoying many additional services (e.g. help with filing patents).

A second strength and distinctive feature of SIP is the deep university–industry collaboration for human resources development. To ensure a sufficient quality and

Table 5.1 SWOT analysis of success factors, challenges, and policy responses for Suzhou Industrial Park

Strengths	*Weaknesses*
• Reliable and distinguishing institutional environment • Deep university–industry collaboration in HR development • Government VC through the Fund of Funds	• Dependence on attracting innovative start-ups from outside rather than local development • Holdovers from its industrial era hamper upgrading to a science city
Opportunities	*Threats*
• Returning overseas Chinese are developing a strong community • Continued support from Singapore helps the upgrading process • Israel as model of start-up entrepreneurship	• Rising wages may outpace SIP's upgrading process • Loss of distinctive status and priority policies • Unstable Chinese real estate market

quantity of human resources, SIP has attracted 23 university departments with a focus on science and engineering majors. These universities are located next to biotech, nanotech, and other specialized firm clusters that include start-up incubation facilities. Colleges of vocational education are even more tightly integrated with local industry. For example, the local SIP Institute of Vocational Technology (SIPIVT) supplies graduates 'on order' to key SIP–based firms such as Samsung according to their specifications and receives expensive industrial machinery for training purposes in return (e.g. equipment for training in semiconductor production donated by Samsung).

A third source of strength is the pro-active role of the Chinese government, helped by both Taiwanese and recently also Israeli development models, in kick-starting the development of VC funding. To compensate for a paucity of venture capital, a Fund of Funds has been set up by the Chinese government to fund VC funds (up to 30 per cent, leaving 70 per cent for private investors to contribute), which in turn provide seed funding to innovative start-up firms. Moreover, incentive programs have succeeded to attract about 1,500 overseas Chinese researchers and entrepreneurs to return to China and set up their research teams or innovative start-ups in SIP.

Several opportunities were identified that can further strengthen the development and innovation performance of SIP in the near future. First, the returning overseas Chinese that have been attracted to SIP are starting to develop a strong sense of community. They may prove to be vital for the upgrading of SIP into innovation and the development of new industry sectors, since they are both highly qualified (many have a PhD degree and working experience at leading innovative companies) and also entrepreneurial, as many of them have set up innovative SMEs in SIP. However, SIP still faces the question of how it can develop this 'bachelor community' into a thriving community consisting not only of entrepreneurs but also their partners and children.

Another opportunity is provided by the continued strong bond of Singapore with SIP. Even though the development process has not always been smooth, and even a major conflict broke out between SIP's Singaporean founders and their partners in Suzhou, SIP can still count on continued attention and support from Singapore. A recent example is the research institute of the National University of Singapore (NUSRI), which is one of the first university departments at SIP to actually be willing to invest in the knowledge base of SIP and supply it with start-up entrepreneurs. Moreover, there may be the potential for SIP to develop a similar long-term partnership with Israel, which has become a source of firms and VC funding as well as being a development model for a start-up based innovation system.

SIP also faces a number of challenges, of which the two most pressing are the following. First, so far SIP has only been able to attract innovative start-ups from outside rather than creating them locally. SIP, much like its development model Singapore, has so far depended on attracting entrepreneurs and innovative SMEs from elsewhere, especially overseas Chinese working in Silicon Valley. In other words, the 'spark' of the innovation happened in a different innovation system rather than within SIP itself, and SIP's role is limited to nurturing an existing business idea. To really become a sustainable innovation system, SIP should become a place of cutting-edge research in which innovation breakthroughs and serendipitous meetings of minds lead to the creation of new ideas. So far the level of scientific research at SIP and the entrepreneurial culture in China have not reached this level yet.

Second, the transition to a science city is hampered by holdovers from SIP's past focus on industrial manufacturing. SIP did not start as a science park but rather as a location for low-cost manufacturing outsourced by multinational companies. As SIP is making a transition from industry park to science city, it needs to overcome the brand image of a factory zone as well as deal with existing tenants that do not fit the new profile of a science city. Low-tech manufacturers who have purchased land at SIP at relatively cheap prices early in the park's development are reluctant to make way for more innovative firms, since relocation is costly and rising land prices make SIP land a lucrative investment they are keen to hold on to. However, SIP's transition to a science city is helped by the fact that from the start, the park was planned according to high-quality specifications. Expensive investments in the attractiveness and efficiency of SIP's infrastructure, natural environment, and amenities (including the state-of-the-art Suzhou Culture and Arts Centre opened in 2007) are now paying off as they help the park attract residents and even tourists and make SIP an attractive location for conferences and expositions.

Finally, two threats are identified that may pose a problem to SIP in the near future. First, as SIPAC realized in the early 2000s, rapidly rising wage levels are changing the competitiveness of China, and especially the Yangtze River Delta in which SIP is located. Low-cost manufacturing, still a substantial part of SIP's industrial profile, is likely to relocate to less developed regions in China or other emerging economies. While SIPAC responded to this challenge by quickly rolling out a strategy of upgrading to innovation and R&D, it would still be threatened if Chinese wages rise too fast before SIP had a chance to fully settle in its new role as a centre of innovation.

Similarly, while SIP enjoyed priority treatment and special economic status in its early days, these have now become more or less ubiquitous in China. Moreover, the special institutional features of SIP (notably the one-stop-shop SME Service Center) have by now been adopted by other Chinese industry parks and no longer give SIP a unique selling point. SIP will have to fully develop its new selling points, namely world-class research capabilities and human resources, before the loss of its prior distinctive features makes it lose competitiveness in the highly competitive Chinese market.

Lastly, an issue that is still evolving and won't be discussed here in detail is the Chinese real estate market. Many observers argue that the quickly increasing real estate prices in China in fact constitute a bubble, which may burst in the near future. SIP's large-scale rollout of residential spaces as well as its ambitious building program of office towers and entertainment facilities around Jinji Lake could be conceived of as being a part of this unsustainable property bubble. Measures taken by SIPAC to limit the purchase of apartments by investors (which drives up prices and leads to large numbers of uninhabited apartments) may limit the damage to SIP in the event that an actual real estate bubble has emerged.

Notes

1 Therefore, in the remainder of this chapter, statistics refer to the entire SIP city district.
2 As the criteria for granting patents are substantially different in China, the absolute patent output cannot be compared with European regions.
3 This is the potential investment capital, not the actually invested VC.
4 Besides these, some other clusters can be distinguished in SIP, though some are less clearly delineated. North of Jinji Lake, an eco-industrial park is being developed for the sustainable technology sector. Moreover, more organically grown clusters in the automotive sector, electronics manufacturing sector, and pharmaceutical sector can be identified.

Sources

Business Wire (2012) *Suzhou Industrial Park: Winning the international race to attract industry talent,* available at www.businesswire.com

China Youth Daily (2011) Who may enrol in higher vocational education – firms also have a voice [Chinese], *China Youth Daily,* 18th April 2011.

DIMACS (2007) *Report to National Science Foundation: insightful understanding of China's higher education and research in computer science and information technology,* DIMACS, Rutgers University: Piscataway (New Jersey, United States).

Dolven, B. (2001) Suzhou: The new frontier, *Far Eastern Economic Review,* 6th December 2001.

Inkpen, A. and Wang, P. (2006) An examination of collaboration and knowledge transfer: China–Singapore Suzhou Industrial Park, *Journal of Management Studies* Vol. 43, No. 4, pp. 779–811.

Joint Venture (2012) *Silicon Valley Index 2012,* San Jose: Author.

Pereira, A. (2004) The Suzhou Industrial Park experiment: the case of China–Singapore governmental collaboration, *Journal of Contemporary China,* Vol. 13, No. 38, pp. 173–193.

Pereira, A. (2007) Transnational state entrepreneurship? Assessing Singapore's Suzhou Industrial Park project (1994–2004), *Asia Pacific Viewpoint,* Vol. 48, No. 3, pp. 287–298.

Porter, B. (1999) Singapore drops control of Suzhou park. *South China Morning Post,* June 29th.

RightSite (2012) *Suzhou Industrial Park's 7 innovation landmarks in 2011,* available at http://rightsite.asia

Saxenian, A. (2006) *The New Argonauts: regional advantage in a global economy,* Cambridge, MA: Harvard University Press.

SIPAC (2010) SIP to focus on ten battlefields in transformation and upgrading, available at www.sipac.gov.cn

SISPARK (2012) About SISPARK, available at www.sispark.com.cn

Suzhou Daily (2011) *Institute of vocational technology and Samsung cooperate on training program* [Chinese].

Suzhou Statistical Office (2013), Suzhou statistical yearbook 2012 [Chinese], available online at www.jsw.suzhou.gov.cn

Walcott, S. (2002) Chinese industrial and science parks: bridging the gap, *The Professional Geographer*, Vol. 54, Issue 3, pp. 349–364.

Wang, J. and Lee, C. (2007) Global production networks and local institution building: the development of the information-technology industry in Suzhou, China, *Environment and Planning A,* Vol. 39, 1873–1888.

Wei, D., Lu, Y. and Chen, W. (2009) Globalizing regional development in Sunan, China: does Suzhou Industrial Park fit a neo-Marshallian district model?, *Regional Studies,* Vol. 43, No. 3, 409–427.

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6 Synthesis and conclusions

6.1 Introduction

This chapter formulates conclusions by comparing results from the three case studies. In the frame of analysis in Chapter 2, we introduced the set of characteristics and contextual factors that, based on the literature, we expect to be of prime importance for understanding the innovation performance of urban innovation systems. In the present chapter, we compare these expectations with the empirical findings presented in Chapters 3 through 5.

This discussion is structured along six themes: firm capabilities and leader firms (section 6.2); higher education and research (6.3); talent attraction (6.4); place branding (6.5); entrepreneurship (6.6); and the institutional environment (6.7). Within each of these themes, we try to answer to what extent our empirical findings match with or differ from the theoretical expectations concerning the factors that influence innovation system development introduced in Chapter 2. Moreover, for each of these themes, we identify the policy approaches implemented by actors in our three case regions as they try to strengthen and manage the innovation systems they are part of. In section 6.8, we address a seventh theme that emerged during our empirical study but has not been studied yet in detail: the trend towards a new, more *urban* planning orthodoxy. The final section (6.9) presents 10 recommendations for policy makers and other actors involved in the development of urban innovation systems.

6.2 Firm capabilities and leader firms

The first set of key characteristics (as proposed in the frame of analysis) is related to the mix of constituent firms and their capabilities. Below, we discuss the distinction between cities dominated by endogenous ('home-grown') firms and those in which firms with external origins are dominant. Second, we analyse the role of leader or anchor firms; and third, we discuss the relevance of dynamic capabilities (knowledge exploration, absorption capacity, and exploitation) and the firm's relative standing within local and global networks.

Development factors

Endogenous versus exogenous origins. Does it matter if the region is dominated by home-grown firms or by foreign ones? We note differences between, on the one hand, Eindhoven and Kista and, on the other hand, Suzhou Industrial Park. The growth of the Eindhoven innovation system can largely be attributed to the growth first of Philips and then of its suppliers, its spin-offs (most prominently ASML), and finally the suppliers of its spin-off firms. Nearly all these firms can be described as Dutch firms with strong roots in Eindhoven or its immediate vicinity. Over time, some of these firms have become international players, but there is little sign that these MNCs are losing their strong functional and emotional bonds with the Eindhoven region. Recently, firms from other parts of the Netherlands as well as from abroad have moved to Eindhoven, adding some exogenous firms to the still largely endogenous mix. Kista's development differs from Eindhoven's in that from the start, a significant number of firms have had external origins. However, Ericsson quickly set itself up as a local anchor firm, much like Philips in Eindhoven, and went on to produce spin-off firms, most of which also located in Kista. Both endogenously created firms and firms attracted from outside of the region continue to play important roles in the further growth of the Kista innovation system.

Both Eindhoven and Kista have benefitted from hosting endogenous leader firms with a strong bond to the region. Firms such as Philips and Ericsson, and more recently also ASML, have invested deeply in their respective regions and helped set up much of the hardware and orgware of their innovation systems. However, these bonds should not be taken for granted. They may weaken in the future depending on the fortunes of the firms themselves and on the extent to which their home regions remain attractive locations. Both Philips and Ericsson have already gone through periods of severe downsizing and have partially relocated out of their home regions. Besides issues such as the supply of specialized labor (see section 6.3), demand-side factors may play a key role in assuring the attractiveness of the region in the future. From the start, the Swedish domestic market has been favorable to the development of Kista, with ample early adopters for high-tech products both among end users and the government and military. Current initiatives such as the Mobile Life Centre promise to add to these demand factors by creating a living lab environment for local firms to test and enhance their newest products. For Philips and its major offshoot ASML, the local market has been less important, but recently Philips started taking steps to create a stronger connection to local users. It is establishing strong relations to local hospitals to gain valuable feedback on its newest medical electronic products, and the first initiatives have been launched to turn the Strijp S design district into a living lab for Philips lighting products.

Suzhou Industrial Park (SIP) forms a sharp contrast in that it started with hardly any endogenous firms, relying instead on attracting foreign MNCs to set up manufacturing subsidiaries within the park. While Kista and especially Eindhoven also started with a significant share of manufacturing activities, some of them low tech, they early on also became key locations for R&D, at least for their anchor tenants. In SIP, after about 20 years of development, this upgrading process is still in a very early stage. Moreover, the rise of knowledge-intensive activities in SIP is again led by the attraction of firms, especially start-ups and SMEs, from outside of the park. A large-scale effort is now under way to kick-start the endogenous generation of start-up firms.

As a consequence of the exogenous character of most constituents of SIP, the strength of functional and emotional bonds of key firms to SIP is likely to remain limited in the near future. However, some firms, in particular Samsung and Hitachi, have to some extent started to behave as leader firms. They have stimulated some of their supplier firms to follow them in setting up branches in SIP, and recently they and other large firms have started to invest in the local education infrastructure of SIP (particularly vocational education). Either the endogenous generation of new firms or the embedding of constituent foreign branches may endow SIP with leader firms in the future and gradually change the exogenous character of its key tenants. In terms of demand-side factors, SIP originally had little to no relationship with its hinterland, starting as a manufacturing location for MNCs catering to mostly Western consumers. With rising income levels in China, domestic consumers of high-tech products may start to play a more important role for SIP firms in the near future.

Dynamic capabilities. Another important development factor is formed by the dynamic capabilities of constituent firms. A survey and/or network analysis would be needed to fully evaluate the dynamic capabilities of the firms in the three case studies, but some preliminary observations can be made. In the cases of Eindhoven and Kista, again, the role of the leader firms appears to be important, as their characteristics and peculiarities have had long-term consequences for the development of their respective innovation systems. In Eindhoven, Philips has long followed a policy of extensive investments in a wide variety of R&D projects, leaving it with, at one point, the world's largest R&D lab (NatLab) and with patents in a variety of product sectors. However, poor connections between its research and business departments meant that exploitation was limited, and instead this rich knowledge base gave rise to high rates of spin-off formation. While ultimately of limited use for Philips itself, it allowed a company town to grow into a reasonably diverse innovation system. Increasing competitive stresses have since caused Philips to change its attitude of favouring knowledge exploration over exploitation, and currently it does not appear to be typical anymore for other Eindhoven firms. For example, ASML has a sizable R&D budget, but targets it at a narrow range of relevant sectors in which it is confident that knowledge exploitation is feasible.

Kista has had a different experience. Leader firm Ericsson has historically had a clear focus in its R&D spending, limiting the range of industry sectors in which it has generated spin-off firms. From the start, the Kista innovation system has also included branches of major international firms, such as IBM and Intel, which helped to shape its development. However, their Kista branches also tend to focus narrowly on those sectors the innovation system is most renowned for and therefore strengthen its narrow specialization. Based on the literature on the impact of sector structure discussed on Chapter 2, it is expected that this narrow specialization puts a limit to the absorption capacity of the Kista innovation system for new knowledge, excluding all but a narrow range of research fields from the attention and grasp of its firms.

Another aspect of dynamic capabilities, besides the ability for knowledge exploration and exploitation, is access to international networks. In this respect, Eindhoven and Kista show a clear similarity. The leader firms of both regions were 'born global', quickly connecting to markets and knowledge far beyond the home region. Because of their strong embeddedness within their respective regions, they have gone on to form gateways through which other local firms could access external sources of knowledge and market information. This is also visible in Philips spin-off ASML, which inherited extensive access and credibility from its parent company and has gone on to assist its own local partners to also set up extra-regional linkages. ASML actively helps suppliers in the region find other clients through its global network. While this reduces the monopsony (single-buyer) power of ASML, it increases the stability of ASML's strategic suppliers and hence reduces risks of supply interruptions.

Finally, in SIP, dynamic capabilities and international network access are growing from a much smaller base, as its major firms are still in the process of upgrading from dependent manufacturing locations to more knowledge-intensive operations. Most R&D activities, with few exceptions, are still limited to market localization and product testing. However, SIP has recently attracted a sizable number of innovative SMEs, which are likely to significantly change its character in the future. While it's still too early to tell how these young firms will develop, they share features that could make them highly capable in knowledge exploration and exploitation. Most are headed by researchers with experience both in academia and in start-up entrepreneurship. Moreover, their founders tend to have strong international connections, especially to Singapore and the United States. These networks are likely to help them access external markets and sources of investment capital. It is an open question what extent these global network linkages also constitute *knowledge* networks, as access to external knowledge sources may be weakened by their relocation to SIP.

Policy approaches

There is a limit to the extent to which policy measures can be deployed to address weaknesses in firm capabilities, as they are closely related to internal strategic decisions taken within private firms (e.g. the decision to limit investment in knowledge exploration). However, indirect policy approaches are feasible that target the sector distribution within the region, for example, to combat over-specialization within a single industry sector. In this way, the absorption capacity of the innovation system as a whole is enhanced without having to interfere in firms' internal decision making. While Kista is the most specialized of the three case studies, there is little sign that this is perceived as a limitation and vulnerability for the innovation system, and no concrete policy measures have been identified to this end.

In Eindhoven, which is less specialized than Kista but still retains a relatively dominant high-tech systems and materials sector, explicit policy attention has been aimed at stimulating diversification. Small but growing ICT and design sectors are now emerging, both starting from private initiatives but being spurred on by policy intervention. Both sectors have benefitted from start-up incubation initiatives, though so far this has tended to generate large numbers of small firms, with few continuing to grow to a significant size. For the ICT sector, a very expensive and complex project called Kenniswijk was rolled out, but with few visible results. The equally large-scale and ambitious project for the design sector, the development of design hub Strijp S, appears to be more successful in raising awareness for the fledgling sector, especially through frequent well-visited events.

6.3 Higher education and research

Another key set of actors mentioned in the frame of analysis is formed by the institutes of higher education and research (here referred to as universities). Universities play an important role in urban innovation systems. As education institutes, they are prime attractors of talented young individuals and trainers of professionals. As research strongholds, they may develop partnerships with companies in the system to conduct pre-competitive collaborative R&D or more mundane contract research, which may help make the companies in the system more innovative. Also, universities can be a source of new business ventures when academics or students start their own science-based businesses (discussed in section 6.6). And finally, universities can play the role of *animateur,* contributing to the connectedness and organization capacity of the innovation system.

Development factors

Most interviewees in the three case studies indicate that the prime role of the university is to attract talented young people and provide them with skills relevant to the local industry. The high-tech clusters in Eindhoven and Stockholm would cease to prosper without the new influx of talent. In Suzhou, during the early days of the industrial cluster development, there were no universities. But when the area upgraded towards an innovation hub during the last decade, companies felt a need to have reputed universities nearby, primarily as a source of new talent. Currently, about 24 university branches (mostly foreign) have opened up in the area.

Most companies consider the research function of universities less important. In each urban innovation system we studied, only a limited number of high-tech firms (mostly large ones) are engaged in substantial collaborative research programmes with the university, and university research is not primarily locally (or regionally) oriented. Typically there is a long road (if any) between basic/fundamental research and commercial application.[1] Smaller, science-based firms tend to have research connections to the university at which the owner obtained his or her PhD (not necessarily the local university). This was especially evident in the case of Suzhou and, in particular, in start-ups with an ongoing bond with the National University of Singapore. Finally, in all of our cases (in contrast to the situation in some successful US universities), there is very little labour mobility between business and academia. This is widely seen as a problem.

Policy approaches

Aligning business and academia. Evidently, the chance of a productive marriage between business and academia in the region is higher when both work in the same (technology) fields or specialisations and when firms have the 'absorptive capacity' to use and exploit the knowledge developed in the university. What policies would help to improve this strategic connection when universities are fully independent and free to choose their own research and education directions? We identified four types of interventions: (1) put university and business physically together in the knowledge hot spot; (2) promote staff exchange between the two systems; (3) attract universities from outside that neatly fit the interests of the industry; and (4) create dedicated platforms/organisations where university and business collaborate.

In Eindhoven, there is a long and continuing tradition of industry–university alignment based on the Philips culture that dominated the innovation system for a century. Philips always had a significant influence at the university, with leading Philips researchers holding university chairs, ensuring a strong connection between industry interests and university research. Over time, the TU/E became less dependent on Philips, but it continued to be perceived (and to perceive itself) as a university in service to local industry. In Stockholm and Suzhou, a different dynamic was at work. In Stockholm, the answer was to increase physical proximity: the city managed to convince the universities to relocate their IT departments and faculty from the city centre to Kista, where the IT industry – led by Ericsson – began to agglomerate. Physical proximity made it easier for students to take internships in Kista companies and for companies to spot talents and develop partnerships. The universities helped the area obtain a global reputation as an IT hot spot. At the time of writing, the area hosts about 7,000 students. In Suzhou, companies were in the lead: they were invited to formulate their need for competences, and the SIP management lured universities from abroad to meet this demand.

Platforms. A common way to bring academia and business together is by creating platforms and institutes for university–company collaboration. In Eindhoven and Stockholm, the key decision makers from academia and business meet each other at strategic 'Triple Helix' platforms (Brainport and Electrum Foundation, respectively), where they discuss strategic directions and find solutions for bottlenecks for the region and commit themselves to common agendas. On the operational level, there are organisations in which academics and companies work on common projects. Eindhoven has its Holst Centre, where companies and academics (not only from Eindhoven) develop innovations, typically in the pre-competitive stage. It has a partnership model with industry and academia based around shared roadmaps and programs. It has more than 180 employees from 28 nationalities and a commitment from close to 40 industrial partners. PhD topics are defined in collaboration with the three technical universities in The Netherlands (Delft, Eindhoven, Twente), and many master and PhD students from these universities are working on the technology programs at Holst Centre. Industry partners may benefit from (commercially interesting) breakthroughs of fundamental research; in return, the universities get market insights and can draw on the experience of the industrial partners to help focus their research activities.

A prime example from Stockholm is the Mobile Life Centre (MLC) in Kista, an institute in the area of mobile services. It is a joint venture of several large firms (including Ericsson, Microsoft, Nokia, and IKEA) and the universities KTH and Stockholm University. It is 33 per cent funded by the state research investment agency VINNOVA and 67 per cent funded by its industrial members. Research undertaken is by and large pre-competitive, providing input into the long-term R&D efforts of all partners involved but not usually leading to immediate applications, which firms prefer to develop in-house. When MLC research does lead to practical IPR, complicated negotiations about the ownership of this IPR are avoided with the simple rule that all partners have equal rights to all IPR resulting from MLC research.

The cases of Eindhoven and Stockholm illustrate that collaboration between industry and academia can be very fruitful but seem to work only with substantial public funding. Active interventions are necessary. They also show how difficult it is to involve smaller companies: typically, the large MNCs have more absorptive capacity to collaborate with universities and benefit from these institutions.

6.4 Talent attraction

Besides the mix of actors and their interactions, the frame of analysis also proposed that a strong urban innovation system should be able to attract and retain talented people, thus safeguarding the competitiveness of firms. Talented people play a crucial role in the development of successful innovation systems. Regions with a high innovation performance are able to attract and retain talents first and foremost because they provide access to opportunities in employment and education. But also the quality of the living and working environment and (urban) amenities are relevant factors of attraction.

Development factors

In all three case studies, interviewees emphasize that the attraction and retention of talent is a key challenge to be addressed. Surveys among (international) knowledge workers in Eindhoven find that professional and academic opportunities are the most important reasons to come to Eindhoven, while amenities such as the natural environment or cultural facilities do not seem to play a major role. The attractiveness of the living and working environment does play an important role in Kista, but in a negative sense. The immediate vicinity of Kista is generally not perceived as an attractive living area, as it lacks any but the most basic urban amenities. Moreover, the surrounding Järva area has a reputation for ethnic segregation and safety issues and is hence not considered as a possible living place by most knowledge workers employed in Kista. This leads to long commuting times for knowledge workers employed in Kista, and firms indicate that this sometimes hinders their recruitment of specialized workers.

The case of Suzhou Industrial Park again shows a very different picture, with very few respondents indicating that the attractiveness of the living environment is an important factor in the attraction of talent. This may be explained by the fact that Suzhou is located in a transition country, in which workers may have different priorities than those in advanced industrial countries. The availability of good job opportunities coupled with a relatively accessible housing market (compared to similar high-tech industry zones in cities such as Shanghai and Beijing) is perceived as more important than natural or cultural amenities. Given the variety in experiences with the role of the environment in attracting talent, an equally broad range of policy measures related to environmental attractiveness was found in the three case studies.

Policy approaches

Attracting universities, research institutes, and firms. Interviewees indicate that universities, research institutes, and (large) firms play a critical role in attracting talented people and ensuring that they acquire the skills and knowledge needed in local industries. This can be realized through education, participation in research projects, and job experience. The question is now if cities can steer this process of attracting 'talent attractors'. The answer is 'yes, to some extent'. In Eindhoven, the development organisation managed to convince TNO Industry (a national research institute founded by the Dutch government) to move its activities to the campus of TU/E, hiring former employees of Philips who might otherwise have left the region. The development of Kista would have been less successful without the pressure of the Swedish government on two Stockholm-based universities to move their ICT and electronics-related departments to this area in the 1980s. More recently, Suzhou Industrial Park succeeded in acquiring around 24 university branches (mostly foreign) in the transition from an industrial cluster to an innovation hub. In response to an increasing need among companies to have reputed universities nearby, primarily as a source of new talent, the SIP administration stimulated universities to settle down by offering them 5-year rent reliefs.

Attracting (international) knowledge workers. Another way to attract talent is by developing specific programmes, facilities, or incentives targeting (international) knowledge workers. The aim of these interventions is to create an environment that takes away all kinds of barriers for (returning) migrants from other regions or other countries. With this objective in mind, the City of Eindhoven invested in a high-quality international school. Also, the development of Strijp S, with innovative living concepts such as the Condotoren, fits in a strategy to make the city more attractive for this specific group. In this area, they want to develop apartments and services that are tailored to the needs of the future residents, which are expected to include a large share of international knowledge workers.

In Suzhou, the attraction of international knowledge workers is high on the agenda. While so far it has been difficult to attract Western knowledge workers and entrepreneurs, the park has seen a large influx of talents from the overseas Chinese community. The main policy for attracting them is through the 1,000 Talents Programme. Entrepreneurs and researchers are offered subsidies or VC investments if they relocate to SIP. Incentives are offered in the first 2 years in the form of lump-sum relocation compensation and assistance in finding suitable housing and arranging tax and other legal issues. In case returnees arrive with their families, advice is offered on finding good education for the children. In the interviews, returnee entrepreneurs say that what mattered most for them were the VC investments offered through the 1,000 Talents Programme, while other financial incentives and subsidies did not play a role in their relocation decision. Moreover, very few of them arrive with their wives and families.

Improving international accessibility. An important condition for international knowledge workers is international accessibility. In all three case studies, we observe local policy initiatives to improve the connection between the innovation system and the nearest international airport (Amsterdam Schiphol Airport, Stockholm Arlanda Airport, and Shanghai Pudong Airport, respectively). The accessibility of Kista Science City, for example, has been improved with the extension of a commuter train connection to Arlanda airport. In the two other case studies (Eindhoven and Suzhou), local policy makers are putting pressure on decision makers on a higher level (the national government, national railways, etc.) in order to realize more frequent and/or faster connections.

Improving the inflow of talents from the commuter region. Talents can be attracted from abroad but also from within the commuter region of the urban innovation system. The ability to attract talents from the region depends, for one thing, on the accessibility of the innovation hot spots. Suzhou Industrial Park and Kista Science City benefit from good connections with neighbouring cities such as Suzhou and Shanghai and Stockholm, respectively. Another relevant factor is the inflow of talents from local universities and schools. This inflow is partly dependent on demographic factors (natural growth) but also on the popularity of technical studies and jobs among young people. Particularly in Europe – where the transition to a services-based economy has progressed much further than in China – regions are struggling with a decreasing interest in 'technical careers' among high school graduates. In Kista, the Electrum Foundation has anticipated this threat by organizing 'Future Friday', an annual event that promotes ICT majors to prospective students (drawing about 1,000 visitors every year). Moreover, they convinced engineers and entrepreneurs from Kista–based firms to make regular visits to secondary schools in the Järva area and to organize site visits. Also worth mentioning here is the Digital Art Centre, an interactive space for exhibitions, meetings, and workspaces in which artists, researchers, and firms from both Kista and elsewhere can showcase their work. In this way, the technology and research results developed at Kista can be made visible to a wider audience in an accessible and inspiring way.

6.5 Place branding

An aspect closely related to the attractiveness of an urban innovation system (e.g. for talents and firms) is its perception in the eyes of relevant target groups. An attractive system, whether its attractiveness stems from its employment and business opportunities or quality of the environment and amenities, only draws workers, entrepreneurs, and firms if its brand name or reputation reflects these attractive characteristics. In all three cases, the brand of the innovation system was found to be very important. These brands are not logos or symbols; they are the accumulated reputation ('having a good name') of the system. The brand is a marker for quality, reducing risk for investors and helping build trust.

Development factors

Our case studies show that the good name or reputation of an urban innovation system exists as a network of associations in the minds of relevant stakeholders. These associations could be leading firms (Ericsson, Philips), cutting-edge start-ups, high-quality universities (such as KTH – the Royal Institute of Technology), and other research institutes (such as the Philips Natlab), innovations, famous people, landmark buildings, previous experiences (SIP's historical relation with Singapore), and other special characteristics of the area (such as the classical gardens and the historical town of Suzhou). Building a brand for an innovation system involves increasing the number of positive and fitting associations in the minds of the relevant audiences. These associations cannot be artificial or superficial but need to be based on real developments. Next, these developments have to be communicated systematically to the relevant target audiences.

It is important to acknowledge the path dependency of place brands and that change is incremental. One of the lessons from the case studies is that the brand of an innovation system is to some extent path dependent. In the two European cases, it started with the relocation and growth of a major corporation (Philips in Eindhoven) and the location of two subsidiary companies of a major corporation (Ericsson in Kista). In the Chinese example, the brand started to evolve with the agreement between Singapore and China to create an industrial park according to the 'Singapore approach'. The precise loading of these brands has evolved over time. The path dependency does not imply that you cannot influence building the brand of an innovation system. However, it does set the margins for changing the brand, and the cases show that most changes are incremental. Only in case of big shocks to the system – such as the crisis in Kista around the start of the new millennium, the economic difficulties in Eindhoven in the late 1980s and early 1990s, and the decision of Singapore to reduce its share in SIP – can change be more drastic. As said before, though, it is crucial to acknowledge that most changes in terms of building up a strong brand are incremental.

Policy approaches

Transforming a business location brand into a city (sub)brand. An interesting policy approach is the ambition to develop the brand of a business location into a city (sub)brand in the case of Kista and Suzhou. For Kista, it has even been suggested to use Kista as the name for a much larger area (including a large part of the Järva area), but this was politically not feasible. However, the planners would still like to see spillover effects of the strong Kista brand to the surrounding areas. For Kista itself, the ambition is to be no longer seen as a science park but as a science city. Some of the plans and ambitions have already been discussed elsewhere in this chapter. This involves a major change in the brand of Kista. The Kista brand scores high on its business and technological reputation, but it is not perceived as a very attractive place to live. Kista needs to change physically to be able to make this shift in the hearts and minds of relevant audiences. This process could be helped by eye-catching projects, with the NOD as the chief accelerator of this brand change.

In the Suzhou case, SIP has been branded as a full-fledged city (which fits the reality), not as an industrial park. However, the chosen brand name Suzhou Industrial Park (SIP) creates confusion among target audiences, as it is clearly not an industrial park. Several discussion partners have suggested changing the name to Suzhou Innovation Park or Paradise. You could say that from the very beginning, the founders of SIP (Singapore and China) used a brand name people would normally associate with a business park. This is a strategic mistake that does not help the development of Suzhou's brand at all. In Eindhoven, the situation is different. Eindhoven's innovation system is not bound to one location but can be found on several locations in the city. There are important locations such as the High-Tech Campus, but the brand is Eindhoven itself. In 2010, the city of Eindhoven decided to create a stronger focus in the city marketing and branding strategy and to develop the Eindhoven brand around technology, design, and knowledge. The reputation of Eindhoven in several high-tech sectors led to its election as the world's Intelligent Community of the Year in 2011.

Developing a compelling story. It is also evident from the cases of Eindhoven and Kista that building a brand is fundamentally developing a compelling story that grasps the essence of the innovation system and that can be told over and over again with small variations. More importantly, this story has to be credible and compelling, and local stakeholders need to be able to identify with that story and have experiences that fit with the story. For example, the story of the crisis of Philips and DAF in the Eindhoven region and the joint response to become stronger in response to this crisis is an 'evergreen' that still can be heard from many stakeholders. Additionally, many stakeholders will point to the widespread and effective local networks where stakeholders meet and get to know each other, leading to new innovations. Several studies have shown that this is really a strength, but it is also an achievement that so many stakeholders tell this story as well. In Eindhoven's innovation system, many stakeholders are 'singing from the same hymn sheet'. In the case of Kista, one can identify a similar pattern in which many stakeholders share the same ideas of Kista as an urban innovation system, and a growing number of stakeholders are also adopting the story of the needed transformation from a science park to a science city. In Suzhou, we see some attempts to 'rebrand' Suzhou Industrial Park as a hot spot for innovation and R&D, replacing the old image dominated by (low-cost) manufacturing industries. The SIP

Administrative Committee (SIPAC) is leading this process, but other stakeholders also tell the same story, promoting SIP also as an attractive place to live with better environmental conditions and lower costs of living than in nearby Shanghai.

In the Dutch and Swedish cases, there are organizations – Brainport and its predecessors in Eindhoven and the Electrum Foundation and Kista Science City in Stockholm – that aim to strengthen the innovation system and at the same time safeguard and develop the brand. In both cases, these dedicated organizations have played a major role in developing the stories of Eindhoven and Kista. The branding strategies of these organizations do not rely on large advertisement campaigns or other traditional ways of brand communication in the mass media. These organizations lack the budgets to deploy such instruments and, more importantly, it is considered to be ineffective for their objectives. The storytelling about Eindhoven or Kista should primarily be done by third parties. These could be local ambassadors (for instance, successful entrepreneurs and universities) but also by giving information and feeding the story to professional media and letting them tell the story as well. In Suzhou, the SIP Administrative Committee is the leading organization responsible for the brand. They started with a more traditional branding strategy by giving seminars and presentations, as awareness of SIP (which started from scratch rather than around a leader firm like Philips or Ericsson) was low at first. As brand awareness increased, the focus of the branding strategy shifted to promoting the 'park-in-a-park' clusters (Biobay, Nanopolis, etc.), specifically to firms in their target industry sectors, setting up these sub-clusters as brand names in their own right. Also, most promotion now occurs through current tenants: if they know a supplier or peer company that is interested in relocating to SIP, a promotion team is sent to target this specific firm.

6.6 Entrepreneurship

Another key building block of urban innovation systems is entrepreneurship. High rates of new firm creation coupled with a supportive environment for start-up firms allows the system to continually renew itself. Entrepreneurs identify and exploit valuable knowledge created at universities and research institutes and lead the regional economy into new industry sectors, preventing the region from becoming dependent on stagnating sectors. However, in each of the three cases studied, start-up entrepreneurship was a relatively problematic aspect of the innovation system's development, and regional actors are still experimenting with policy interventions to strengthen it.

Development factors

The major problem, experienced in all three cases, was a lack of a well-developed venture capital community. Private angel investors are lacking in all regions, and government agencies fill this gap by providing small seed investments to promising start-ups. But after the seed phase, most start-ups require a much larger second round of VC before they are mature and stable enough to attract investments from regular investors, and in this second stage, VC is too scarce in all regions studied. This problem by itself keeps start-up rates below their potential level in the three regions and pushes some entrepreneurs to leave the region and look for one where VC is more readily available.

Despite the shortage of venture capital, the Eindhoven region has produced a limited number of highly successfully start-up firms. The most important of these are spin-offs from existing firms, mostly notably Philips, which supports spin-off formation as part of its 'open innovation' strategy. A special feature of the Eindhoven region is the high level of trust that exists among firms and other local actors, resulting in a supportive environment for start-up firms. Employees of firms and research institutes are supported to start their own firms and are welcomed into the region's supply chains. But the rate of new firm creation is not as high as may be expected of a leading innovation system, and there is an unhealthy dependence on the region's leader firms, as there are few other sources of start-ups that grow into mature firms. Kista is another example of a successful innovation system that depends on large established firms rather than a vibrant start-up community. Compared to Eindhoven, major Kista–based firms are less open to spin-off activities of their employees, and even within the firms themselves, engineers have often struggled with a conservative management board to get innovative ideas implemented. Finally, SIP has only recently begun the transformation from a manufacturing park to a science and innovation hub and is still building up the knowledge base and infrastructure needed for generating and nurturing start-up firms. It has the ambition to become a source of indigenous start-up entrepreneurs, but so far it still depends on attracting entrepreneurs from elsewhere to build up and diversify its innovation system.

Policy approaches

Venture capital. Many different policy interventions have been developed in Eindhoven, Stockholm-Kista, and Suzhou to support entrepreneurship, and from these three types of intervention can be distinguished. First, the three regions have developed ways to tackle the main problem of a lack of (second-round) venture capital. In contrast to small seed investments, second-round investments require very large sums (depending on the industry sector, it can be in the order of $1 to $10 million or more), which makes it impossible for most governments to fill the gap single-handedly. Since these investments are still quite risky, private investors are unwilling to supply enough money, but in Suzhou's SIP, an intermediate solution is tried. A state-funded Fund of Funds has been set up that provides VC funds with a base of 30 per cent of their funding, leaving 70 per cent of the funding to be supplied by private investors. In case of losses on the VC investments made by these funds, the government takes the first hit, so only major losses will filter down to private investors. In this way, funds have been created that are large enough to supply investments beyond the initial seed funding stage. However, this approach still requires very large public investments that not every state can afford.

In Eindhoven and Kista, a different approach is taken that focuses on the mobilization of networks of private VC investors. In regions such as Silicon Valley, networks of private angel investors are able to raise large sums of money, because they share the investment risk and because the investors themselves are intimately familiar with the technology they invest in (since many of them made their fortunes as start-up entrepreneurs themselves). Attempts are made in Eindhoven and Kista to bring angel investors into contact with each other and with the start-up community that needs their investments, hoping that a vibrant VC community will emerge. However, one can question whether a ‘Silicon Valley mindset’ of high-profile, risk-taking investors who take pride in enabling successful IPOs can be engineered in this way.

Incubators and creative hot spots. The second type of policy intervention is the creation of start-up incubators. In addition to providing VC investment, a broad range of other services can be supplied to entrepreneurs, including coaching by experienced entrepreneurs, (subsidized) business space, and access to expensive facilities such as cleanrooms and training courses on, for example, pitching a business plan to potential investors. These services are relatively inexpensive compared to the cost of seed investments and can increase the returns on these investments by allowing start-ups to avoid common mistakes. The STING start-up incubator is a good example of such an integrated approach of stimulating entrepreneurship, making a strict pre-selection of candidate start-ups and then providing these high-potential start-ups with relatively generous support. In SIP, start-up incubation is taken a step further by not only providing a broad range of services to start-ups but also by creating specialized innovation hot spots that are intended to create the ideal environment for start-up firms to succeed. For example, biotech firms are incubated in the Biobay cluster, in which they are surrounded by biotech firms, academic research and education institutes specialized in biotech, and, of course, other biotech start-ups. Similar tailor-made clusters are under development for the nanotech, ICT, and business services sectors. Great care is taken to make these clusters highly attractive environments for working, living, and studying, and every cluster has its own organizations to organize meetings and stimulate the formation of social networks among the cluster’s tenants.

A somewhat comparable approach is taken in the Strijp S project in Eindhoven, in which entrepreneurs in the design sector are offered an affordable and attractive working and living environment, which also includes museums, galleries, and a design academy. However, while such initiatives can be helpful for nurturing entrepreneurial talent, they only provide the hardware and cannot substitute for inadequate software (talents and mindset) and orgware (networks and regulations). Especially in SIP, heavy investments are made in creating these innovation hot spots because they are intended to attract entrepreneurial engineers from outside of the park, as the park lacks a well-established academic infrastructure. So far they have been successful in attracting returning overseas Chinese (many of whom were planning to return to China anyway), but it is questionable whether the approach also works for attracting entrepreneurs from other countries.

Educating entrepreneurial engineers. A more sustainable approach than depending on attracting talents from outside the region is to educate them within the region itself. This is related to the skills imparted to students but also to the fostering of informal habits and rules that favour entrepreneurship. In Eindhoven and Kista, local universities are developing courses to train entrepreneurial engineers with the skills needed to create high-tech start-ups. In most regions (with only rare exceptions such as Silicon Valley), there is a disconnection between engineers and entrepreneurs. Engineers are trained as specialists with advanced technical skills but without the skills and mindset needed for entrepreneurship. On the other hand, young entrepreneurs tend to originate in business schools and lack the technical skills for identifying valuable technical knowledge and applying it in innovative products. To address this, at the Technical University of Eindhoven (TU/E) entrepreneurship courses have been made mandatory for engineering majors.

At Kista, an even more radical approach is tried out in the form of the Stockholm Science and Innovation School, a high school that cooperates closely with Kista-based high-tech firms to instil an interest in technology and even offers international traineeships through the network of MNCs like Ericsson. Such interventions can create the software needed for a vibrant start-up community, but their success depends on the willingness of local firms to take part. Moreover, organizational changes are needed before the gap between engineers and entrepreneurship can be closed. Academic researchers should be free to try out entrepreneurship without losing their (cosy) tenureship, and it should be easier for knowledge workers to cross over from private to academic positions and back. This is especially a problem in Kista and, to a lesser extent, at Eindhoven. At SIP, by contrast, it is much easier to combine an academic position with start-up entrepreneurship, but there it is not the result of a healthy orgware but rather a lack of regulation. This results in university professors investing public funds in their private enterprises and unclear IPR ownership situations. Clear but flexible regulations are needed to facilitate the entrepreneurial engineer.

6.7 Institutional environment

Another important factor in the development of urban innovation systems is the institutional environment of an urban innovation system. The frame of analysis made a distinction between formal and informal institutions.

Formal institutions refer to the governance structures that create constraints and opportunities for the behaviour of actors involved in the urban innovation system. This includes the organization, management, and financing of policy interventions to strengthen the urban innovation system. It comprehends formal rules and the top-down political-administrative framework (the division of tasks and responsibilities among various levels of government, e.g. regarding urban planning) but also the bottom-up development of public–private partnership.

Besides formal institutions, there are also informal institutions that guide the behaviour of the actors of an urban innovation system. As discussed in Chapter 2, urban innovation systems are assumed to have some level of connectedness and cohesion, which gives rise to unwritten habits and assumptions that are to some extent shared by its constituents. For example, much attention is paid in the literature to the role of informal institutions in encouraging or discouraging entrepreneurship (also see section 6.6). The current section focuses on the extent to which urban innovation systems function as communities and on the particular informal rules that are shared within these communities. Also, it asks to what extent a sense of community can be fostered in an urban innovation system.

Development factors

In all three case studies, aspects of the institutional environment have been identified as important strengths explaining the current innovation performance. Often these factors relate to unique contextual circumstances that are strongly rooted in the history and culture of the region or the country: examples are the shared Brabant and Philips mentality in Eindhoven and the openness of the Swedish society to innovation and the entrance of foreign companies. It will be difficult to create similar circumstances in another region, although the case of SIP demonstrates that it is not impossible. In Suzhou, the city developers managed to create a legal, administrative, and political micro-environment that is substantially different from the macro-institutional conditions in China. Suzhou is the first successful example of cooperation between Singapore and China, with the development of a Singapore-style science park (mini-Singapore) on the Chinese mainland as result. Several other regions in China copied this model, again with support of the two nations. The conclusion is that governance models (in particular formal institutions, but also to some extent including informal institutions) can be transferred. In China, employees of SIPAC give on-the-job trainings for other science park managers, just like Singapore did for SIP. However, doubts about the effectiveness of IPR protection in China still forms a limitation to the extent of R&D activities developed there, especially by foreign companies and entrepreneurs. Several policy approaches have been developed in the three case regions to strengthen their formal institutional framework.

When it comes to informal institutions and the role of communities in urban innovation systems, two main types of communities can be discerned in the three case studies: urban communities (residents of an urban area that share a certain identity and form all sorts of social networks) and innovation communities (networks of people and firms that share or use each other's knowledge and competences to create innovations, i.e. a more functional type of network). In an urban innovation system, the two types may partly overlap. Urban communities are place bound by definition, whereas innovation communities have no strict geographical boundaries. In our study, we focused on innovation communities, with special attention for their local components.

The development of communities – characterised by strong networks, social capital, and high levels of trust – is to some extent a matter of history and regional culture. In Eindhoven and Kista, for example, two major firms – Philips and

Ericsson – played a key role in the development of communities: many talents in the region used to work at one of these firms or their parents did. This shared background has created a high level of trust and hence facilitates interaction between actors. In other words, the gradual development of communities in Eindhoven and Kista lead to the emergence of shared informal institutions that now support their innovation systems. This is all very informative, but maybe not so helpful for regions that want to develop their system from scratch. How can they create places in which researchers, engineers, entrepreneurs, and venture capitalists meet each other on a regular basis? Is it possible to develop urban areas where residents have a strong sense of community? What interventions can stimulate planned and unplanned meetings? The three case studies provide some answers to these questions.

Policy approaches

Governance style. Several policy measures were found that relate to the formal institutions of urban innovation systems. First, a good style of local governance can stimulate the development of innovation systems in many ways. It is difficult, however, to formulate general requirements for good local governance. The case studies show that the preferred role of the government – what tasks to assume and how to implement these tasks – depends on the wider context in which the innovation system develops – for example, where it is located in an advanced industrial country or a transition country. In SIP, the Administrative Committee assists firms with patent registrations, legal and financial issues (including VC), and trade licenses, which is seen as an important selling point. In Eindhoven and Kista, this has appeared less relevant. Another example: the SIP government works with a master plan – promoting strict zoning and planning stability – that would be somewhat out-dated in the European context of Eindhoven and Kista.

Developing partnerships. Another way to strengthen the formal institutional environment works through the development of public–private partnerships. One of the challenges is how to involve leader firms and leading knowledge institutes in the management of innovation systems, using their knowledge and expertise but also their 'global linkages'. If we compare the three case studies, we must conclude that the two European regions have been more successful in this respect. Both the Brainport region and Kista Science City are managed by economic development organizations and foundations with representatives of the Triple Helix. Projects that aim to improve the innovation performance and the attractiveness of the system are initiated and managed not only by the government but by non-governmental actors as well. Apparently both regions have an environment in which governments allow other actors to take the lead and in which these other actors are willing to look beyond their short-term private interests. Samsung's leading role in the SIP Institute of Vocational Technology (SIPIVT) might be seen as a first step towards more private-sector involvement in Suzhou Industrial Park.

Planning for interaction. Moving on to policy measures related to the informal institutional environment, one strategy to stimulate community development is planning for interaction: stimulating spontaneous meetings between people through the design of buildings and zoning of areas. In Kista, it was attempted to enforce interaction through the design and location of the iconic Electrum Building, built in the 1980s. It has a strategic location between the university campuses on one side and business premises on the other side, with the main entrance on the central axis through Kista. The ground floor was planned to function as an indoor street, with restaurants and shops, while the other floors accommodate academic institutes, firms, and R&D labs. They all have their entrances – linked by elevated walkways – towards the open gallery. Facilities are concentrated in specific rooms, thus inviting users to cross through the gallery frequently. Most walls are made of glass, again to stimulate interaction.

But did it work? Not really. On most days, visitor traffic on the ground floor is too limited, except during events and exhibitions. Not that many shops and restaurants have opened their doors due to high rental prices and insufficient customers. One explanation for the disappointing visitor flow is the invisibility of the open gallery from the street. Furthermore, there are doubts if the regular flow of workers through the building has actually resulted in unplanned meetings, since there are few places that invite them to stop and stand or sit down.

Similar examples can be found in the case of Eindhoven. In Strijp S, all main buildings have large public cafes on the ground floor, enabling residents and workers to lounge and meet each other. At High-Tech Campus, people are more or less obliged to have lunch in one of the centrally located facilities of the Strip, as other private canteens have been banned by the campus management. This physical layout surely encourages human interaction, but if it also succeeds in stimulating the exchange of ideas and collaboration is hard to prove. Maybe it does, but only in combination with other interventions to be discussed below.

Organizing meetings and events. A second strategy to stimulate community development is organizing meetings and events, thus facilitating encounters between people with the same backgrounds, similar interests, and/or complementary competences. Clearly these interventions recognize the relevance of social, institutional, and cognitive proximity in community building.

In Suzhou Industrial Park, interaction between actors in the same industry sector (cognitive proximity) is not only stimulated by trying to concentrate them in the same area (e.g. Biobay and Nanopolis; geographical proximity) but also by organizing cluster meetings on a regular basis, leading to social proximity. Interestingly, we see that top-down policies are combined here with bottom-up initiatives undertaken especially by one group of foreign knowledge workers, namely returnees with Chinese roots (cultural proximity). These returned Chinese researchers and entrepreneurs have organized themselves in clubs that provide assistance with financial and legal issues, thus also functioning as meeting places. One of the returnees we interviewed even bought a restaurant together with other returnees working at SIP as a meeting place for their community. Hence, in SIP's 'park-in-a-park' clusters, many dimensions of proximity are combined, creating the opportunity for strong communities based on mutual trust to emerge.

The High-Tech Campus (HTC) and Strijp S stimulate interaction not only by design but also through the organization of meetings. When a famous scholar or entrepreneur visits one of the firms located at HTC, the campus management organizes a meet-and-greet session. The developer of Strijp S organizes networking events for residents.

6.8 Towards a new planning orthodoxy?

In each of the cases we studied, we found that policy makers are convinced that the 'ivory tower model' of innovation is not appropriate anymore. In this model – based on a linear view of innovation and with the traditional science park as archetypical expression – innovation hot spots were developed as stand-alone, mono-functional places, somewhat isolated from the urban fabric, where scientists and scientific entrepreneurs could elaborate their ideas and turn scientific discoveries into new products. This suburban or even 'anti-urban' model is being challenged under influence of a number of new insights and fundamental changes: the rise of open and networked innovation practices where companies innovate together and work in all sorts of alliances; the blurring of boundaries between disciplines and emerging interplays between technology, design, finance, and behavioural sciences in the development of new products and services; new insights into the nature of innovation processes and human behaviour; changing preferences of skilled people concerning their working environment – they increasingly prefer an identity- and amenity-rich 'social' place; changing balances between work and social life; and a shift from hierarchical structures to networked and project-oriented ways of working (a 'project economy').

In the new planning orthodoxy, the science park model, is replaced it by a more urban innovation concept: vibrancy and compactness as central notions, with liveliness and diversity in a densely built environment, a mix of old and new, with amenities such as restaurants, hotels, all sorts of leisure and consumption opportunities, cultural facilities, and so forth. These sorts of areas generate a dynamic identity and give rise to unexpected encounters and plenty of networking and are believed to be hotbeds for innovation and attractors of talented people. Innovation is not planned or managed; it 'emerges' in this dynamic urban cocktail. Proponents of this new model call for mixing functions and open architectures, with many meeting places and central points. They advocate self-governance: instead of rigid zoning or planning, give people and firms room to shape their own innovative environments that fit their needs best.

In the case of Stockholm, the Kista area (being a stand-alone mono-functional IT hot spot) is no longer the only eye of the storm: it is being challenged by a fast-growing cluster of new media companies (apps, social media, gaming) in the most dynamic parts of the city centre. In all our case studies, we see that developers face tensions between planning and spontaneous development, between functionality and serendipity, between uniformity and diversity, between creating a new city and defining the hot spot as part of a larger metropolitan area. Also, we have indications that different types of innovation might prosper in different types of environments. Finally, there is a cultural component. The European love for micro-mixed areas is not equally shared in Asia and parts of the US.

Redesigning mono-functional hot spots. All over Europe, and also in Stockholm and Eindhoven, older, mono-functional hot spots and campuses are being redesigned or 'retrofitted' to include more diversity. New functions are added, such as residential zones, amenities, cultural facilities, and education; there is an attempt to generate 'buzz' by attracting visitors from outside the area through events, cultural amenities, or by adding consumption functions like shopping malls or cinemas. The question is if new inhabitants and visitors will ever generate sufficient buzz to make these places somewhat comparable to lively inner cities.

Kista is a good example where all of this happens. This area has developed since the 1970s as a prime IT hot spot (mainly focused on telecom network technology), with Ericsson as leader firm. It is a work-only area, and the employees commute from other areas in the Stockholm region. After office hours, the area is dead, except for the shopping mall that is built on top of the metro/train station. In the last decade, the need was felt to make the area more urban. Although Kista is functioning well (its companies are flourishing, many new ones came in), key decision makers in the area believe that leaving the area unchanged would undermine Kista's long-term innovative identity and make it increasingly difficult for companies in Kista to attract skilled staff.

Therefore they started a massive 'urbanization offensive'. Over the last years, the main street was redesigned and now has shops, coffee houses, restaurants, and the like. The Kista Tower (a recent high-rise) also has a lot of amenities on its first floors and attracts many people at lunchtime. A shopping mall connects Kista to the surrounding residential areas, but these are mainly inhabited by poor inhabitants (many of them immigrants) and do not provide the urban character that appeals to Kista's employees. Recently, new plans were drawn up to further urbanize the area: there are plans to build a high-quality residential quarter, to open a secondary school – with a technology profile – and also to build the NOD, an open building that should function as exhibition space, as a centre where technology meets culture and arts, and as a place for start-ups. It will occupy a central place in Kista and should attract visitors from outside into the area. If this will actually happen remains to be seen.

Developing urban innovation hot spots from scratch. Based on the same philosophy, newly planned hot spots are being developed as urban, mixed, and diverse places from scratch; the new Strijp S area in Eindhoven is being developed in this vein. It should become a vibrant and mixed creative quarter of Eindhoven. Old Philips buildings are refurbished and turned into apartments and offices. Several urban amenities, like restaurants, bars, and indoor sport facilities (including a skateboard park), should make the area attractive for young, dynamic 'creatives'. Design-related events are organised to attract people from outside and to shape the identity of the area as a design district.

Developing mono-functional areas with good and quick access to city amenities. A recurrent question is how 'urban' a knowledge hot spot really has to be, especially when it is located very near a larger city or city centre. In Eindhoven, the High-Tech Campus has some features of an old-school science park: it is mono-functional, and after office hours, the place is empty. Nevertheless, it is very popular, and firms are ready to pay premium rents to locate there. They benefit from the facilities, the networking opportunities with neighbours (there is tenant selection), and the brand name of the area. The city centre, with all its amenities, is very near (about 10 minutes' drive), and there is sufficient high-quality housing available for the many (international) knowledge workers. This case suggests that well-functioning mono-functional areas can thrive as long as they have a clear brand identity, they are well managed, and there is good and quick access to city amenities. The same story goes for SIP, although this area is much larger; actually, SIP is a city in its own right, but one with a rather strict zoning plan. There is diversity, but on a rather high-scale level. University and office campuses are not 'micro-mixed' with housing and amenities but are located in their own dedicated zones; there are separate residential quarters. SIP has some central 'CBD-like' districts offering all the needed amenities – shopping malls, restaurants, cinemas, sports facilities, etc.). Some outstanding facilities even attract many visitors from outside.

Mixing technology with art and design. Another debate is whether diversity is helpful or even necessary to promote innovative behaviour. The new orthodoxy claims it is, that innovations would emerge from mixing technology with art and design and from blending different types of people in multidisciplinary teams (with Apple as the mother of all examples). Spatial mono-cultures simply would not cater for that. In our study, however, we found two highly successful areas (Kista and High-Tech Campus, Eindhoven) with few urban characteristics, focusing on a well-defined 'hard' technology core. In Suzhou, which used to be a place for 'hard' technological innovation, policy makers try to infuse the area with creative inputs from artists, designers, and more creative industries. The Creative Industry Park with the Idea Pumping Station start-up incubator, aimed at, among others, animation and game design, is the main example of such policies. While the Idea Pumping Station is also open to artists, so far none have settled there. Moreover, SIP has invested heavily in its state-of-the-art Suzhou Culture and Arts Center with a broad offering of classical (Western and Chinese) and modern performances but also a public library focused on art and culture and an art training centre that draws visitors from all over Suzhou. So far, there are no measurable indicators that this approach has led to results; also, none of the companies we interviewed mentioned it as very relevant for their business processes.

6.9 Recommendations

The three case studies provide valuable lessons for initiatives to develop urban innovation systems. We have shown that the development of an innovation system is a very complex and essentially long-term process. Developers need to be aware that each system finds itself in a unique contextual setting, requiring specific approaches in different stages of development. We conclude this book with 10 recommendations for actors involved in the (planned) development of an urban innovation system.

1. Be realistic about the influence of planners on innovation

Urban planning for innovation is problematic in its own right. Most successful knowledge hot spots were never planned as such. They emerged out of a diverse and thrilling urban environment. This is especially true for the current wave of innovations in new media, which are socio-cultural inspired rather than technological only.

2. Try to find a balance between openness and protection

The dominant discourse about open innovation hides an important reality: the struggle of innovators to find a balance between openness and protection, between sharing and hiding, between giving and taking. Innovation planners are wise to take this into account when planning knowledge hot spots.

3. Try to find a balance between specialization and diversity

Specialization of a hot spot (e.g. through strict tenant selection) will give it a distinct identity and perhaps increase the chance of meaningful interactions between tenants (as they are in similar fields). But it reduces the scope for unexpected, out-of-the-box combinations. A somewhat more diverse profile could facilitate such combinations.

4. Stimulate the development of conceptual innovations

An innovation hot spot will fail as innovation catalyst when stakeholders/tenants merely see it as a new premise to continue their business as usual. The challenge is to use the development to achieve conceptual innovations.

5. Be aware of the trade-off between short-term profits and long-term concept value

Building a thriving knowledge location takes time, and this could mean that short-term profits must be forgone to protect the concept. Can a developer refuse a large but unrelated tenant to rent a large premise and dominate the place? This can be a painstaking dilemma, especially in difficult market circumstances or when the concept has not yet clearly proven itself.

6. Pay more attention to software and orgware

Physical interventions (planning for interaction and serendipity) are insufficient to promote innovation. Software and orgware elements are needed as well: networking institutions, events, community-building efforts.

7. Attract knowledge from other regions

Generating and incubating innovative start-ups is one of the hardest steps in building an innovation system. Even some of the world's most successful innovation systems struggle to educate entrepreneurial engineers, and VC funding tends to be inadequate. Attracting entrepreneurial knowledge workers from abroad can be a viable strategy for kick-starting entrepreneurship, and the case of SIP suggests that it's also possible to learn VC funding from experienced (foreign) partners.

8. Improve the entire VC chain instead of focussing on the seed funding stage only

Making VC funding a strength rather than a weakness for an innovation system requires getting the entire chain right, from early-stage angel and seed funding to second-stage funding for maturing start-ups and to later-stage funding of expanding young firms. If one stage in the chain is weak, as is nearly always the case, the potential for entrepreneurship is seriously weakened. Policy initiatives tend to focus on the seed funding stage, but this is not enough. Public–private cooperation (e.g. CSVC in SIP) and building a strong local VC community is needed to make second stage and later-stage VC funding work.

9. Target the right audiences in your branding strategy

The urban innovation system should develop a strong brand ('have a good name') among knowledge workers, venture capitalists, researchers, and corporate leaders, while the perceptions amongst the general public, policy makers, and real estate developers are far less important.

10. Develop a compelling and credible story

Building a strong brand of an innovation system implies developing a compelling and credible story that grasps the essence of the system and that can be told over and over again with small variations by local stakeholders and the media to stimulate positive word of mouth.

Note

1 Note that research and education are deeply linked: research is an important driver of education and PhD education is fully intertwined with research.

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