CHINA'S ECONOMIC GROWTH

A miracle with Chinese characteristics

Yanrui Wu

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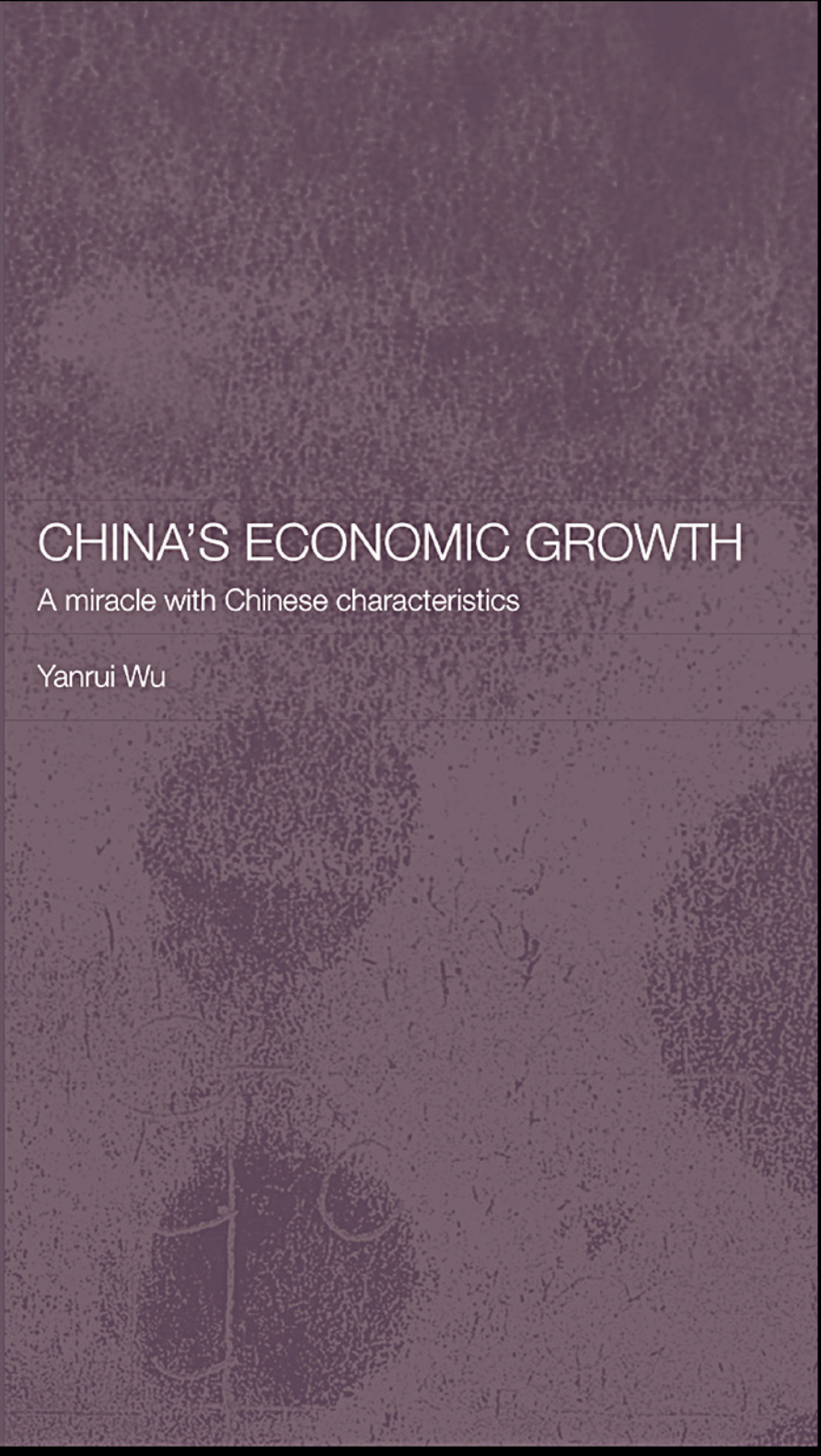

China's Economic Growth

The current growth of the Chinese economy is of immense importance for the global economy. This book outlines the main characteristics of Chinese economic growth over the last two decades, and investigates in detail the key determinants of growth, especially capital formation and productivity issues. It goes on to examine the important related questions of regional disparity and convergence, and economic integration, exploring in detail how far economic integration has taken place in south China, including the economies of Hong Kong and Taiwan, and how far this integration has been a determinant of economic growth. The book also presents two case studies of the impact of deregulation on growth at the industry level and concludes with a consideration of the prospects for continuing growth in the twenty-first century.

Yanrui Wu is an economist specialising in development economics and applied econometrics. His research interests are the Chinese and Asian economies, economic growth and productivity analysis. He is the author of *Productive Performance in Chinese Enterprises*, *China's Consumer Revolution* and *The Macroeconomics of East Asian Growth*.

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In memory of my mother

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Preface

This book aims to examine China's economic growth at the economy level, among the regions and in selected industrial sectors. It is one of the few books that have focused on understanding economic growth in post-reform China. Some of the material covered in this volume has never been published before. China has completed a two-decade reform programme and began a new era of economic development in the twenty-first century. This book is thus timely and it extends the existing literature. The data series generated in this book are themselves important resources (e.g., capital stock and regional price deflators) and can be used by other researchers. This book can be used as a valuable reference by academia, students, business economists and trade advisers. It may also be used as a textbook for units focusing on business and economic issues in China.

Over the lengthy course of preparing this volume, the author benefited from the help of many students, colleagues and friends. In particular, I would like to thank Zongsheng Chen, Kenneth Clements, Nicholas Groenewold, Yongzhi Hou, Shantong Li, Michael McAleer, Paul Miller and Yunbo Zhou. I also thank Kathleen Chindarsi, Jasmine Denhka, Patricia Wang and Gina Yoon for their excellent research assistance over the years. Work on this volume was also supported by a UWA Economics Departmental Teaching and Research Grant, an Australian Research Council small grant and a UWA research grant. Lastly, but not least, I thank my family (Xiumei, Amy and David) for their love, support and understanding.

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1 Growing with Chinese characteristics

An introduction

The dramatic takeoff of the Chinese economy during the last two decades of the twentieth century has had significant impact on mankind in general and the Chinese people in particular. This is because of the fact that one-fifth of the earth's inhabitants live in China and that the majority of them have now climbed out of poverty. For the same reason, understanding China's recent economic success has occupied many authors in the profession. This book contributes to the growing pool of papers in the literature. The objectives of this introductory chapter are twofold: (a) to describe briefly the characteristics of China's growth in the past two decades; and (b) to introduce an outline of the chapters.

1.1 Growth miracle with Chinese characteristics

The People's Republic of China was founded in 1949. Its economic development over the past five decades can be divided into two periods: the post-reform and pre-reform periods. According to Figure 1.1, economic growth was extremely volatile in the pre-reform period (1954–77), with the rate of growth ranging from 21.3 per cent in 1958 to –27.3 per cent in 1961. Many authors have presented detailed studies of the pre-reform period (e.g., Rawski 1979, Dernberger 1980, Chow 1987 and Lin *et al.* 1996). In this volume, the focus is the post-reform period from 1978 onwards. Figure 1.1 clearly shows that China enjoyed sustained growth in the 1980s and 1990s. Though this growth slowed down in late 1990s, it still achieved a rate of 7 per cent in 2001 and is expected to reach 8 per cent in 2002. This growth is predicted to continue in the coming decade (Economic Analytical Unit 2002 and Asian Development Bank 2002).

China's economic growth in recent decades has been driven by several important factors such as the development of the rural non-farming sector, massive inflow of foreign capital, structural transformation, reform-induced efficiency improvement and promotion of trade. There are some special features associated with these factors. The following sections present a brief description of these special features.

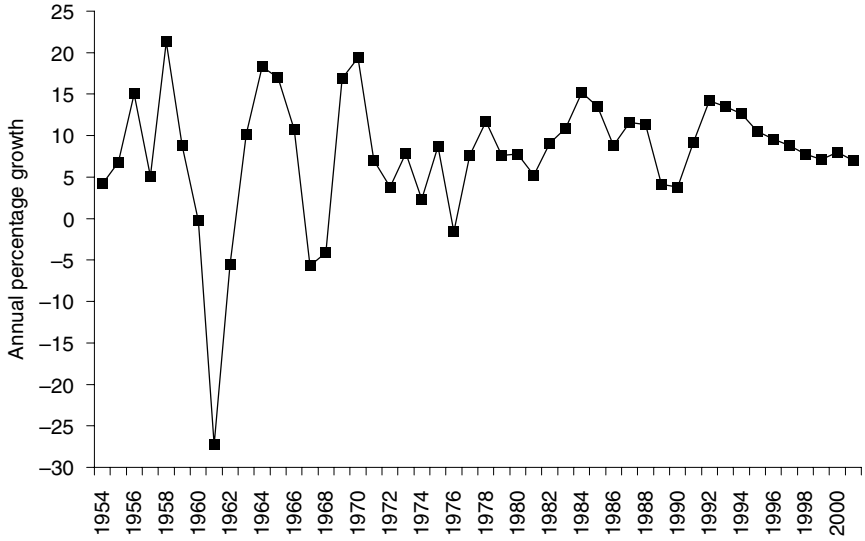

Figure 1.1 The rates of growth of the Chinese economy, 1954–2001

Source: State Statistical Bureau (various issues).

Development of the rural non-farming sector

China's economic reform began in the farming sector in late 1970s. The reform was very successful and has led to dramatic improvement in efficiency (McMillan *et al.* 1989 and Lin 1992). As productivity increased in the farming sector, surplus rural labour emerged rapidly in the early 1980s. In the mean time, rural residents were prohibited from migrating to the cities due to the stringent household registration system. As a result, farmers developed their own industrial sector, that is the so-called rural township, village and private enterprises (TVPs). The growth and development of TVPs in China is distinct in the world and directly the result of rural–urban segmentation under the household registration system.[1] Ironically, the TVP sector was the most dynamic sector and essentially became the main driving force for China's economic growth in the 1980s. The spectacular growth of TVPs is illustrated in Figure 1.2. In terms of employment, the TVP sector overtook the state sector in 1990. In 2001, its size was more than twice as great as the state sector. Though individual TVPs vary in scale, some of them have become multinational companies such as Haier, a white goods producer based in Shangdong.

Massive inflow of foreign capital

Among the developing nations, China has for years been the most popular destination for foreign direct investment. In 2002 China for the first time

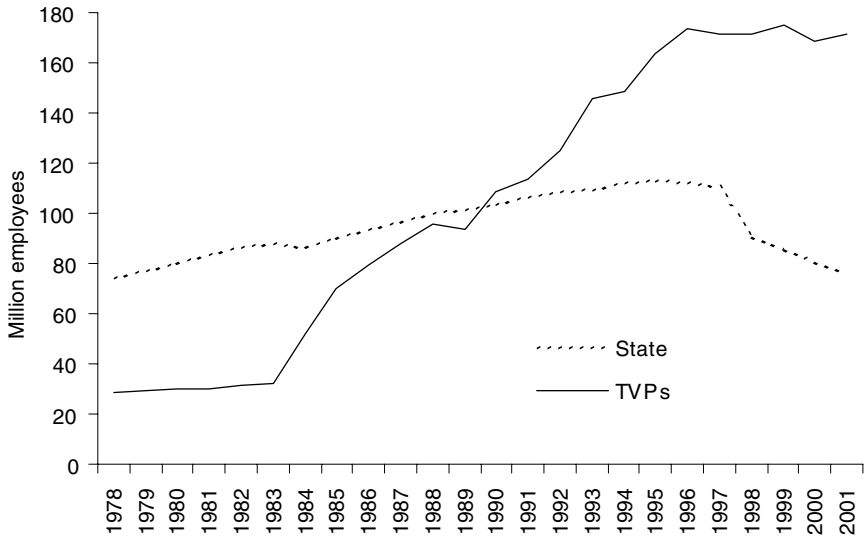

Figure 1.2 Employment in Chinese State and TVP sectors, 1978–2001

Sources: State Statistical Bureau (various issues and 2002).

overtook the United States as the world's largest recipient of foreign capital. China's success in attracting foreign investment has caught the headlines in the press. There is no doubt that foreign investment has played an important role in China's recent growth.[2] After the absence of foreign capital in its economy for decades, China received its first offshore investment in 1979 (see Figure 1.3). Since then, foreign companies have injected more than US$568 billion into the Chinese economy. Foreign capital created millions of jobs and contributed to a substantial proportion of China's exports. The major hosting regions (e.g., Guangdong, Shanghai, Jiangsu, Shandong and Fujian) in China tend to enjoy a high rate of growth. The pattern of foreign capital flow seems to coincide with that of China's high growth in the 1990s according to Figure 1.3.

Structural transformation

Accompanied by economic growth there was rapid structural transformation in the Chinese economy in the past two decades. The trend is very similar to the pattern of changes undertaken by other countries (see Table 1.1). That is, as an economy develops, the primary sector declines and the service sector expands in terms of both employment and income shares. What is special about China is that the employment share of agricultural sector falls relatively slowly. Once again, this situation may be due to China's population policy which for many years restricts rural out-migration.

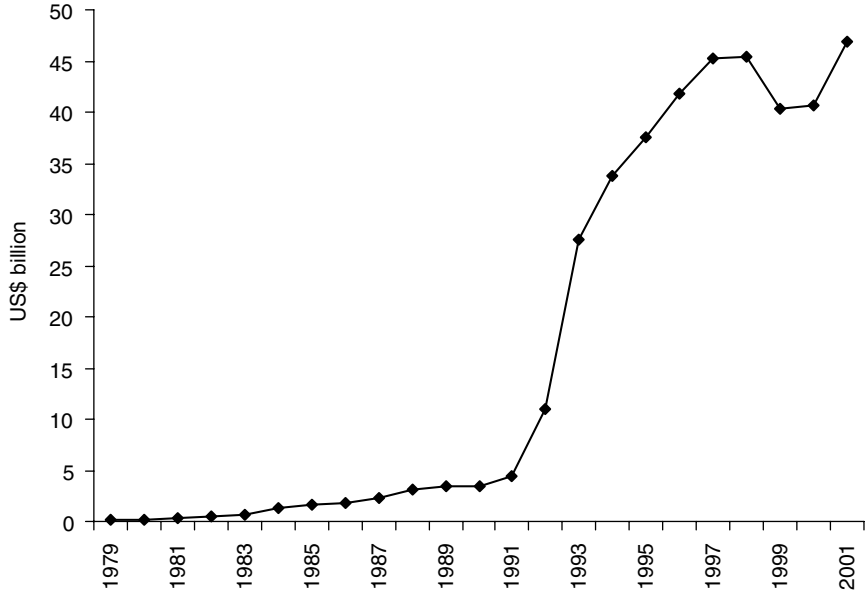

Figure 1.3 Foreign direct investment in China, 1979–2001

Sources: State Statistical Bureau (various issues and 2002).

Table 1.1 Sectoral shares of GDP and employment in China (%)

Year	*GDP*			*Employment*		
	I	*II*	*III*	*I*	*II*	*III*
1980	30.1	48.5	21.4	68.7	18.2	13.1
1990	27.1	41.6	31.3	60.1	21.4	18.5
2000	15.9	50.9	33.2	50.0	22.5	27.5
2001	15.2	51.1	33.6	50.0	22.3	27.7

Source: State Statistical Bureau (2002).

Notes I, II and III represent the primary, secondary and tertiary sectors, respectively.

Reform-induced efficiency improvement

One of the main goals of economic reform in China was to improve efficiency in the economy. Has this goal been achieved?[3] The answer to this question is clearly demonstrated in Figure 1.4. According to this chart, labour productivity has increased rapidly in China in the past two decades, particularly in the 1990s. There is however considerable variation among the three sectors. The secondary sector has been the main driver of productivity growth. The primary sector

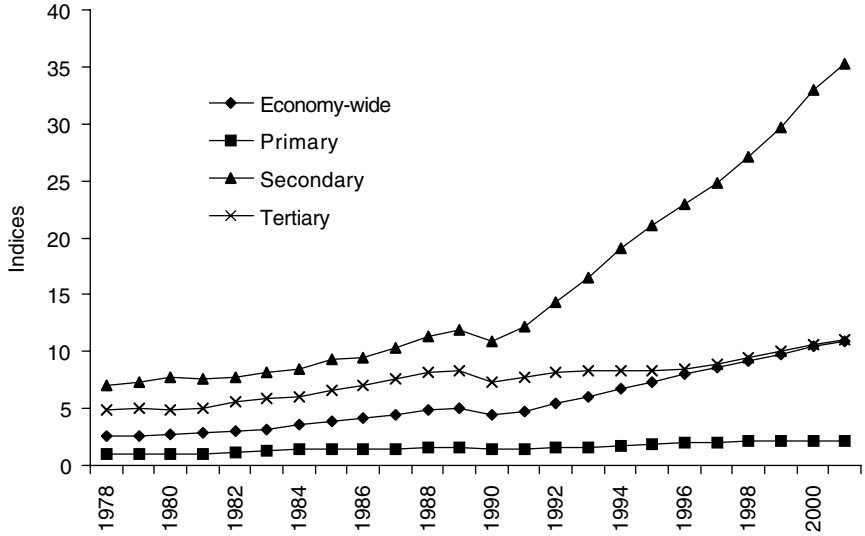

Figure 1.4 Labour productivity indices in the Chinese economy, 1978–2001

Sources: State Statistical Bureau (various issues and 2002).

Note: The indices are relative to labour productivity in the primary sector in 1978 (unity).

experienced only modest growth. The economy-wide trend is a continuing increase in productivity during 1978–2001.

Promotion of trade

China has followed the East Asian model of development by encouraging foreign trade, in particular exports. Trade expanded rapidly in the past two decades, especially in the 1990s (Figure 1.5). Trade not only generated China's much needed foreign exchange but also promoted technology transfer and brought about competition in the former centrally planned system. China's total trade amounted to US$509.8 billion in 2001, being the sixth largest in the world. There is no doubt that trade has played an important role in China's recent growth.[4]

Summary

In summary, China's growth greatly benefited from economic reforms initiated in the late 1970s. One of the key reform initiatives was the open-door policy. Under that policy, China embraced foreign trade and investment. With China becoming an official member of the World Trade Organization (WTO) in November 2001, the Chinese economy will become more liberalised and the Chinese market more accessible in the near future. In the meantime, China will

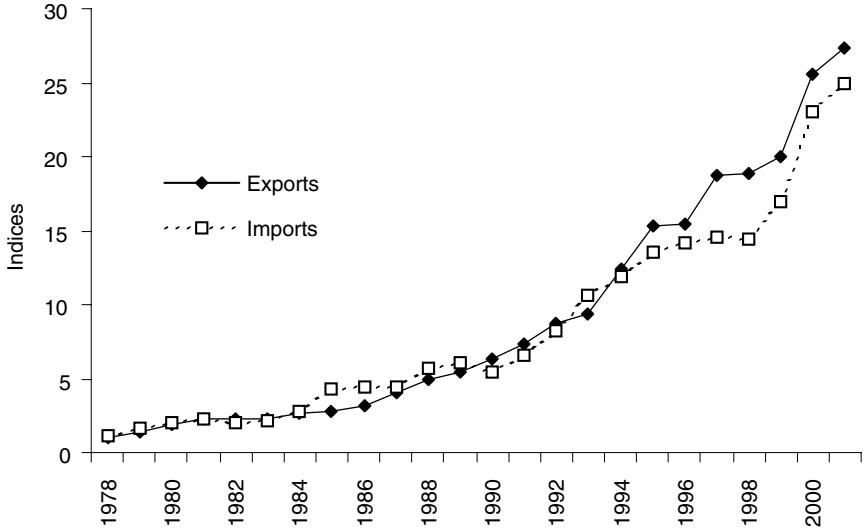

Figure 1.5 Indices of China's exports and imports, 1978–2001

Source: State Statistical Bureau (2002).

Note: The indices are relative the value of exports in 1978 (unity).

attract more foreign investment and Chinese firms will face more competition from foreign counterparts. These changes will affect China's growth in the twenty-first century. This volume contributes to the understanding of China's economic growth and attempts to examine some of the issues associated with growth in the Chinese economy, among its regions and in selected industries. An outline of the chapters is presented in the following section.

1.2 Outline of the chapters

The core body of this book consists of seven chapters (Table 1.2). They are partitioned into three parts. Part I deals with growth at the macro level. It begins with Chapter 2 which presents estimates of capital stock in China and its regions. These data series are used in other chapters and made available for other researchers (see the appendix to this book). Chapter 2 also briefly examines the relationship between capital formation and growth. However, more detailed investigations of the impact of capital formation on economic growth are partially presented in Chapters 3 and 4. The focus of Chapter 3 is the source of economic growth. Some key economic and policy variables are considered in this chapter. They include capital stock, human capital, economic reform, infrastructure, initial conditions, openness, productivity and foreign capital. In this chapter, appropriate indices or measures are developed for each of these variables. A regression approach is applied to assess the impact of these

Table 1.2 Chapter plan

Chapter	*Topic*	*Issues*
2	Capital formation and growth	Estimates of capital stock Methodology Price deflator Capital formation and growth
3	Sources of growth	Determinants of growth Eight factors Sensitivity analysis
4	Role of productivity	Accounting for growth Efficiency changes Technological progress
5	Regional growth	Regional disparity Convergence
6	Integration in South China	Growth in South China Convergence Productivity
7	Industry study: telecoms	Deregulation Growth
8	Industry study: energy sector	Deregulation Growth Energy structural change

variables on economic growth. The final chapter in Part I is Chapter 4 which explores the role of productivity in China's economic growth in the 1980s and 1990s. The approach applied extends the traditional growth accounting technique. According to the extended technique, growth is decomposed into three components associated with factor inputs, efficiency change and technological progress, respectively. Each component is potentially linked with different policy implications.

Part II contains two chapters with a regional focus. Chapter 5 sheds some light on China's regional disparities and convergences which have attracted a lot of attention since the late 1990s. The perception is that economic reform has resulted in worsening regional disparities and hence divergence among the Chinese regions. This chapter contributes to the debate by critically reviewing the existing literature and presenting new estimates of regional disparity and convergence. These estimates are based on the recently released national accounting statistics of China. The second chapter in Part II examines a special case – the Greater or South China region covering Taiwan, Hong Kong, Fujian and Guangdong (Chapter 6). On the one hand, the two mainland provinces have been frontrunners of China's economic reform. On the other hand, Hong Kong and Taiwan are two of the four 'tiger' economies in East Asia. Geographical closeness and shared cultural backgrounds make these four areas an interesting

group. The investigation focuses on integration and convergence among the several economies.

Part III moves away from macro and regional issues to present two case studies at the industry level. Chapter 7 examines deregulation and growth in the telecommunications industry in China. The telecommunications industry has been one of the high growth sectors in the Chinese economy in the 1980s and 1990s. Growth has been driven by deregulation and rapidly increasing demand for services. Telecommunications industry presents a good example of growth through deregulation. The second case study focuses on the energy sector (Chapter 8). The energy sector has been dominated by the state-owned enterprises. It has for a long time been the bottleneck of the Chinese economy. A series of restructurings and reforms have contributed to the rapid expansion of this sector in the 1990s. Chapter 8 looks into each sector of the energy industry (oil, gas, coal and electricity) and attempts to gain some insight into growth prospects for the industry.

Part I

Growth at the macro level

This part contains three chapters (2, 3 and 4). They deal with growth-related topics at the macro and aggregate levels. Chapter 2 lays the foundations for investigations in later chapters by deriving capital stock series for China and its thirty regions over the past decades (1953–2001). These series are themselves important additions to the literature as they are released in this study for the first time. Chapter 2 also briefly examines the relationship between capital formation and economic growth in China in the past two decades (1980–2001). Chapter 3 extends Chapter 2 by exploring the impact of a set of key economic and policy variables on growth. Those variables include human capital, productivity, foreign investment, openness, reform, initial conditions and infrastructure as well as addition to capital stock. This type of work is often applied to cross-country studies. Chapter 3 contributes to the literature by focusing on a single country and hence overcomes some of the problems associated with cross-country studies. Chapter 4 addresses the role of productivity in economic growth, – a topic fiercely debated by economists and policy makers. In particular, the debate has centred on the newly industrialized economies in East Asia, i.e., Hong Kong, Taiwan, Korea and Singapore. Chapter 4 focuses on China and thus enriches the productivity debate.

2 Capital formation and growth

China's continuingly high growth over the past two decades has attracted a lot of attention. In particular, a vast literature has focused on the understanding of that growth.[1] While working on China's economic statistics, researchers have confronted a major problem, i.e., Chinese statistical system does not report data on capital stock. As a result, researchers have often used gross investment figures as a proxy of capital formation in China. This is obviously problematic. Some researchers have also attempted to derive their own data. The methods involved vary considerably. So do the results. The objective of this study is to improve over previous work. Specifically, this chapter employs the recently released official accounting figures to derive capital stock series for China and its thirty regions. A review of the literature is presented in Section 2.1. This is followed by discussion of the methodology in Section 2.2 and new estimates in Section 2.3. The relationship between capital formation and growth in the Chinese economy is examined in Section 2.4. Finally, summary comments are reported in the conclusions.

2.1 Literature review

Chow (1993) represents one of the earlier studies on economic growth in China. His study covered the period of 1952–85. He derived capital stock series for five economic sectors, i.e., agriculture, industry, construction, transportation and commerce. Chow's empirical estimations were based on data of national income, accumulation of fixed assets and circulating funds. He also derived an estimate of capital stock in agriculture by using data of the original value of fixed assets. The problem with the data on 'accumulation' or 'original value' of fixed assets is well known (e.g., Chen *et al.* 1988). Though Chow presented the most comprehensive study of capital formation and its relationship with growth, unfortunately his estimates have attracted few empirical applications in the literature. Li *et al.* (1995) derived capital stock series by using the values of fixed and current assets. Their estimates suffer from the same problem as in Chow (1993). Borensztein and Ostry (1996) and Woo (1998) also applied the same database as used in Li *et al.* (1995). More recent works include Hu and Khan (1997), World Bank (1997) and Maddison (1998). Hu and Khan (1997) derived

their own capital stock series following the conventional perpetual inventory approach. They used Chow's estimates of the initial value of capital stock. World Bank (1997a) used the database derived by Nehru and Dhareshwar (1993). The latter also applied the perpetual inventory method. The initial value of capital stock was derived by assuming that the rates of growth of capital and output are equal if the capital–output ratio is constant in a given period. Maddison (1998) derived gross fixed capital stock by 'cumulating the increments in investment' and assuming that capital had a life span of 25 years.

A common problem associated with these estimates is the derivation of the initial value of capital stock. While Chow (1993) provided detailed information and conducted sensitivity analysis, Li *et al.* (1995) and Maddison (1998) did not elaborate how they estimated the initial value. This chapter presents an alternative approach to avoid the use of the initial value of capital stock.

2.2 Capital stock estimation methods

This section aims to derive new estimates of China's capital stock series. These estimates are based on recently released national account data and on the application of an alternative approach. The general technique of estimating capital stock value in this study belongs to the category of the perpetual inventory approach. The value of capital stock is estimated from gross investment in each year. Symbolically, the estimation technique can be expressed as

$$K_{i,t} = (1 - \delta)K_{i,t-1} + \Delta K_{i,t} \tag{2.1}$$

where $K_{i,t}$ is the real value of capital stock for the i^{th} region or economy in the t^{th} year, $\Delta K_{i,t}$ the real value of incremental capital stock and δ the rate of depreciation. It is clear in Equation (2.1) that the value of capital stock can be computed if the rate of depreciation and the initial value are known. In this study, three approaches in estimating the initial value of capital stock are considered. They are called the integral, initial value and backcasting approaches, respectively.

Integral approach

The core of this technique is that the capital stock in the first period is assumed to be the sum of all past investments. Symbolically,

$$K_{i,1} = \int_{-\infty}^{1} \Delta K_{i,t} dt = \frac{\Delta K_{i,0} e^{\theta}}{\theta} \tag{2.2}$$

where $\Delta K_{i,t} = \Delta K_{i,0} e^{\theta t}$, and θ and $\Delta K_{i,0}$ are estimated by linear regressions using the investment series available. Therefore, given a depreciation rate, δ, a capital stock series can be derived.

Initial value approach

Assume that the initial capital stock in t_0 was K_{i,t_0} for the i^{th} region or economy, Equation (2.1) can then be converted into

$$K_{i,t} = \Sigma_0^{t-t_0-1} (1-\delta)^j \Delta K_{i,t-j} + K_{i,t_0} (1-\delta)^{t-t_0} \tag{2.3}$$

In the above formula, the only unknown is the initial value of capital stock (K_{i,t_0}), given the rate of depreciation. In the existing literature, there are some estimates of the value of capital stock in 1952 (e.g., Chow 1993, Nehru and Dhareshwar 1993, and Li *et al.* 1995). One may apply these estimates to Equation (2.3) to derive capital stock series for the Chinese economy.

Backcasting approach

The data series for $\Delta K_{i,t}$ are first backcasted to the year 1900. Accordingly, Equation (2.1) is expanded to

$$K_{i,t} = \Sigma_0^{t-1901} (1-\delta)^k \Delta K_{i,t-k} + (1-\delta)^{t-1900} K_{i,1900} \tag{2.4}$$

Equation (2.4) implies that, given the value of capital stock in 1900 and an appropriate rate of depreciation, a capital stock series for each region or economy can be derived. However, $K_{i,1900}$ is often assumed to be zero when the period of study only covers recent decades, e.g., the 1980s and 1990s.

Comparison of the approaches

Obviously, capital decay is not taken into consideration in the integral approach of estimating the initial value of capital stock. In practice, this approach tends to overestimate the growth of capital stock. For example, Wu (2000a) derived an average real rate of growth of 21.5 per cent during the period 1981–95. This figure is twice as big as the estimates derived by other authors, e.g., 8.86 per cent by Maddison (1998) and 7.90 per cent by the World Bank (1997a). The initial value approach relies on the estimation of the initial value of capital stock. Though there are some estimates for China at the national level, there are no data at the regional level.

Thus, both the integral and the initial value approaches are constrained. This study adopts the backcasting approach to estimate capital stock series for the Chinese regions. These series will be used in other chapters in this volume. As an exercise and for the purpose of comparison, the initial value approach will be applied in Chapter 4.

2.3 Estimation results

Price indices

In the empirical literature on the Chinese economy, there are at least two problems with the price deflators. One is that regional variations are rarely taken into consideration. Another is that the official deflators are ambiguous. Figure 2.1 presents three versions of the official deflators: Index I derived by using nominal GDP values and real GDP growth rates; Index II computed from nominal and real GDP figures; and Index III the retail price index. All statistical series considered are available to the public in China.

In Figure 2.1, several observations are worth noting. First, due to price controls under the central planning system, prices hardly changed in China during the pre-reform decades. Second, the movement of prices has been more volatile during the reform period as the economy has been transformed towards a market economic system. Finally, while the three sets of deflators show similar trends of movement over time, their magnitudes vary considerably, particularly in the 1980s and 1990s. Thus, empirical analyses applying these deflators can be distorted. For example, applications of Indexes II and III could lead to biases upwards and downwards, respectively. In this book, Index I is used for the final estimations and sensitivity analyses for two reasons. First, according to Figure 2.1, it seems that Index I is close to the mean of Indexes II and III. Second, Index I can be derived for all regions covering the period 1953–2001. To estimate this price index (Index I), the following approach is adopted

$$P_{it}^{con} = \frac{Y_{it}^{cur}}{Y_{it}^{con}} \tag{2.5}$$

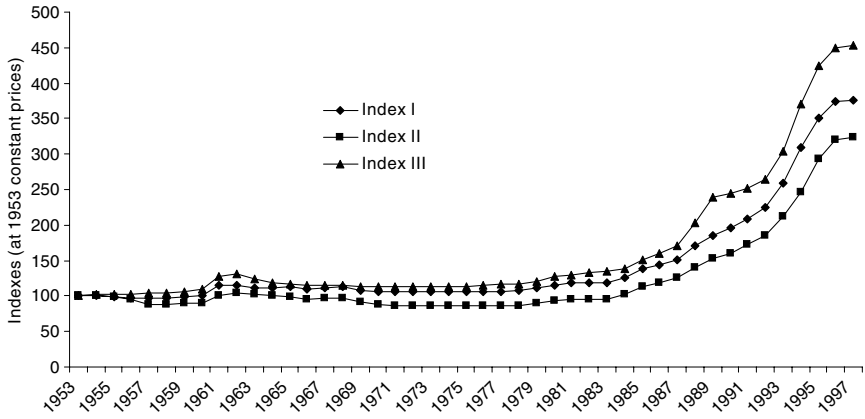

Figure 2.1 China's official price indexes, 1953–97

Source: The State Statistical Bureau (various issues).

where P_{it}^{con}, Y_{it}^{cur} and Y_{it}^{con} represent price index in constant prices, income in current prices and income in constant prices for the i[th] region at period t. Y_{it}^{con} is defined as

$$Y_{it}^{con} = Y_{i0}^{cur} \prod_{0}^{t} (1 + r)^{k} \tag{2.6}$$

where r is the real rate of growth in income which is available from 1953 onwards for all regions and Y_{i0}^{cur} is the initial income at current prices for the i[th] region.

Capital stock series

The derived regional price indices can be used for the estimation of capital stock in each region. As a result, GDP and capital stock data are deflated using Index I and measured in 1953 constant prices.[2] These statistics are attached in the appendix of this book. According to the estimates, China enjoyed rapid capital accumulation immediately after the foundation of the People's Republic (with an average rate of growth of 14.3 per cent during 1954–60). But the growth was interrupted due to political campaigns and chaos in the 1960s (with an average rate of growth of 3.4 per cent during 1961–69). Fortunately, rapid growth has resumed since the early 1970s, maintaining an average rate of growth from 8.5 per cent in the 1970s to 10.4 per cent in the 1990s. Among the thirty Chinese regions, in terms of the value of capital stock, Shanghai, Jiangsu and Shandong are the top three regions, followed by Guangdong, Beijing, Hebei, Zhejiang and Liaoning (see Figure 2.2). Other regions have accumulated much less stock. As expected, Guangdong has recorded the highest average rate (16.91 per cent) of capital accumulation during 1954–2000. Behind Guangdong are Shanghai (13.71 per cent), Fujian (12.44) and Zhejiang (12.22).

For a comparison with estimates by other authors, the growth rates of the derived capital stock in some periods are illustrated in Table 2.1. According to this table, the estimate of capital stock in this chapter is slightly higher than others cited. However, the estimated rate of growth per annum is well below the rate of 11.5 per cent for Singapore, 13.7 per cent for South Korea and 12.3 per cent for Taiwan during the period 1966–90 (Jorgenson 1997). The lower estimates derived by other authors are debatable. The explanation may lie in the estimation of the initial capital stock and the choice of the rate of depreciation. For example, while the World Bank (1997a) used a rate of 4 per cent, Maddison (1998) assumed an average asset life of 25 years, which is equivalent to an annual rate of depreciation of 20 per cent.

2.4 Capital formation and growth

The contribution of capital formation to economic growth is a classical topic.[3] The objective here is not to be exhaustive but to present a simple analysis of the

Figure 2.2 Map of China

Source: Modified from Wu (1996a, p. 82).

Table 2.1 Growth rates of China's capital stock

Source	*Period*	*Growth rate (%)*
Li *et al.* (1995)	1979–90	9.15
Hu and Khan (1997)	1979–94	7.70
World Bank (1997a)	1979–95	7.90
Maddison (1998)	1978–95	8.86*
This chapter	1979–90	8.92
	1979–97	9.58

Note: *Non-residential capital only.

relationship between capital formation and economic growth in China. Figure 2.3 demonstrates the close movement between the growth rates of China's capital stock and GDP during the past decades. The association between the two indicators is very clear in the 1980s and 1990s. This relationship can also be

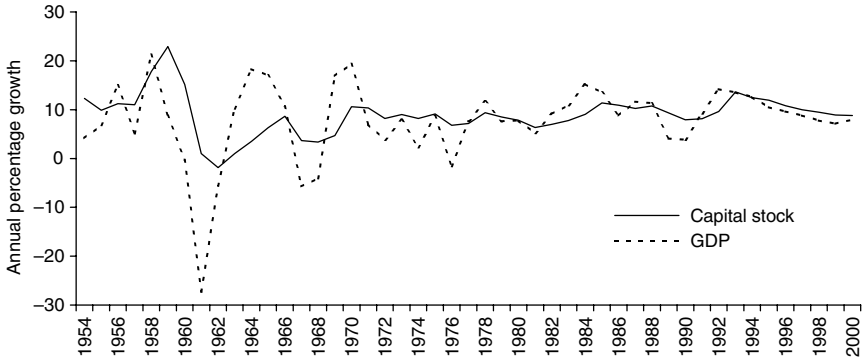

Figure 2.3 Growth rates of capital stock and gross domestic product (GDP), 1954–2000

Source: See the appendix to this book.

demonstrated by examining regional statistics. Table 2.2 presents the correlation coefficients between the growth rates of regional capital stock and GDP during 1954–2000. Most coefficients are greater than 0.40. One can thus speculate that capital accumulation has been an important contributor to China's growth in the past two decades. Detailed investigation of this topic is presented in later chapters of the book.

2.5 Conclusions

In summary, this chapter introduces an alternative approach to estimating capital stock series for the Chinese economy and its regions. The derived series are presented in the appendix of this book. They can be used for other research purposes. Preliminary analysis indicates a close association between capital stock formation and economic growth in China. This is also confirmed by examinations of regional statistics. Further econometric investigations will appear in the rest of the book.

Table 2.2 Correlation coefficients between growth rates of GDP and capital stock

Region	*Correlation coefficient*
Beijing	0.3796
Tianjin	0.3294
Hebei	0.3652
Shanxi	0.5043
Inner Mongolia	0.4412
Liaoning	0.5451
Jilin	0.4025
Heilongjiang	0.4777
Shanghai	0.4861
Jiangsu	0.4267
Zhejiang	0.4733
Anhui	0.2950
Fujian	0.5450
Jiangxi	0.4134
Shandong	0.4023
Henan	0.2190
Hubei	0.4243
Hunan	0.4596
Guangdong	0.1329
Guangxi	0.5607
Sichuan	0.3595
Guizhou	0.4829
Yunnan	0.3403
Shaanxi	0.4405
Gansu	0.0657
Qinghai	0.5812
Ningxia	0.5456
Xinjiang	0.5922
National	0.4240

3 Sources of growth

Recent resurgence of interest in economic growth has led to a blossoming literature.[1] Among the many approaches proposed, cross-country growth regressions have been widely applied to examine the role of various structural and policy indicators in economic growth. The findings in this large and growing literature are often conflicting and yet to be sorted out. For example, Levine and Renelt (1992) carried out a sensitivity analysis of the determinants of the average annual growth rate of GDP per capita for a sample of 101 countries during the period 1960–89. According to their extreme bounds analysis, among many only three variables (i.e., investment, international trade and initial income) are found to possess fairly robust predictive power. Recently, Sala-i-Martin (1997) presented a more optimistic study showing that a substantial number of variables are strongly related to growth. This finding is supported by Ley and Steel (1999).

One common feature of the existing studies is their reliance on cross-section statistics. The main drawback associated with cross-country analyses is the presence of heterogeneity in data aggregation, economic structure and institutional framework among the countries considered.[2]

This chapter may overcome the problems associated with heterogeneity in the existing literature and hence shed further light on the determinants of economic growth. The objective of this chapter is to present a timely assessment of China's economic performance in the past two decades by focusing on a panel of Chinese provinces. The findings can help gain insights into the sources of growth in the Chinese regions and hence contribute to the debate on the determinants of economic growth. The analytical framework and data issues are described in Section 3.1. The estimation results and analyses of the empirical findings are presented in Section 3.2. This is followed by an investigation of the robustness of the empirical results in Section 3.3, with summary remarks reported in the concluding section.

3.1 Analytical and data issues

In the growth literature, a set of variables has been identified to be related to growth.[3] The standard analytical framework is based on the following growth regression

$$Y = \alpha X + \beta Z + \varepsilon \quad (3.1)$$

where Y is the average annual growth rate of GDP per capita, X a set of variables or the so-called conditioning variables which are always included in the regression and Z a subset of variables chosen from a pool of variables which are assumed or identified to be important explanatory variables to growth. The choice of X-variables is based on either past empirical studies or economic theory. For example, Levine and Renelt (1992) selected the initial income, the initial secondary-school enrolment rate, the average annual rate of population growth and the investment share of GDP as the X-variables. Sala-i-Martin (1997) chose the level of income, life expectancy and primary school enrolment rate in the initial year by assuming that these variables are 'good' a priori. It is noted that Equation (3.1) implies causality from X and Z to Y. This causal relationship should be tested; this, however, is beyond the scope of this chapter.

Since this chapter focuses on a single country, the number of variables to be considered becomes relatively small. For instance, the political and institutional factors are not relevant in the case of a single country. As a result, we investigates the influence of several key economic and policy indicators, i.e., physical capital stock, human capital, economic reform, infrastructure, the initial income, openness, labour productivity and foreign capital. Some stylised facts about these variables are presented in Table 3.1.

To capture the impact of foreign investment in China, capital stock is divided into domestic and foreign components. The value of domestic capital stock is the total value of capital stock net of the value of foreign capital stock. The latter is derived by applying a formula similar to Equation (2.4) with the initial year being 1981. China started receiving foreign capital in 1979 (see Figure 1.3, p. 4). At first, foreign direct investment (FDI) was small in scale and concentrated mainly in two southern provinces, Guangdong and Fujian. It slowly spread to other regions in the early 1980s. As the result of this development process, FDI figures by region are only available for the period 1982–97. To estimate foreign capital stock series for the regions, it is assumed that foreign capital was zero in 1981 and that the annual rate of depreciation is 7 per cent.[4] In addition, in the empirical analyses, capital stock and GDP are deflated by region-specific price indexes and expressed in 1990 constant prices (see Section 2.3 in Chapter 2 for details).

According to Table 3.1, the western and central regions have lagged behind coastal China. Their relatively slow economic growth matches their poor performance in many other areas such as capital formation, foreign investment, openness, infrastructure development and human capital. This relationship should be captured by the growth regressions to be conducted in the following sections.

3.2 Determinants of China's regional growth

Given the aforementioned data, the empirical analysis begins with a baseline model which is employed to investigate the impact of physical capital

Table 3.1 Summary statistics of selected variables

Region	*Y*	*GDP*	*K*	*PRO*	*INF*	*FK*	*REF*	*HK*	*OPEN*
Coastal regions									
Beijing	1087	10.5	12.4	17.3	15.1	5.1	50.6	73.5	17.8
Tianjin	741	9.6	9.8	17.4	20.5	4.2	77.6	61.1	25.8
Hebei	325	12.0	10.3	19.1	18.9	0.9	76.8	48.2	5.0
Liaoning	569	9.7	9.8	17.9	18.2	3.2	68.6	58.7	11.8
Shanghai	1307	10.0	13.6	16.3	20.1	6.2	70.8	74.1	28.6
Jiangsu	441	13.5	14.3	20.5	23.8	2.6	82.3	47.9	10.2
Zhejiang	477	13.8	13.7	20.7	25.4	1.4	90.6	44.2	14.5
Fujian	385	14.2	11.6	22.8	27.8	10.0	88.8	39.0	24.3
Shandong	399	12.7	11.1	19.9	21.3	1.9	74.8	43.3	9.5
Guangdong	531	14.5	11.3	21.8	29.8	9.9	87.3	47.7	66.4
Guangxi	228	10.5	7.8	18.1	20.9	2.5	72.1	38.1	6.6
Sub-mean	590	11.9	11.4	19.3	22.0	4.4	76.4	52.4	20.1
Central regions									
Shanxi	302	10.0	8.5	16.3	13.6	0.3	68.0	53.8	6.6
Inner Mongolia	309	10.4	9.6	17.9	15.6	0.4	56.8	48.1	4.7
Jilin	353	10.6	9.9	18.4	19.0	1.1	40.5	55.1	12.1
Heilongjiang	435	7.8	9.9	18.0	19.4	0.8	45.7	55.2	16.9
Anhui	218	11.4	12.7	17.4	21.2	0.5	80.2	41.5	4.2
Jiangxi	228	11.0	7.9	16.7	17.5	0.8	59.0	42.7	4.7
Henan	226	11.2	10.0	18.2	19.7	0.5	72.4	49.5	3.0
Hubei	317	11.1	10.2	18.8	20.0	0.9	75.9	46.0	5.1
Hunan	255	9.5	9.1	16.9	20.2	0.9	75.2	45.0	4.7
Sub-mean	294	10.3	9.8	17.6	18.5	0.7	63.7	48.5	6.9

Region	*Y*	*GDP*	*K*	*PRO*	*INF*	*FK*	*REF*	*HK*	*OPEN*
Western Regions									
Sichuan	240	9.9	8.6	17.3	17.8	0.6	66.6	38.1	3.5
Guizhou	168	9.4	7.3	14.1	13.3	0.3	44.0	29.3	3.0
Yunnan	259	10.6	9.4	17.2	18.5	0.2	45.5	28.5	5.3
Shaanxi	265	10.2	8.0	16.8	14.6	1.7	48.8	45.7	5.4
Gansu	226	10.5	5.5	15.7	15.9	0.3	45.9	37.4	3.8
Qinghai	310	8.0	6.3	15.5	12.1	0.1	27.2	27.2	3.6
Ningxia	284	9.6	6.8	15.1	18.5	0.1	40.8	42.8	4.4
Xinjiang	395	11.1	11.9	19.8	17.0	0.3	24.7	45.9	5.0
Sub-mean	268	9.9	8.0	16.4	16.0	0.5	42.9	36.9	4.3

Sources: All statistics are computed using raw data from various sources including *Statistical Yearbook of China,* various years, Statistical Publishing House, Beijing, *China's GDP Data 1952–95*, Dongbei University of Economics and Finance Press, Daliang. *Population Yearbook of China*, various years, Statistical Publishing House, Beijing. *1982 Population Census of China*, Statistical Publishing House, Beijing.

Notes
Hainan Island and Tibet are excluded due to missing data;
Y: 1991 GDP per capita in US dollars;
GDP: average growth rate (%) of GDP, 1982–97;
K: average growth rate (%) of domestic capital stock, 1982–97;
PRO: average growth rate (%) of labour productivity, 1982–97;
INF: average rate (%) of growth in infrastructure, 1985–95;
FK: average share (%) of foreign capital stock over total capital stock, 1982–97;
REF: output share (%) of non-state industrial sector over industrial total, 1997;
HK: proportion (%) of population at 6 and over with at least six year schooling, 1997;
OPEN: share (%) of the value of exports over GDP, 1993.

accumulation and the initial income on regional growth. For the purpose of comparison, the empirical analyses focus on two periods, i.e., 1982–90 and 1991–97. The point of division is largely dictated by the availability of statistics. For example, many Chinese regions began receiving FDI in 1982, and population censuses were conducted in 1982 and 1990, respectively.[5] In addition, it is interesting to compare regional growth in the 1980s and 1990s.

Capital accumulation and initial conditions

Capital accumulation has often played a key role in economic growth (e.g., Young 1995). The average growth rate of capital stock is used in the estimations in this chapter. It is expected to be positively correlated with the rate of economic growth. The initial income is regarded as an important factor underlying growth.[6] It is argued that less developed economies may be able to take advantage of backwardness and hence enjoy faster growth (Abramovitz 1986). The initial income variable in the empirical models takes the value of GDP per capita in the first year of the time period considered and its coefficient is expected to have a negative sign. Table 3.2 presents the estimation results by applying Equation (3.1) to cross-section data of twenty-eight Chinese provinces. The results from the baseline model (model 1) are reported in column 2. The estimates of all coefficients have an appropriate sign and are statistically significant at a given level of significance.

As expected, the growth of physical capital stock (domestic) has made a significant contribution to economic growth over the periods considered. The initial level of income is found to be negatively related to economic growth. This relationship is significant at a given level of significance. Thus, it may be concluded that there is evidence of conditional convergence among the Chinese regions during the past two decades. The rate of convergence is about 1.5 per cent per annum according to the baseline regressions. The coefficients of the two regional dummies have shown that the western regions grew relatively fast in the 1980s but lagged behind both the coastal and central regions in the 1990s. Thus, the estimated convergence as indicated by the sign of the initial income took place mainly within the regions. This finding is consistent with observations from regional disparity studies (e.g., Wu 2000b).

Other factors such as infrastructure, labour productivity conditions, foreign capital, economic reform, openness and human capital have also played important roles in China's growth over time. However, these variables cannot enter the regressions simultaneously due to the existence of multicollinearity. For example, the coefficient of correlation between the variables representing infrastructure and economic reform and that between foreign capital and openness is relatively high (see Table 3.3). As a result, various alternative models are estimated. The interpretation of the results from selected models is presented in the following sections.

Table 3.2 Regression results

Variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
Panel A: 1982–90									
Initial income	–1.158[b]	–1.035[b]	–1.680	–1.309[b]	–0.117	–0.266	–1.290[a]		0.344
	(–2.577)	(–2.644)	(–1.620)	(–3.107)	(–0.217)	(–0.454)	(–3.053)		(0.650)
Domestic capital	0.280[b]	0.223[b]	0.166	0.281[a]	0.088	0.199[c]	0.283[b]		–0.008
	(2.383)	(2.161)	(1.531)	(2.587)	(0.709)	(1.725)	(2.591)		(–0.067)
Infrastructure		0.178[a]							0.056
		(2.945)							(0.392)
Productivity			0.291[a]					0.229[a]	0.226[b]
			(2.981)					(3.039)	(2.361)
Openness				4.721[b]					–4.611
				(2.211)					(–0.889)
Reform					10.033[a]			9.016[a]	8.620[b]
					(2.804)			(4.359)	(2.331)
Human capital						0.948[b]			0.223
						(2.165)			(0.501)
Foreign capital							0.611[b]	0.396[c]	0.732
							(2.144)	(1.885)	(1.463)
Constant	13.118[a]	11.248[a]	6.752[b]	13.769[a]	6.634[b]	5.033	13.759[a]	3.246[a]	0.263
	(5.376)	(5.099)	(2.251)	(6.050)	(2.105)	(1.152)	(6.012)	(2.898)	(0.066)
Coastal dummy 1	–0.420	–1.380[c]	–0.606	–1.056	–2.632[b]	0.155	–0.979	–2.793[a]	–2.677[b]
	(–0.553)	(–1.881)	(–0.921)	(–1.392)	(–2.549)	(0.206)	(–1.301)	(–4.282)	(–2.340)
Central dummy 2	–1.234[c]	–1.419[b]	–1.003[c]	–1.339[b]	–1.822[a]	–1.059[c]	–1.210[c]	–1.525[a]	–1.445[b]
	(–1.834)	(–2.422)	(–1.711)	(–2.146)	(–2.908)	(–1.681)	(–1.933)	(–3.278)	(–2.526)
R-squared	0.309	0.504	0.508	0.434	0.491	0.430	0.428	0.706	0.729

Variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
Panel B: 1991–97									
Initial income	–1.361[a]	–0.950[b]	–1.125[a]	–1.404[a]	–0.799[b]	–1.232[a]	–1.461[a]	–0.781[b]	–0.710[c]
	(–3.698)	(–2.398)	(–3.565)	(–3.606)	(–2.167)	(–3.069)	(–4.122)	(–2.427)	(–1.891)
Domestic capital	0.570[a]	0.452[a]	0.262[c]	0.562[a]	0.425[a]	0.538[a]	0.556[a]	0.209[c]	0.227
	(5.206)	(3.877)	(2.007)	(4.961)	(4.017)	(4.607)	(5.322)	(1.781)	(1.648)
Infrastructure		0.092[b]							–0.006
		(2.092)							(–0.121)
Productivity			0.407[a]					0.319[a]	0.300[b]
			(3.315)					(2.859)	(2.129)
Openness				0.823[c]					–1.506
				(0.406)					(–0.655)
Reform					7.323[a]			5.716[b]	5.835[b]
					(2.997)			(2.707)	(2.491)
Human capital						0.161			0.061
						(0.840)			(0.378)
Foreign capital							0.101[c]	0.045	0.075
							(1.843)	(1.015)	(1.057)
Constant	11.584[a]	7.456[b]	5.512[c]	11.888[a]	6.828[b]	10.631[a]	12.263[a]	3.408	3.146
	(4.278)	(2.325)	(1.894)	(4.160)	(2.420)	(3.601)	(4.711)	(1.186)	(0.973)
Coastal dummy 1	5.064[a]	4.378[a]	3.700[a]	4.994[a]	2.787[a]	5.022[a]	4.414[a]	1.932[b]	1.919[b]
	(7.091)	(5.891)	(5.108)	(6.679)	(2.850)	(6.969)	(5.764)	(2.250)	(2.083)
Central dummy 2	1.934[a]	1.704[a]	1.247[b]	1.926[a]	0.867	1.878[a]	1.887[a]	0.542	0.550
	(3.504)	(3.233)	(2.469)	(3.424)	(1.460)	(3.356)	(3.588)	(1.046)	(0.979)
R-squared	0.886	0.905	0.924	0.887	0.919	0.890	0.902	0.948	0.950

Notes
[a]Significant at 1%. [b]Significant at 5%. [c]Significant at 10%.

Table 3.3 Selected coefficients of correlation, 1982–90

	Reform	*Openness*	*Productivity*
Domestic capital	0.53 (0.68)	0.32 (0.38)	0.27 (0.82)
Infrastructure	0.58 (0.72)	0.91 (0.26)	0.50 (0.76)
Foreign capital	0.32 (0.53)	0.92 (0.81)	0.30 (0.54)

Note: The numbers in parentheses are the coefficients for the period 1991–97.

Infrastructure and labour productivity

The level of infrastructure development can be proxied by several indicators such as the length of roads and number of telephones.[7] However, the use of the length of roads is likely to be biased against regions where railway is the dominant means of transportation. As a result, this chapter focuses on the number of telephones. Due to the fact that the large and relatively more developed regions always have more telephones, the growth rate of the number of telephones per head is used to reflect the change in infrastructure among the regions. The use of growth rate rather than level is also consistent with other variables. It is clear, from Table 3.1 that the regions led by Guangdong and Fujian achieved substantial growth in infrastructure during 1982–97. This growth should have contributed positively to the regions' economic performance. The estimation results in Table 3.2 (model 2) show that the coefficient of the infrastructure variable is positive and significant. Thus, it may be concluded that infrastructure development is positively correlated with economic growth in the Chinese regions.

Improvement in labour productivity is expected to make a positive contribution to growth. This is confirmed in Table 3.2 (model 3), where the growth rate of labour productivity is positively related to growth during the two periods considered.

Impact of economic reform and openness

It is argued that economic reform has contributed significantly to China's growth in the past two decades. This claim is supported by empirical studies of the agricultural sector (e.g., Mcmillan *et al.* 1989, Lin 1992). In particular, one of the key reform initiatives was to open China to the world. As a result, China's economic takeoff over the past decades has been accompanied by rapid expansion of international trade. How have domestic reforms and external trade affected growth performance among the regions? To answer this question, reform and openness indicators are developed and incorporated into the growth regressions.

In the growth literature, the ratio of the total value of exports and imports (or the value of exports) over GDP is employed as an indicator of openness. In the

case of the Chinese provinces, it is found that the ratio of the total value of exports and imports over GDP is highly correlated with the ratio of the value of exports.[8] Thus, either ratio can be used as the indicator of openness. In the final estimation, the ratio of the value of exports over GDP is used to represent openness.[9] Not surprisingly, Table 3.1 indicates that Guangdong and Shanghai have the most open economies in China.

To reflect the progress of economic reform among the regions, the role and development of the non-state sector is examined. The non-state sector includes all but the state sectors. Three indicators can be used to assess the development of the non-state sector: the shares of the non-state sector over urban employment, industrial output and total retail sales in the Chinese regions. In general, these three shares (which are available for various periods) have been rising over time, implying the deepening of China's economic reform (see Figure 3.1). In the empirical models, after preliminary checking, the mean output shares of the non-state sector between 1985 and 1990 and between 1990 and 1997 are used to proxy the degree of economic reform during the two periods. Coincidentally, the value of the output share is bound by the value of the employment and sales shares. The estimation results are reported in Table 3.2 (models 4 and 5). The coefficients of both reform and openness variables have correct signs and are significant, implying that China's reform and openness have contributed positively to economic growth in the past decades.

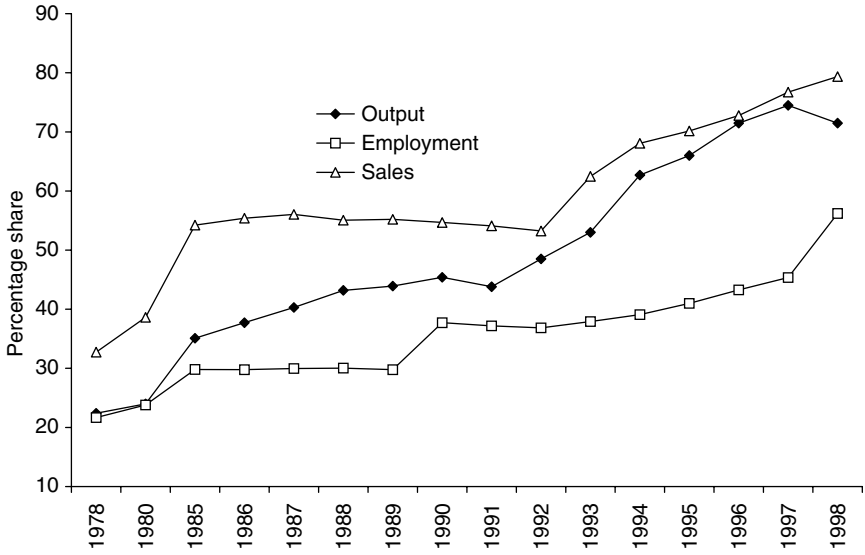

Figure 3.1 Selected shares of the non-state sector

Source: State Statistical Bureau (various issues).

The role of human capital

The impact of human capital on China's growth has rarely been researched in the literature due to the paucity of data. The few exceptions are Wei (1995), Moody and Wang (1997) and Demurger (2000).[10] Wei used the number of 'scientific and technical personnel' as a proxy of human capital. The other two authors employed school enrolment rates. These existing studies focused on one single cross-section only and hence ignored the growth of human capital over time. This chapter applies information from recent censuses to derive an estimate of human capital stock in the Chinese regions.

China conducted population censuses in 1982 and 1990. A sample survey was also carried out in 1997. The census and survey data have now been published in various sources. This chapter uses two sets of data, i.e., the average level of schooling of the population and level of education of the labour force. Ideally, the latter is an appropriate indicator of human capital but it is available for 1990 and 1997 only. However, statistics on the level of schooling of the population are available for 1982, 1990 and 1997. To justify the use of the 1982 census data, the two sets of data for 1990 and 1997 are compared. It is found that these data sets are highly correlated, with a coefficient of correlation greater than 0.99. Due to this close relationship, the average level of education of the population is used to derive the level and growth rate of human capital stock among the regions.

The average rates of growth of human capital stock during 1982–90 and 1990–97 are employed in the regressions. It turns out that the coefficient of this variable is either negative or insignificant. Other authors have reported the same problem with the human capital stock variable (e.g., Benhabib and Spiegel 1994 and Pritchett 1997). This may be due to measurement errors and technical constraints in deriving human capital stock data (Temple 1998). To overcome this problem, this chapter employs an alternative proxy for human capital, that is, the proportion of population aged six and over with at least six years of schooling (i.e., the completion of primary school education). The average growth rate of this figure is used in the final estimation. According to Table 3.1, as expected, Shanghai and Beijing have the most educated populations in China. It is also found that Anhui and Jiangxi, two central regions, have achieved the highest growth in human capital during 1982–97. The human capital variable has a positive coefficient which is significant during 1982–90 and insignificant during 1991–97 (model 6 in Table 3.2). This result may imply that changes in human capital stock growth are positively correlated with economic growth in the Chinese regions. Obviously, this conclusion is subject to qualifications as better data and human capital theories become available in the future.

FDI as an engine of growth

According to new growth theory, FDI has been an important factor propelling economic growth.[11] China's FDI increased significantly in the 1990s but the amount of investment varies considerably across the regions. In particular, some

regions experienced hypergrowth in certain years only due to the launch of a few large projects. As a result, regional growth rates of FDI vary a lot over time and the outliers in the data sample are problematic. To overcome this problem, the proportion of foreign stock over the total capital stock is employed in the empirical estimations. As shown in Table 3.1, foreign capital still plays a minor role in many regions, in particular in central and western China. The final estimation results are reported in Table 3.2 (model 7). According to this table, the contribution of FDI to China's growth in both the 1980s and 1990s was significant.

Results of pooled estimations

The preceding sections examined the effect of various regional characteristics on economic growth. The objective of this section is to pool the data to investigate the joint impact of the variables on growth. As mentioned earlier, one of the problems with the estimation of the pooled model is the existence of multicollinearity between the growth correlates (see Table 3.3). For example, according to Table 3.3, the variables for foreign capital and openness are highly correlated, and thus their appearance in the same growth equation would be problematic. Due to this problem, several models with different independent variables are estimated. The estimation results from two of these models are presented in the last two columns of Table 3.2. It is clear that these variables considered jointly explain about 70 and over 90 per cent of the growth in the 1980s and the 1990s, respectively.

3.3 Sensitivity analyses

As capital (domestic, human and foreign) is an accumulated factor, the growth equation has been hampered by the problem of endogeneity. Benhabib and Spiegel (1994) provided evidence of upward biases on the coefficients of capital stock variables. To correct this problem, researchers have resorted to the difference equation and instrumental variable approaches (Barro 1997). The estimation results from the difference equation and instrumental variable approaches are presented in Table 3.4. The results from the difference equation regressions support the claim of biased estimates from the OLS regressions (e.g., the coefficients of domestic capital are biased upwards). However, the results from the instrumental variable estimations are consistent with the OLS estimation outcomes presented in Table 3.2.

3.4 Summary remarks

Cross-country studies on economic growth have been criticised for overlooking heterogeneity among the world economies. Studies focusing on a single country, instead, may suffer less from this problem. In this chapter, for the first time, several regression techniques are applied to investigate the determinants of recent

Table 3.4 Estimates of instrumental variable models

Variable	*Difference equation*		*Instrumental variable approach*					
			1982–90			*1991–97*		
Initial income	–3.289[b]	–3.264[b]		0.189	0.343	–0.814[a]	–0.745[a]	–0.711[b]
	(–2.071)	(–2.008)		(0.473)	(0.832)	(–3.022)	(–2.610)	(–2.431)
Domestic capital	0.136[c]	0.135[c]		0.019	–0.007	0.195[b]	0.193[c]	0.227[b]
	(1.654)	(1.647)		(0.217)	(–0.085)	(1.979)	(1.907)	(2.114)
Infrastructure	0.104[a]	0.115[a]			0.055			–0.005
	(3.275)	(3.593)			(0.494)			(–0.146)
Productivity	0.209[a]	0.220[a]	0.223[a]	0.219[a]	0.226[a]	0.331[a]	0.326[a]	0.300[a]
	(3.159)	(3.444)	(3.372)	(3.101)	(3.031)	(3.531)	(3.477)	(2.732)
Openness					–4.590			–1.510[c]
					(–1.136)			(–0.843)
Reform		0.547	8.976[a]	8.053[a]	8.628[a]	5.637[a]	5.607[a]	5.831[a]
		(0.126)	(4.905)	(2.814)	(2.994)	(3.177)	(3.144)	(3.195)
Human capital		–0.230		0.250	0.222		0.055	0.059
		(–1.500)		(0.745)	(0.641)		(0.461)	(0.468)
Foreign capital	0.102[c]	0.117[c]	0.415[b]	0.400[b]	0.733[c]	0.048	0.042	0.075
	(1.687)	(1.840)	(2.239)	(2.127)	(1.882)	(1.286)	(1.109)	(1.361)
Constant	–1.241	–1.873	3.336[a]	1.416	0.279	3.568	3.092	3.153
	(–0.971)	(–1.229)	(3.384)	(0.471)	(0.090)	(1.481)	(1.230)	(1.252)
Coastal dummy 1	4.501[a]	4.557[a]	–2.799[a]	–2.545[a]	–2.677[a]	1.945[a]	1.957[a]	1.919[a]
	(6.744)	(6.677)	(–4.849)	(–2.858)	(–3.004)	(2.692)	(2.705)	(2.672)
Central dummy 2	2.465[a]	2.506[a]	–1.521[a]	–1.465[a]	–1.444[a]	2.542	0.531	0.550
	(4.955)	(4.555)	(–3.688)	(–3.297)	(–3.241)	(1.239)	(1.219)	(1.259)
R-squared	0.897	0.905	0.706	0.715	0.729	0.948	0.949	0.950

Source: Author's own calculation.

Notes
[a] Significant at 1%. [b] Significant at 5%. [c] Significant at 10%.

The difference equations are estimated by an instrumental variable approach. The instrumental variables include all regressors in the equations and their lagged values. The instrumental variables employed in the instrumental variable approach estimations include all regressors and their initial values.

economic growth in China. This chapter therefore adds to the existing literature and contributes to the current debate on the sources of economic growth.

Given the data available, the focus of this chapter is the impact on economic growth of eight region-specific factors (i.e., capital formation, initial income, infrastructure, labour productivity, economic reform, openness, human capital and foreign investment). In general, it is found that the growth of physical capital, infrastructure, labour productivity, human capital and foreign investment are positively related to China's economic growth in the 1980s and 1990s. This chapter also confirms the popular perception that China's economic reform and openness have made positive contributions to recent economic growth. Furthermore, initial income is found to have a negative impact on growth rates, implying conditional convergence among the Chinese regions. This trend of regional convergence was particularly strong in the 1980s, according to this chapter. The findings also show that convergence has occurred mainly within the three regions i.e., the coastal, central and western. There is no evidence of catch-up of the western and central provinces to their affluent counterparts, the coastal provinces. Overall, the empirical estimates show that the eight factors together account for 70–90 per cent of China's growth in the past two decades.

Finally, alternative models are estimated to take account of endogeneity and outliers. The above findings remain unchanged according to the alternative regressions. The findings are still subject to qualification, however. One qualification is the measurement of human capital which is constrained by both methodology and statistics available, as agreed by other authors (e.g., Sachs and Warner 1997). In addition, there is also scope for improvement in the measurement of economic reform and openness as more information becomes available over time.

4 The role of productivity

The contribution of productivity to economic growth in China has been of particular concern since the publication of an article on the East Asian newly industrialised countries (NICs) by Krugman (1994). He quoted work by Young (1994a, 1994b) and Kim and Lau (1994) to argue that rapid growth in the East Asian NICs has been driven mainly by massive injection of factor inputs rather than innovation and that growth in these countries would not be sustainable. As China's growth is likened to the East Asian NICs, can the same argument be made about the Chinese economy? The aim of this chapter is to examine the role of productivity in China's economic growth in the past two decades.

Several authors have so far attempted to shed light on this issue. For example, by employing a growth accounting method, Borensztein and Ostry (1996) and Hu and Khan (1997) found a significant contribution of total factor productivity to growth in China during the reform period. Fleisher and Chen (1997) investigated the impact of human capital and foreign investment on regional variations in productivity. More recently, Woo (1998) presented a comprehensive study on the sources of China's growth. He found that China has largely followed an extensive growth model with little technological progress.

This chapter extends previous studies by applying the latest statistics as well as an alternative approach. In this chapter, productivity growth is decomposed into two components, i.e., efficiency change and technological progress. The former refers to catching up to the production frontier and the latter to outward shifts in the production frontier. This decomposition allows the identification of productivity growth due to either improvement in efficiency (i.e., catch-up) or technological progress (i.e., innovation). In particular, this technique can be applied to estimate the impact of economic reforms on China's growth. Economic reforms can boost productivity growth in two conceptually different ways. One way is by increasing the efficiency with which the existing resources are utilised in production. For well-known reasons, centrally planned economies like the Chinese economy produce well below their best-practice outputs. Economic reform aims to raise production close to the frontier (i.e., improvement in technical efficiency). Another way to boost productivity growth is by stimulating innovation, i.e., technological progress. Centrally planned

economies have recorded low levels of technological progress according to international standards (Lau and Brada 1990). An investigation of China's productivity performance, in particular the two components of productivity growth, can provide valuable insight into the understanding of that country's spectacular growth over the last two decades.

In this chapter, Section 4.1 introduces the methodology. This is followed by a description of the empirical models in Section 4.2. Data issues are discussed in Section 4.3. The estimation results and preliminary analyses are shown in Section 4.4. Section 4.5 presents further analyses including some comparative issues, sensitivity analyses and the findings from the extended growth accounting approach. The final section concludes the chapter with some summary remarks.

4.1 An extended Solow approach

The econometric model used in this chapter, hereafter called the frontier model, is related to the concept of output-oriented technical efficiency first proposed by Farrell (1957) and popularised by Aigner *et al*. (1977), and Meeusen and van den Broeck (1977).[1] The important difference between the traditional growth accounting method and the production frontier technique is that the latter allows for production below the best practice output. The panel data version of this model can be presented as follows:

$$y_{it}^{F} = f(x_{it}, t) , \qquad t = 1, \ldots, T \text{ and } i = 1, \ldots, N \tag{4.1}$$

where y_{it}^{F} represents the frontier production level or the so-called 'best practice' output for the i^{th} country or region at time t, given technology f(•). Then any observed output y_{it}, given input x_{it}, may be expressed as

$$y_{it} = y_{it}^{F} TE_{it} = f(x_{it}, t)TE_{it} \tag{4.2}$$

where TE_{it} indicates technical efficiency, defined as the ratio of the observed output over the best practice output. Equation (4.2) can be transformed into

$$\dot{y}_{it} = f_x \, \dot{x}_{it} + f_t + \dot{TE}_{it} \tag{4.3}$$

where dotted variables denote percentage changes, and f_x and f_t represent, respectively, output elasticities with respect to x and t.

Solow (1957) attributed output growth to input growth and technical change. The decomposition in Equation (4.3) enriches Solow's dichotomy by attributing growth in observed output to movement along a path on or beneath the production frontier (input growth), movement toward or away from the production frontier (technical efficiency change), and shifts in the production frontier (technological progress). According to this decomposition, total factor productivity growth (T$\dot{F}$P), defined as the growth in output not explained by

input growth, is the sum of technological progress and changes in technical efficiency, that is

$$\dot{TFP}_{it} = \dot{TP}_{it} + \dot{TE}_{it}\,, \qquad t = 1, \ldots, T\,, \quad i = 1, \ldots, N. \tag{4.4}$$

According to Solow's growth accounting method, productivity growth is mainly due to technological progress. The decomposition in Equation (4.4) has however shown that, even without technological progress, productivity growth can still be positive as backward economies or regions close their gaps with the best practice output (i.e., improvement in efficiency). Thus, the conventional growth-accounting method cannot distinguish between technological progress and changes in technical efficiency, yet the former can be assumed to be the consequence of innovation or adoption of new technology by best practice countries or economies, and the latter mainly due to the effect of catching up. These two are analytically distinct and may have quite different policy implications, as argued by Nishimizu and Page (1982). Qualitatively, this decomposition emphasises a distinction between a 'level' and a 'growth' effect of economic reform on the long-run growth (Lucas 1988). On the one hand, the level effect of economic reform causes upward shifts in actual production (i.e., movement towards the frontier). On the other hand, the growth effect implies that economic reform not only raises the level of production in the short run but also stimulates technological progress and hence leads to sustained growth in the economy. The fundamental difference between these two effects is that level effects can be drawn out over time but not growth effects which can be large and sustainable.

Isolation of changes in efficiency and technological progress is also embodied in the increasingly popular Malmquist productivity approach which is, however, nonparametric.[2] This approach has recently attracted a lot of interest and has been widely used in empirical analyses partly due to the fact that it typically employs linear programming models. Though this approach has a number of virtues, its main drawback is that it is deterministic (Lovell 1996). In contrast, the econometric approach employed in this chapter is stochastic and capable of distinguishing the effects of statistical noise from these of inefficiency. The original technique was popularised by Nishimizu and Page (1982) who estimated a programming model. More recent empirical work includes Lau and Brada (1990) who also applied programming models, Fecher and Pestieau (1993) who estimated an econometric model in which the rate of technological progress is constant, and Färe *et al.* (1994) who employed a non-parametric approach. This chapter attempts to estimate a parametric econometric model.

4.2 The empirical model

To estimate Equation (4.4), consider the following specification of a frontier production function

$$\ln Q_{it} = \alpha_0 + \alpha_1 d_1 + \alpha_2 d_2 + \alpha_3 d_3 + \alpha_4 t + \frac{1}{2}\alpha_5 t^2 + (\beta_0 + \beta_1 t)\ln L_{it} + (\gamma_0 + \gamma_1 t)\ln K_{it} + \frac{1}{2}(\eta_1 \ln \mathrm{L_{it}} \ln \mathrm{L_{it}} + 2\eta_2 \ln \mathrm{L_{it}} \ln \mathrm{K_{it}} + \eta_3 \ln \mathrm{K_{it}} \ln \mathrm{K_{it}}) + \varepsilon_{\mathrm{it}} \quad (4.5)$$

where

$$\varepsilon_{\mathrm{it}} = \mathrm{v_{it}} - \mathrm{u_{it}}\,, \quad (4.6)$$

$$u_{it} = \varsigma_0 + \Sigma_1^4 \varsigma_j d_j t + \omega_{it} \geq 0\,, \quad (4.7)$$

$$\beta_0 + \gamma_0 = 1,\ \beta_1 + \gamma_1 = 0,\ \eta_1 + \eta_2 = \eta_2 + \eta_3 = 0, \quad (4.8)$$

Q, L and K represent GDP, labour and capital stock, respectively; d_1, d_2, d_3 and d_4 are four dummy variables representing the three large cities, the coastal, central and western regions;[3] α_i's, β_j's, γ_k's, η_l's and ς_m's are parameters to be estimated; $\varepsilon_{\mathrm{it}}$ is the error term combining the white noise, $\mathrm{v_{it}}$, and the term associated with technical inefficiency, $\mathrm{u_{it}}$; $\mathrm{v_{it}}$ and ω_{it} are assumed to be independently distributed; $\mathrm{v_{it}}$ has a normal distribution with zero mean and variance σ_{v}^2; ω_{it} is defined by the truncation of the normal distribution with zero mean and variance σ_{u}^2 such that the point of truncation is $(-\varsigma_0 - \Sigma\varsigma_j d_j t)$, that is, $\omega_{it} \geq -\varsigma_0 - \Sigma\varsigma_j d_j t$; thus, $\mathrm{u_{it}}$'s are non-negative and obtained by truncation at zero of the normal distribution with mean $(\varsigma_0 + \Sigma\varsigma_j d_j t)$ and variances, σ_{u}^2; and Equation (4.8) ensures constant returns to scale.

The above specification exhibits some distinct features. These can be summarised as follows:

- the proposed model assumes that the production process has constant returns to scale so that the Solow growth accounting framework can be applied;
- it allows structural change as output elasticities vary over time;
- it incorporates differential rates of technological progress; and
- it permits efficiency changes over time as well as at a different speeds for each region.

The distributional assumptions on the inefficiency effects, the $\mathrm{u_{it}}$'s, permit the coefficients of the two t-terms to be identified in addition to the coefficients of other terms (Battese and Coelli 1995). The model constituting Equations (4.5) to (4.8) can be estimated by the maximum likelihood method using the computer programme, FRONTIER 4.1.[4] Given the estimates of the parameters in Equations (4.5) to (4.8), technical efficiency rates for the $\mathrm{i^{th}}$ region at the $\mathrm{t^{th}}$ period are computed as the conditional expectation of $\mathrm{e^{-u_{it}}}$ with respect to $\varepsilon_{\mathrm{it}}$, i.e.,

$$\mathrm{TE_{it}} = \mathrm{E}[\exp(-\mathrm{u_{it}})|\varepsilon_{\mathrm{it}}] \text{ where } \varepsilon_{\mathrm{it}} = \mathrm{v_{it}} - \mathrm{u_{it}} \quad (4.9)$$

Finally, the rate of efficiency change is calculated as

$$\dot{T}E_{it} = \frac{TE_{it}}{TE_{i,t-1}} - 1 \tag{4.10}$$

and the rate of technological progress ($\dot{T}P_{it}$) for the i^{th} region at the t^{th} period t is given by

$$\dot{T}P_{it} = \alpha_4 + \alpha_5 t + \beta_1 \ln L_{it} + \gamma_1 \ln K_{it} \tag{4.11}$$

Both $\dot{T}E_{it}$ and $\dot{T}P_{it}$ vary over time and across the regions.

4.3 Data issues

Income and labour

The models specified above are applied to a panel data set of twenty-seven Chinese provinces during the period 1981–97.[5] Regional GDP data are from China's State Statistical Bureau.[6] Labour statistics are drawn from the statistical yearbooks of China for the period 1985–97 and are estimated for the period 1981–84 by extrapolation. The total numbers of people employed are used instead of manhours due to the lack of data on the latter.

Capital stock

The value of net capital stock in each year is estimated from annual incremental capital stock which is available for the period 1952–97 for all regions. The initial value approach is employed in this section (see Chapter 2 for details). Therefore, given a rate of depreciation, δ, the value of capital stock for the i^{th} region in the t^{th} year can be expressed as

$$K_{it} = K_{i,t-1}(1 - \delta) + \Delta K_{it} \tag{4.12}$$

where ΔK_{it} is the value of incremental capital stock and all variables are expressed in constant prices. If the initial capital stock in 1952 was $K_{i,1952}$ for the i^{th} region, Equation (4.12) can then be converted into

$$K_{it} = K_{i,1952}(1 - \delta)^{t-1952} + \Sigma_0^{t-1952-1}(1 - \delta)^j \Delta K_{i,t-j} \tag{4.13}$$

In Equation (4.13), the only unknown is the value of the 1952 capital stock. Several authors have attempted to estimate the value of China's total capital stock in 1952. Chow (1993) derived a figure of 175 billion yuan. Li *et al.* (1995) reported that the rate of growth of capital stock in 1953 was 20.83 per cent. This rate together with the value of the incremental capital in 1953 implies that China's capital stock was about 95.2 billion yuan in 1952. Given these estimates,

one may ask how much value of the 1952 capital stock has remained by 1981, which is the initial year of the sample employed for the empirical analyses. The answer to this question depends on the rate of depreciation used. Table 4.1 lists three options showing the percentage of the remaining value of the 1952 capital stock. It ranges from 4.7 to 30.6. It is thus clear that the value of the initial capital stock cannot be ignored and may affect the robustness of the final findings. In the rest of this section and Section 4.5, the estimations and analyses are based on the assumption that the value of the 1952 capital stock was 95.2 billion yuan. Other options are to be further discussed in the sensitivity analyses in Section 4.6.

In the existing literature, the rate of depreciation is often selected arbitrarily. To justify the choice in this chapter, the above-mentioned three options are attempted and in each case the value of the annual capital stock is estimated for all regions. Then this estimated value of capital stock and the actual value of depreciation which is available for the period 1978–97 for all regions are used to derive a series of rates of depreciation over time as well as across the regions. Subsequently, Student *t* tests are conducted to check whether the mean of the derived rates of depreciation is equal to the actual percentage rate used, i.e., 4, 7 and 10, respectively. The testing results presented in Table 4.2 confirm that 7 per cent is the preferred rate of depreciation. Given this rate, following Equations (4.12) and (4.13), a capital stock series is generated and used for the final analyses. In addition, the sensitivity of the rate of depreciation will be further investigated in Section 4.6.

Summary of the sample data

The final sample has 459 observations. Summary statistics are presented in Figure 4.1. Not surprisingly, over the past sixteen years (1982–97), the Chinese

Table 4.1 Rates of depreciation and remaining values

Rate of depreciation (%)	*Original value in 1952 (%)*	*Remaining value in 1981 (%)*
4	100	30.6
7	100	12.2
10	100	4.7

Table 4.2 Choice of the rate of depreciation

Assumed rate of depreciation A (%)	4.0	7.0	10.0
Mean of the derived rates of depreciation B (%)	5.13	6.29	7.43
t value calculated	5.13	–2.70	–8.32
t value tabulated (at the level of 1%)	2.77	2.77	2.77
Null hypothesis (A = B)	reject	accept	reject

economy has achieved an average growth rate of 10.4 per cent. In the meantime, the growth rate of employment has been declining over time. However, capital stock recorded a steady rate of growth of about 11.6 per cent annually during 1982–97. According to Figure 4.1, it is clear that the growth rates of GDP and capital stock have moved closely over the past sixteen years. This trend of movement may imply that capital input has played an important role in driving China's economic growth.

4.4 Estimation results and interpretation

The initial estimates of the parameters in Equations (4.5) to (4.8) are presented in Table 4.3. Most coefficients are statistically significant with correct sign. The positive sign of the coefficient of the time trend indicates technological progress. The sign of the coefficient of the second-order term of the time trend implies that technological progress has accelerated as reforms deepen over time. The rates of efficiency change, technological progress and total factor productivity growth derived by applying the techniques described in Sections 4.1 and 4.2 are presented in Table 4.4. In general, the performance of productivity and efficiency in China has experienced considerable fluctuations during the period 1982–97. The downturn in 1989 can be attributed to the political upheaval in that year. However, the worst performance was recorded in the second half of the 1980s and, more recently, in the mid 1990s. These findings are interesting and deserve detailed investigation.

Technological progress tends to grow steadily over time. The average performance of the three indicators is positive for the entire period 1982–97,

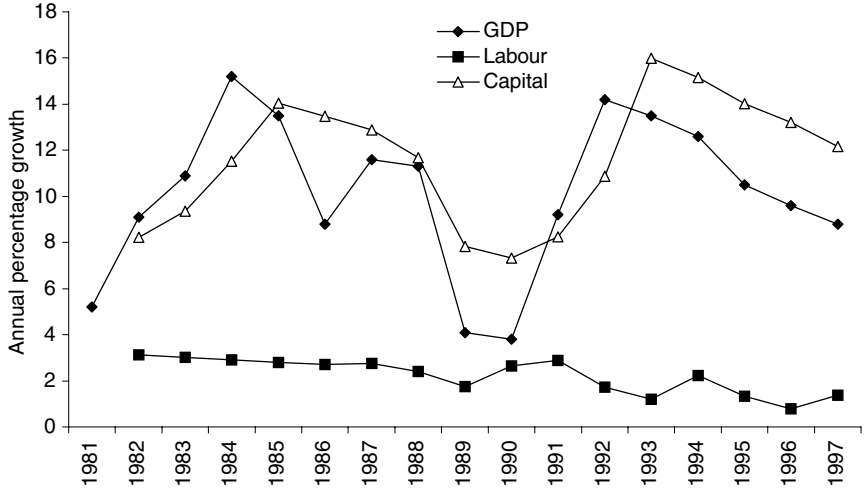

Figure 4.1 Growth rates of GDP, labour and capital stock, 1982–97

Sources: State Statistical Bureau (various issues) and author's own calculation.

Table 4.3 Estimation results of frontier production functions

Parameter	*Estimate*	*Standard error*
α_0 (intercept)	–0.4619	0.0635
α_1 (d_1)	0.3503	0.0330
α_2 (d_2)	0.2053	0.0171
α_3 (d_3)	0.2040	0.0186
α_4 (t)	0.0088	0.0067
α_5 ($0.5t_2$)	0.0002	0.0005
β_0 ($\ln L$)	0.3524	0.1233
β_1 (t ln L)	0.0039	0.0056
γ_0 (ln K)	0.6476	0.1233
γ_1 (t ln K)	–0.0039	0.0056
η_1 ($0.5 \ln L \ln L$)	0.1791	0.1230
η_2 (ln L ln K)	–0.1791	0.1230
η_3 ($0.5 \ln K \ln K$)	0.1791	0.1230
σ^2	0.0072	0.0009
λ	0.9993	0.0112
ς_0 (intercept)	0.1600	0.0234
ς_1 (td_1)	0.0099	0.0038
ς_2 (td_2)	–0.0035	0.0021
ς_3 (td_3)	0.0017	0.0027
ς_4 (td_4)	–0.0064	0.0029

with technological progress dominating productivity growth. Therefore, according to the findings in this chapter, it can be concluded that technological progress has contributed positively to China's growth in the past two decades. In addition, it is obvious from Table 4.4 that the movement of the three indicators can be examined in three separate periods, i.e., the early 1980s (1982–85), the second half of the 1980s (1986–91) and the 1990s (1992–97). For convenience of presentation, a summary of the mean rates of performance during the three periods is presented in the lower panel of Table 4.4.

It is clear from Table 4.4 that the Chinese economy had its best performance in the early 1980s, i.e., the years after the initiative of the reforms. Both efficiency and technological progress have experienced significant growth. Thus, China's economic reform has indeed brought about significant improvement in efficiency, that is, a level effect as also concluded by Borensztein and Ostry (1996). This finding is consistent with reality. China's reform began in the agricultural sector in the late 1970s and the success of rural reforms has now been well documented (e.g., McMillan *et al.* 1989 and Lin 1992). Economic reform boosts efficiency in several ways. First, reforms such as the introduction

Table 4.4 Estimated percentage rates of technological progress, efficiency change and productivity growth in China, 1982–97

Year	*TE*	*TP*	*TFP*
1982	0.39	1.23	1.62
1983	0.79	1.24	2.03
1984	2.17	1.25	3.42
1985	1.07	1.25	2.33
1986	–1.13	1.26	0.13
1987	–0.35	1.26	0.91
1988	0.79	1.26	2.06
1989	–1.25	1.28	0.03
1990	–0.40	1.29	0.89
1991	–2.74	1.30	–1.44
1992	1.90	1.30	3.20
1993	1.00	1.30	2.30
1994	0.42	1.30	1.72
1995	0.64	1.30	1.94
1996	–1.53	1.30	–0.22
1997	0.27	1.31	1.58
	Mean rates in selected periods		
1982–85	1.11	1.24	2.35
1986–91	–0.84	1.27	0.43
1992–97	0.45	1.30	1.75
1982–97	0.13	1.28	1.41

Note: TE, TP and TFP represent technical efficiency, technological progress and total factor productivity, respectively.

of the household responsibility system provided Chinese farmers with incentives to increase production and thus released suppressed growth potential in the old system. Second, the increase in rural labour productivity due to the reforms has encouraged rural out-migration which might lead to a gain in overall efficiency in the economy. According to estimates by the World Bank (1997a), the transfer of rural surplus labour has added one percentage point to China's overall growth rate. More recently, Woo (1998) derived a similar estimate.

However, according to Table 4.4, China's productivity performance in the second half of the 1980s suffered from a major downturn. During 1986–91, efficiency declined every year except 1988. As a result, the overall performance was the worst during the entire sample period 1981–97, with the average rate of

efficiency change being negative during 1986–91. The decline in efficiency may have occurred in all sectors in the economy. For example, Jefferson *et al.* (1992) observed a decline in efficiency in the industrial sector in the second half of the 1980s. The poor performance in the agricultural sector during this period has now been well analysed by economists (e.g., Kalirajan *et al.* 1996, Mao and Koo 1996). Finally, according to Fong and Tong (1998), the non-state sector, mainly the township, village and private enterprises (TVPs), also recorded poor efficiency during 1988–90 in all regions. There are a number of explanations for the poor productivity performance in the second half of the 1980s.

First, agricultural decline during that period contributed negatively to the overall performance of the economy. The decline was due to several factors such as the lack of investment in land and agricultural infrastructure by both farmers and governments, and the deteriorating terms of trade against agricultural products. Second, in the mid 1980s, a series of urban and enterprise reform packages were initiated and experimented with in China. Unlike the agricultural reform, these reform policies (including price reforms, decentralisation and industrial reforms) were much more complicated and took a longer time to bear fruit. Third, the reforms in the mid 1980s coincided with the austerity programme implemented in 1985. As a result, the state enterprise sector was badly affected by the credit squeeze. In the meantime, many TVPs had just started businesses and most of them entered sectors where resources were severely underpriced by the state. With limited channels for obtaining resources at that time, these TVPs were also hit hard by the austerity programme. Fourth, one of the most important reforms in the mid 1980s was the introduction of a dual-track system in the industrial sector. As argued by Young (2000), this system might encourage rent-seeking activities which are harmful to growth. Decentralisation in that period provided further opportunities for rent-seeking. All these developments undermined efficiency performance in the economy.

Fortunately, efficiency performance recovered in the early 1990s. All three indicators have shown an upward tendency. Several factors may have contributed to this phenomenal performance of the Chinese economy. First of all, the impressive performance may be the result of reforms initiated in the mid 1980s as these reform policies materialised over time. In particular, price decontrol was almost completed by the early 1990s. The removal of price distortions has created a better business environment for both domestic and foreign investors. Second, more comprehensive reforms were implemented in the early 1990s. These reforms have led to a massive inflow of foreign capital and the movement of rural surplus labour into the urban sector. Third, industrial reforms have resulted in the reallocation of workers out of the state-owned enterprises (SOEs). According to the World Bank (1997a), the gain from the reallocation of SOE workers in the 1990s has accounted for half a percentage point of China's growth rate.

Finally, according to Table 4.4, total factor productivity has recorded an average growth rate of 1.41 per cent during 1982–97. This growth is dominated by technological progress. Thus, China's economic reform has resulted in both a level as well as a growth effect. This finding may be used to support the

argument that China's growth is sustainable in the long run. However, Table 4.4 also shows that the major downturns in efficiency performance have been associated with the austerity programmes implemented by the government in 1985, 1989, 1992 and 1995, respectively. Credit squeeze under austerity policies has been partly responsible for the decline in efficiency for two to three years. The only exception was the 1995 adjustment that caused only a temporary interruption in 1996. This has been credited as a soft-landing which might be the result of a combination of factors such as favourable development in agriculture, the improved structure of the economy, more gradual tightening of economic policies and application of more effective policy instruments e.g., the interest rate and exchange rate (Oppers 1997). This last observation has important implications. It highlights the costs of macroeconomic management relying on administrative interventions rather than economic policy instruments.

4.5 Further analyses

Comparative issues

The estimation results and findings in the proceeding section can be compared to these reported in the literature on China and other countries. First, as a comparison, the estimates of TFP growth applying the conventional growth accounting method are computed as follows:

$$\dot{TFP} = \dot{Q} - (\alpha\dot{L} + \beta\dot{K}) \tag{4.14}$$

where dots indicate percentage changes, and the parameters α and β are the factor shares estimated from Equation (4.5) without the one-sided error term. Next, the calculated TFP growth rates together with selected estimates by other authors are shown in Table 4.5. According to this table, there are variations in the magnitude of productivity growth derived from both the frontier and conventional methods. Färe *et al.* (1994) applying OECD statistics have made the same observations and they attribute these variations to the difference in the techniques applied. However, according to Table 4.5, the trend of productivity changes estimated by the two approaches is similar during the period 1982–97. The Chinese economy achieved its best performance in the early 1980s but experienced a major downturn after 1985. In addition, it is worth pointing out that the average rates of productivity growth derived in this chapter using the two approaches are very close.

Sensitivity analyses

The objective of sensitivity analyses is to examine the robustness of the final estimation results. To achieve this goal, the modelling exercise conducted so far is repeated by assuming various values of the initial capital stock and different rates of depreciation. The choice of the value of the initial capital stock is based on the estimate (175 billion yuan) by Chow (1993) and the implied figure

Table 4.5 Estimated percentage rates of productivity growth in selected countries

Sources/countries	*Period*	*Frontier*	*Conventional*
China			
Li *et al.* (1995)	1979–90		2.53
Borensztein and Ostry (1996)	1979–94		3.80
Hu and Khan (1997)	1979–94		3.90
Maddison (1998)	1979–95		2.23
Young (2000)	1979–94		1.10
This chapter	1982–85	2.35	3.39
	1986–91	0.43	0.22
	1992–97	1.75	2.47
	1982–97	1.41	1.86
Other countries (Färe *et al.* 1994)			
Belgium	1979–88	0.92	0.61
Canada	1979–88	1.51	0.08
France	1979–88	0.81	0.16
Germany	1979–88	1.17	0.52
Italy	1979–88	1.95	1.43
Japan	1979–88	2.87	1.14
Sweden	1979–88	0.19	1.04
UK	1979–88	0.12	1.17
USA	1979–88	0.85	0.79

Source: As cited in the table.

(95.2 billion yuan) from Li *et al.* (1995). Table 4.6 shows the average rates of technological progress, efficiency change and productivity growth derived under different scenarios. According to this table, the estimated rates of performance during 1982–97 show a similar trend of change and the figures are surprisingly close to each other. In particular, with the preferred rate of depreciation of 7.0 per cent, the discrepancy between the estimated rates is trivial. Thus, it appears that the findings from sensitivity analyses provide no evidence against the robustness of the final results.

Accounting for China's growth

Finally, given the empirical results, the extended Solow growth accounting approach discussed in Section 4.5 is employed to decompose China's GDP growth into four components, that is, contributions due to labour and capital inputs, efficiency change and technological progress. The decomposition results are presented in Table 4.7. According to this table, the bulk of China's economic

Table 4.6 Results of sensitivity analyses

Values of initial capital stock (100 million yuan) and assumed depreciation rates	*Growth rate (%)*		
	TE	*TP*	*TFP*
Rate of depreciation 4%			
152	0.87	1.01	1.87
552	0.79	1.07	1.86
952	1.51	–0.03	1.48
1350	0.64	1.31	1.95
1750	1.45	0.14	1.59
Rate of depreciation: 7%			
152	0.15	1.26	1.41
552	0.23	1.15	1.38
952	0.13	1.28	1.41
1350	0.15	1.21	1.36
1750	0.13	1.26	1.39
Rate of depreciation: 10%			
152	0.08	1.32	1.40
552	0.07	1.29	1.36
952	0.18	1.13	1.31
1350	0.18	1.15	1.33
1750	0.18	1.16	1.34

growth was due to capital accumulation that on an average accounted for over 50 per cent of the total growth during 1982–97.

During the same period, total factor productivity on average contributed to 13.5 per cent of China's growth. This contribution came mainly from technological progress. It is also clear that efficiency improvement contributed to economic growth significantly in the early 1980s and modestly in the 1990s. As a result, the overall contribution of efficiency to growth was positive during the sample period. In comparison with other studies (with the exception of Woo (1998)), this chapter has derived a much smaller share for the contribution of total factor productivity. By either relying on ad hoc weights or using conventional growth accounting methods, previous studies may have over-estimated the share of productivity change over output growth.

4.6 Summary remarks

Applying a stochastic frontier technique to regional statistics, this chapter examined the role of productivity in China's economic growth during the period

Table 4.7 Accounting for China's growth

Source	*Period*	*Percentage shares*					
		L	*K*	*TFP*	*TE*	*TP*	*Residual*
This chapter	1982–84	12.2	44.3	19.3	9.1	10.2	24.2
	1986–91	15.2	64.4	5.3	–10.4	15.7	15.2
	1992–97	5.9	62.3	15.2	3.9	11.3	16.6
	1982–97	10.4	57.7	13.5	1.2	12.3	18.4
Borensztein and Ostry (1996)	1979–94			41.3			
Hu and Khan (1997)	1979–94	12.8	45.6	41.6			
World Bank (1997a)	1978–95	17.0	37.0	46.0			
Maddison (1998)	1978–95			29.8			
Woo (1998)	1979–94	14.0	52.7	12.9			

Source: As cited in the table.

1981–97. In particular, the analyses have focused on the performance of technological progress and technical efficiency change. The former refers to outward shifts in the frontier due to innovation and the latter refers to movements towards the frontier due to catch-up among the regions. It has been found that during the reform period, the bulk (57.7 per cent) of China's economic growth was due to capital input and that partial or incremental reforms did lead to a one-off increase in observed output in China. In contrast to Krugman's claim, productivity is found on average to be responsible for 13.5 per cent of China's total growth in the past two decades. This may indicate that China's growth will be sustainable in the near future.

However, according to this chapter, the contribution of total factor productivity to China's growth is much smaller than what has been observed in other economies. For example, according to Dougherty and Jorgenson (1996), productivity accounted for 26.2, 49.8 and 57.6 per cent of output growth during 1960–89 in the United States, Japan and Germany, respectively. It is thus clear that there will be ample scope for improvement in productivity performance in the Chinese economy. In addition, the estimation results have shown that efficiency performance has experienced considerable fluctuations. In particular, the major downturns have been associated with the austerity programmes implemented in the economy. This may imply that macroeconomic management through administrative interventions rather than economic policy instruments has been very costly to the Chinese economy. Recently, Chinese leadership has endeavoured to deepen the reform of the financial and state enterprise sectors. The completion of these reform programmes may help transform the Chinese economy into a more efficient one and hence ensure sustained growth in the future.

Finally, while this chapter has helped gain important insight into the performance of the Chinese economy in the past two decades, there are still other topics needing further study. These topics include the role of human capital, foreign direct investment and international trade. They are however beyond the scope of this chapter.

Part II

Growth in regional perspective

Part II moves away from the aggregate studies in Part I to focus on the Chinese regions. Two special topics are addressed in this part. The first topic is regional disparity and convergence (Chapter 5). The perception is that regional inequality has worsened as economic reform progresses in China. Worsening regional disparity is regarded as a potential threat to social stability. Chapter 5 contributes to the debates and presents new evidence of regional disparity and convergence/divergence. The second topic investigates economic growth and integration in the Southern China region including Hong Kong, Taiwan, Guangdong and Fujian (Chapter 6). This region has the most vibrant economies in the world over the past two decades. Have the economies benefited from increasing economic integration? Have the economies been converging? These are the questions to be answered in Chapter 6.

5 Regional growth, disparity and convergence

With two decades of reforms and subsequent economic growth, the Chinese economy in general and the well-being of the world's largest populace in particular has improved significantly. However, has the improvement been equal across regions? More importantly, has rapid economic growth led to reduction of regional disparities? These issues have become the focus of the recent debate on regional disparities in China. Understanding these issues has important implications not only for regional development policy but also for the continuation of the reforms in China. The objective of this chapter is to review the existing literature and to present new evidence of regional disparities in China. It thus contributes to the current debate and adds to the literature.

Specifically, this chapter extends the existing literature in several ways. First, there are already quite a few papers examining regional disparities in China. This chapter attempts to present a critical review of the literature. Second, this chapter makes use of China's regional GDP figures for the period 1952–97. This data set was released quite recently by the Chinese government (State Statistical Bureau 1997). Third, in the existing studies, China's three autonomous cities, Beijing, Shanghai and Tianjin, are often included in the 'coastal region' category. In this chapter it is argued that the three city economies are outliers as far as income per capita is concerned and that the findings in the existing literature may be biased due to the inclusion of these cities in the same group as the coastal provinces. One of the objectives here is to isolate the impact of these cities on the measurement of regional disparities. Finally, in the existing literature, one single deflator is often used for China's thirty regions. This is problematic, given China's vast size and market segmentation. To overcome the problem, this chapter for the first time applies regional price indexes in the empirical analysis. This is an important addition to the literature.

The rest of the chapter begins with a critical review of the existing literature (Section 5.1). Then data and methodological issues are discussed. This is followed by the computation and interpretation of new estimates of the indicators of regional disparities (Section 5.2). Subsequently, Section 5.3 presents evidence of regional convergence. The final section summarises the main findings and indicates the direction of further research (Section 5.4).

5.1 Previous studies: a review

It is argued that greater equality implies higher human capital accumulation and hence better economic performance (see Alesina and Rodrik 1994, Persson and Tabellini 1994, Chiu 1998, Clarke 1995). Empirical evidence has also shown that inequality exacerbates socio-political conflicts that in turn reduce growth.[1] This finding is of particular relevance to large countries like China. Because of concerns about social instability and unrest, regional disparity in China has for a long time attracted the attention of both scholars and policy makers. Reports on this topic have hence appeared continuously in the literature.

Existing studies have focused on assessing inequalities among regions (coastal, central and western), between rural and urban areas, and within the rural and urban households in China. These studies can be divided into two broad groups. Group one, covering the pre-reform period, consists of research work published in the 1970s and 1980s.[2] Group two, focusing on the post-reform period, includes the literature that appeared in the 1990s. Due to the limitations of Chinese statistics, the literature in group one presented mainly descriptive analyses often from the perspective of political economy. The findings from this literature are conflicting. For example, while Riskin (1987) and Lippit (1987) showed evidence of reducing disparities, Selden (1988) and Friedman (1987) argued the contrary. Since the earlier studies have been intensively surveyed in various sources, this chapter focuses on the group two literature only.[3]

There are more than thirty published studies focusing on post-reform China. A summary of some of these studies is presented in Table 5.1. According to this table, regional disparity has been investigated in the context of GDP per capita, household income, consumption, poverty and livelihood.[4] Not surprisingly, the findings from these studies are inconsistent. The dominant view in the literature is that inequality in China has worsened during the past two decades (e.g., Knight and Song 1993, Hussain *et al.* 1994, G. Wan 1998, Li and Zhao 1999). Tsui (1996) has however shown that regional disparity was reduced in the early 1980s but deteriorated in the late 1980s.

Researchers have used either GDP per capita or household survey data to address two main issues, i.e., regional disparity and its sources. The Gini coefficient has been the most popular indicator used. Other less popular indicators of inequality include the Theil index and the coefficient of variation.[5] However, few researchers have explained how they calculated their Gini coefficients. This makes it difficult to compare the findings from various sources as different methods are available for the computation of Gini coefficients.[6] The magnitude of the Gini coefficient estimated by different authors varies considerably. For example, the estimates have a mean of 0.34 in Lin *et al.* (1998), 0.29 in Zhang (1998) and 0.22 in Tsui (1996). There are also variations in the trend of movement of these indexes. While the Gini ratio has been rising according to Zhang (1998) and Zhao and Li (1997), it has been stable in the past two decades according to Tsui (1996) and Lin *et al.* (1998). These differences are due to several drawbacks in the existing literature.

Table 5.1 Summary of selected studies on regional disparities in China

Source	*Sample*	*Methods*	*Main findings*
Lyons 1991	1952–87/GVO/consumption	CV	disparity ↓ (consumption) ↑ (output)
Knight and Song 1993	1987/counties	Income functions	rural inequality ↑ among counties
Hussain *et al.* 1994	Survey data (1986) 5000 (urban/rural each)	Gini ratio Decomposition	low inequality / sources: urban non-wage and rural non-farming
Lee 1994	1984–90/NI	Growth equation	disparity in export contribution
Chen 1995	Survey data (1978–88)	Gini ratios	disparity ↑
Hu, Wang and Kang 1995	1978–94/GDP	CV Descriptive analysis	disparity ↓ but large regional disparity in international standard
Wei 1995	1952–91/NI	Gini ratios/CV	disparity ↓ (1978–91) but ↑ (1952–78)
Chen and Fleisher 1996	1978–93	Growth equation	regional convergence
Jian, Sachs and Warner 1996	1952–93 / GDP	Income dispersion	disparity ↓ and convergence
Chen and Ravallion 1996	Survey data (1985–90)	Rural poverty	increase in poverty
Rozelle 1996	Survey data (1983–92)	Gini ratio and sources	disparity ↑ late 1980s source: rural industrialisation
Tsui 1996	Post-reform	Gini/CV/GE sources	disparity ↓ early 1980s disparity ↑ late 1980s
Lyons 1997	1990/Fujian	Cross-tabulation	large disparity among countries
Zhao and Li 1997	Survey data (1988 and 1995)	Gini ratio	disparity ↑ (and sources of disparity)
Research Team 1997	1978–96	Gini ratio/descriptive analysis	disparity ↑ but still low by international standards
Meng and Wu 1998	1000 rural households	Income equation	sources of income differential
Hu 1997	1980–95/GDP	Regional shares	increase in disparity
Li, Zhao and Zhang 1998	Survey data (1988 and 1995)	Gini ratio, CV	disparity ↑ / sources

Source	*Sample*	*Methods*	*Main findings*
Lin, Cai and Li 1998	1978–95 GDP and household income	Gini and Theil ratios decomposition	disparity ↑ between regions disparity ↓ within regions
Tian 1998	Post-1978 / GDP	CV	interprovincial disparity ↓ coastal-interior disparity ↑
Duncan and Tian 1998	1952–95/NI	CV	disparity ↓ (output) ↑ (livelihood)
G. Wan 1998	1984–96/aggregate household income	Gini ratio decomposition	rural inequality ↑ sources: wage/non-wage incomes
Gustafsson and Li 1998	Survey data (1988)	Income equation locational aspects	rural-urban gap accounts for 30% of total disparity
Zhang 1998	Survey data (1988 and 1995) 1980–95 aggregate	Gini ratios/ Decomposition	rural inequality ↑ source: non-farming income
Khan and Riskin 1998	Survey data (1988 and 1995)	Gini ratios decomposition	inequality ↑ and more in urban China source: non-farming and rental income
Tsui 1998	Rural household data/late 80s	Theil indexes/decomposition	sources of regional disparities
Khan *et al.* 1999	Survey data (1988 and 1995)	Gini ratio	inequality ↑
Yang 1999	Survey data	Gini ratio	inequality ↑

Source: As cited in the table.

Notes
CV, Gini ratio and GE stand for coefficient of variation, Gini coefficient and methods, respectively. 'disparity ↓' and 'disparity ↑' indicate disparity-reducing and disparity-increasing. GVO, GDP and NI represent gross value of output, gross domestic product and national income.

The first is associated with the choice of income data. Both GDP and household survey data are used in the existing studies. Data on per capita GDP for the pre-reform period were released in 1997 for the first time.[7] Earlier studies covering the pre-1978 period were based on either national income (NI) figures or GDP data estimated by scholars outside China. These data sets themselves are not consistent and are often subject to biases. As for household survey data, the selection of samples is problematic and the size of samples is often too small to represent all regions of China. In addition, household survey data are often available for particular years only and hence can hardly provide any information on the dynamics of inequality.

The second problem is related to the methodological issues. The empirical findings are based on the application of various methods. In the case of Gini coefficients, without more detailed information about computations, a comparison of the final results is very difficult. For the coefficient of variation, both weighted and unweighted indexes are reported without explanations in the literature.

Finally, few researchers state clearly whether they use income in constant prices. In some cases, the price deflators are not described satisfactorily. There are two problems with price deflators. One is that regional variations are rarely taken into consideration due to the lack of regional price indexes. Another is that official deflators are imprecise.

5.2 New evidence on regional disparities

This section attempts to improve on previous studies by using the recently released GDP data to derive new estimates of disparities among China's thirty regions.[8] In particular, the focus of the analysis is the impact of the three largest cities on the estimates of regional disparity. Regional GDP data for the period 1953–77 are employed here for the first time, as far as the author knows.[9] Region-specific price indexes are used to deflate income figures so that regional price variations are taken into account (see Chapter 2 for details). In addition, this section also aims to compare the findings from different methods, e.g., the Gini ratio, coefficient of variation and Theil index. Furthermore, for the purpose of comparison, following the official grouping, China's thirty regional economies are geographically divided into three groups, i.e., the coastal, central and western regions (Figure 5.1). According to this classification, the three autonomous cities, Beijing, Shanghai and Tianjin, are included in the coastal category. Thus, these large cities together with the provinces in the coastal group are often compared to other regions which consist of provincial economies only. This is problematic as these three cities are mainly urban economies. They should be compared to other cities rather than to the provinces. A similar argument has also been raised against comparing Singapore and Hong Kong to other continental economies (Easterly 1995).[10]

As a matter of fact, GDP per capita in 1998 amounted to 28,236 yuan (US$3410) in Shanghai, 18,423 yuan (US$2225) in Beijing and 14,041 yuan

Figure 5.1 Mainland China's three regions

Source: Modified from Wu (1996a, p. 82).

(US$1696) in Tianjin. These income figures are far greater than the national average of 6,404 yuan (US$773) in the same year. Thus, the three cities are truly outliers in terms of per capita income. For these reasons, the three cities are separated from the provincial economies in this chapter. In what follows, a description of the data used is presented first. Then various estimates of regional disparities are reported and investigated.

Data and methodological issues

Income used in this chapter takes the value of GDP per capita, released by the State Statistical Bureau (1997, 1998a), which is available for the period 1952–97.[11] It is expressed in 1953 constant prices. The deflators are described in Chapter 2. The use of the derived price series implies that the official GDP growth rates, though debatable, are accepted in this chapter.[12] One may also question the accuracy of the official estimates of GDP for the pre-1978 period. But these issues are beyond the scope of this chapter.

For the purpose of comparing this study with the existing literature, the Gini ratio, Theil indexes and weighted coefficients of variation are calculated and

analysed in the following section. These indicators of regional disparity are computed by using the following formulae:

$$\sqrt{\sum p_i (Y_i - \mu)^2} \;/\; \mu \quad \text{(weighted coefficient of variation)} \tag{5.1}$$

$$\sum Y_i \log (Y_i / \bar{Y}) \;/\; n\bar{Y} \quad \text{(Theil index)} \tag{5.2}$$

$$\sum \sum \sqrt{(Y_i - Y_j)^2} \;/\; 2n^2 \bar{Y} \quad \text{(Gini coefficient)} \tag{5.3}$$

where p_i is the share of population of region i (over the national total), Y_i income, $\bar{Y}$ the mean of Y_i, μ population-weighted average income, i.e., $\mu = \sum p_i Y_i$ and n the number of regions.

Interpretation of estimation results

Given the above descriptions, the empirical results are reported in Figures 5.2, 5.3 and 5.4. Surprisingly, these indexes show consistent patterns of regional disparity over time. As a result, interpretation of the results can be based on any of the charts. Due to its popularity, the Gini ratio is referred to in the following analysis. Several observations are worth noting.

First, the impact of the three city economies on the magnitude of these indexes is dramatic in Figures 5.2, 5.3 and 5.4. With the inclusion of these cities, the magnitudes of the indexes double or triple. For example, without

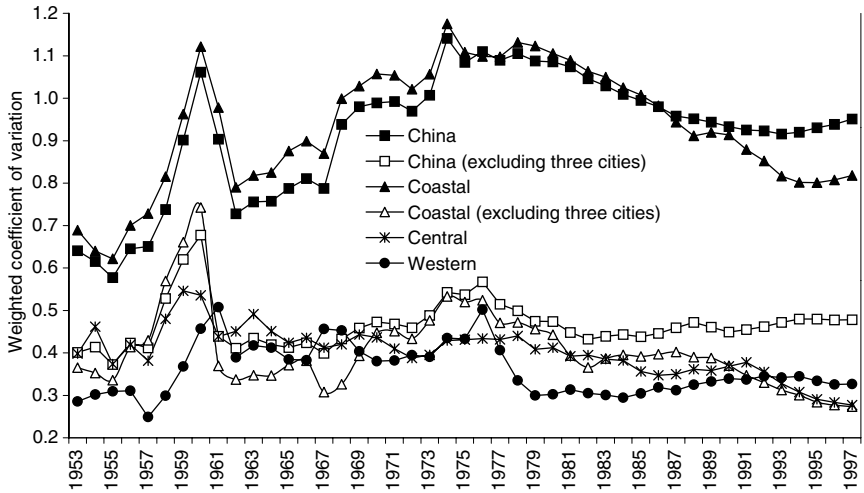

Figure 5.2 Estimates of the weighted coefficients of variation

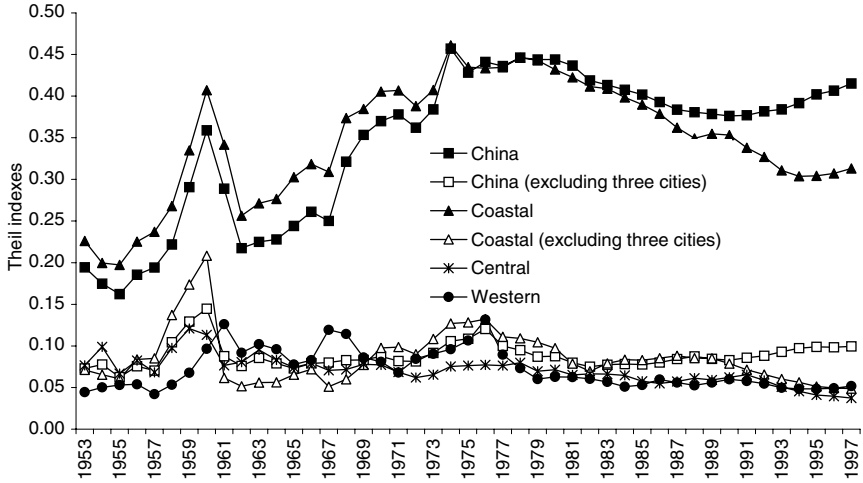

Figure 5.3 Estimates of the Theil indexes

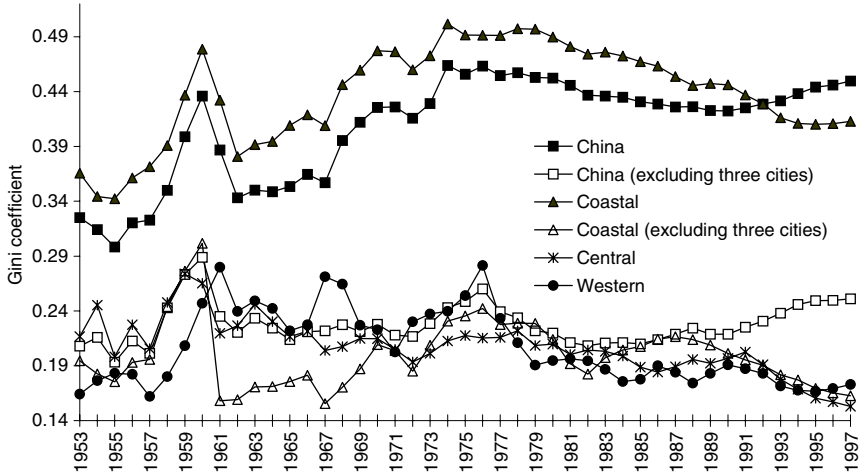

Figure 5.4 Estimates of the Gini coefficients

these three cities, the Gini ratios in Figure 5.4 range from 0.15 to 0.30, which implies low disparity within the regions according to international standards. However, with the presence of the three cities, the Gini ratios imply much severer disparities between the Chinese provinces (China in Figure 5.4) and within the coastal region (Coastal in Figure 5.4). The greater value of the Gini coefficient reflects the larger disparity between the three cities and the rest of

China. This is also the case within the coastal region if the three large cities are included.

Second, according to Figures 5.2, 5.3 and 5.4, regional disparity in China was reduced slightly in the early 1950s but has deteriorated dramatically since the late 1950s. It peaked in the mid 1970s. Once again, this worsening situation was mainly due to the widening gap between the three cities and the rest of China. To some extent, this gradually widening gap captured the rising disparity between the rural and urban areas during the pre-reform period. Li and Zhao (1999) argued that urban and rural disparity accounted for over 40 per cent of China's total inequality. Figures 5.2, 5.3 and 5.4 show clearly that if the three cities are excluded from the analysis, regional disparity has been relatively stable in the pre-reform decades with the exception of a few years in the late 1950s. The exceptional period coincided with the Great Leap Forward movement initiated in 1958. Data for that period are notoriously unreliable. For example, during the period 1958–60, Shanghai's GDP grew at the rate of 33 per cent per annum. In addition, the then Chinese leader's ambition to achieve a great leap forward for China's industrial sector boosted relatively industrialised regions at the expense of other regional economies. Regions with a relatively more developed industrial sector include the three large cities, three north-eastern provinces (i.e., Liaoning, Jilin and Heilongjiang – heavy industrial areas) and three north-western regions (Xinjiang, Ningxia and Qinghai – concentrations of military establishments). Due to the biased development strategy during the period 1958–60, the average annual growth rates for the above-mentioned three regions were 26, 23 and 24 per cent respectively, while that for the rest of China was only 6 per cent.[13]

Third, regional disparities declined in the 1970s and 1980s, in particular in the late 1970s and early 1980s. This decline was due to the fall in disparity not only between the three cities and the rest of China but also within each region. One of the contributing factors was the rising rural income which narrowed the gap between the rural and urban areas during that period. Thus, in contrast to most studies, this investigation shows that economic reforms in the late 1970s and early 1980s led to a reduction in regional disparities in China. However, this finding can easily be overlooked if the three cities are not singled out in the analysis. This is the main problem with previous studies. With the inclusion of the three large cities, the value of the Gini ratio is estimated to be as great as 0.50 in the 1970s according to Figure 5.4.

Finally, disparities within each region have shown a trend of continuing decline since the late 1970s. This trend has resumed in the 1990s. The three charts also show that the gap between the three cities and other coastal provinces has narrowed in the past two decades. However, a phenomenal development in the 1990s is the widening disparity between the coastal group and the other two groups (central and western regions). This is true whether the three cities are excluded from the analysis or not. As a result, overall regional disparity in China has been deteriorating according to Figures 5.2, 5.3 and 5.4. Many authors have arrived at the same conclusions (e.g., Tsui 1996, World Bank 1997b, Lin *et al.* 1998). Major contributing factors include the bias of development strategy

towards the coastal regions after Deng Xiaoping's much publicised tour of South China in 1992 and the subsequent massive inflow of foreign capital to the coastal areas. However, with the exclusion of the three cities, the Gini ratios indicate that China's regional disparity, though rising in the 1990s, is still modest (Gini coefficient still below 0.30). Thus, if the three cities are not singled out, the indicators of regional disparity are inflated considerably and the resultant conclusions can be misleading.

To sum up, the presence of the three cities may partly explain the variation in empirical estimates of Gini ratios for China. Figure 5.5 illustrates the Gini ratios derived in this study and by several other authors. Estimates of the Gini ratios with and without the three cities are reported in this chart. It appears that the two estimates derived in this study represent the upper and lower bounds of the estimated Gini ratios in Figure 5.5. If the three cities are isolated, the estimates show that the trend of regional disparity in China is not as alarming as claimed by many observers. With the exclusion of the three mega-cities, China's regional disparity (with a Gini ratio of 0.20–0.25) is still low by international standards.

China's regional disparity in international perspective

To shed some light on China's regional disparities in international perspective, this section presents some evidence from selected cross-country studies (Table 5.2). The figures presented in Table 5.2 are of course subject to serious qualification. They are constrained by the availability and consistency of statistics for the countries involved and are reported here for the sake of illustration. For

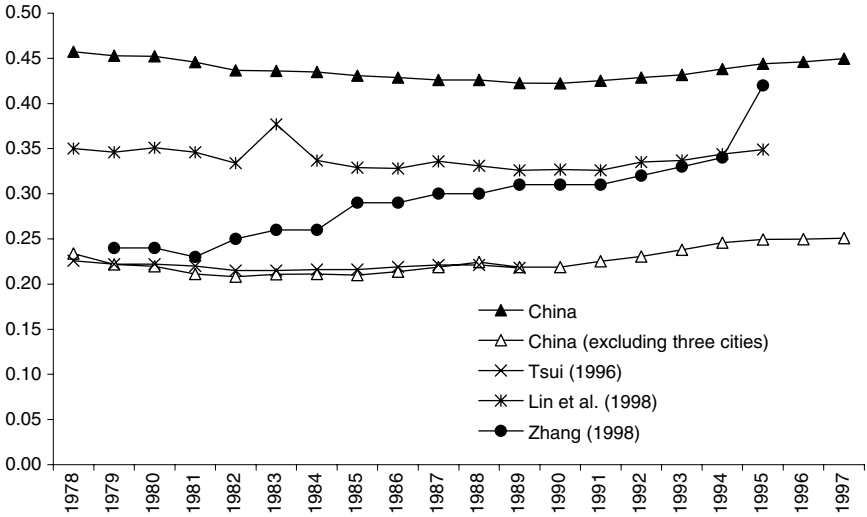

Figure 5.5 Various estimates of Gini ratios

Source: Lin *et al*. (1998), Tsui (1996), Zhang (1998) and author's own estimates.

Table 5.2 Indicators of regional disparities in selected countries

Country	*GDP ratio*	*Gini ratio*	*CV*
China			
1953	4.1 (8.9)	0.21 (.33)	0.52 (0.80)
1963	4.3 (12.8)	0.23 (0.35)	0.53 (0.87)
1973	7.4 (24.9)	0.23 (0.43)	0.57 (1.21)
1978	7.2 (27.4)	0.23 (0.46)	0.58 (1.34)
1985	6.3 (23.6)	0.21 (0.43)	0.41 (1.17)
1993	7.0 (25.8)	0.24 (0.43)	0.45 (1.13)
1997	7.6 (33.1)	0.25 (0.45)	0.45 (1.20)
India	3.3 (1980)	0.42 (1975/76)	0.36 (1980)
Indonesia	4.0 (1983)	0.32 (1987)	0.34 (1983)
South Korea	1.53 (1985)	0.36 (1971)	0.15 (1985)
USA	1.4 (1983)		0.11 (1983)
UK	1.6 (1988)		0.15 (1988)
Japan	1.5 (1981)		0.12 (1981)

Notes and sources:
GDP ratios are the ratios of GDP per capita of the richest region over the poorest region. The figures for China are derived in this chapter and two sets of them are computed with the exclusion and inclusion (in parentheses) of the three large cities, respectively. The estimates for other countries are from Khan *et al.* (1993, p. 61) for the Gini ratios and Hu *et al.* (1995, p. 92) for the GDP ratios and the coefficients of variation (CV).

international comparisons of regional disparity, researchers have focused on comparing the value of the Gini coefficients and the income ratio of the richest to the poorest cohort in an economy. Table 5.2 shows conflicting results. On the one hand, the magnitudes of the GDP ratios and the coefficients of variation show that regional disparity is much severer in China than in other countries. On the other hand, the estimates of the Gini ratios provide evidence of relatively less disparity in China than in other countries. Once again, China's regional disparities are significantly inflated if the three large cities are included in the analysis. The slight increase in regional disparities in the 1990s is also very clear in Table 5.2. Any conclusion on the basis of either of these indexes is likely to be biased. Thus, the statements in some previous studies can be misleading due to researchers' choice of indices.

5.3 Convergence or divergence

In the growth literature, two types of convergence have been defined, i.e., the sigma and beta convergence (Barro and Sala-i-Martin 1995). The observed periodical decline of the disparity indices as described in Section 5.3 can be treated as evidence of sigma convergence following the neoclassical growth

theory. Sigma convergence occurs if cross-sectional disparity of per capita income declines over time. Another concept is beta convergence which measures how fast poor regions catch up with rich ones. It is shown that beta convergence is a necessary but not a sufficient condition for sigma convergence (Barro and Sala-i-Martin 1995, p. 385). Beta convergence can be estimated in the following framework

$$\log Y_{iT} - \log Y_{i0} = A - \left(1 - e^{-\beta T}\right) \log Y_{i0} + \varepsilon_i \tag{5.4}$$

where Y_{i0} and Y_{iT} are the initial income and income at the end of the period considered, T the length (years) of the period, β the convergence rate per annum, A the intercept and ε_i the error term.

Various time intervals were tried to derive estimates of beta convergence. Judging from the sign and the value of the coefficients, per capita income has diverged in most time periods. To reflect regional variations in convergence, two dummy variables representing the central and western regions were added to the regressions. It is argued that the inclusion of these dummies would help to obtain accurate estimates (Barro and Sala-i-Martin 1995). However, the estimation results from the expanded regressions were more or less the same. For the sake of brevity, a summary of the findings for the time interval corresponding to the Five Year Plan periods in China is presented in Table 5.3. It is clear that, during the eight Five Year Plan periods, the regions have mainly shown the tendency of divergence or weak convergence. The only period during which convergence was strong was 1981–85, with an annual rate of convergence of about 1 per cent.

Table 5.3 Estimation results of β-convergence

Period	*Without dummies*	*With dummies (intercept)*
Five Year Plans (FYP)		
1st: 1953–57	Weak convergence	Weak convergence
2nd: 1958–62	Divergence	Divergence
3rd: 1966–70	Divergence	Divergence
4th: 1971–75	Divergence	Divergence
5th: 1976–80	Weak convergence	Weak convergence
6th: 1981–85	Strong convergence	Strong convergence
7th: 1986–90	Weak convergence	Weak convergence
8th: 1991–95	Divergence	Divergence
1991–97	Divergence	Divergence
1953–97	Weak convergence	Weak convergence

Note: The dummies considered include one each for the western and central regions.

This trend of convergence has also been found in studies of other variables such as efficiency (Wu 1998) and income (Jian *et al.* 1996).

To make a comparison with the existing work by Jian *et al.* (1996), Gundlach (1997), and Raiser (1998), regressions applying data of the same periods were run and, unfortunately, none of these regressions appeared to result in the same findings by the above-mentioned three studies (Table 5.4). The discrepancy may be due to the inconsistency of statistics used. For example, Raiser applied GDP per worker while GDP per capita is used in this study. However, both this study and Raiser's have shown that (1) there was evidence of beta convergence in the late 1970s and early 1980s, and (2) convergence slowed down in the second half of the 1980s. In addition, results from regressions including regional dummies show that convergence was faster in the central and western regions than in the coastal region. Furthermore, convergence has occurred within the central and western regions in the entire period of 1978–97 (Table 5.5).

5.4 Concluding remarks

This chapter presented a comprehensive review of the existing literature on regional income disparities and convergence in China. The focus of the debate in the literature is the impact of China's economic reform on regional disparity. The findings of existing studies are inconclusive and often conflict with each other due to several common problems associated with statistics and methodologies. This chapter uses recently released regional GDP data to estimate various indicators of disparity and these estimates are compared to the findings by other authors. In addition, the same database is used to examine regional convergence in China and to estimate the rate of convergence if there is

Table 5.4 β-convergence estimates in this and other studies

Period	*Without dummies*				*With dummies (intercept)*	
	This study	*Raiser*	*Gundlach*	*Jian et al.*	*This study*	*Raiser*
1978–83	1.0**	3.1*	n.a.	n.a.	1.0**	n.a.
1984–89	0.3	1.8***	n.a.	n.a.	0.3	n.a.
1978–89	0.7***	2.2*	2.2**	n.a.	1.1***	n.a.
1978–85	0.9**	3.4*	n.a.	n.a.	1.4*	4.0*
1985–92	0.0	0.8	n.a.	n.a.	0.0	2.1***
1978–92	0.5	2.6*	n.a.	1.6**	1.4*	3.4*
1978–97	0.4	n.a.	n.a.	n.a.	1.5*	n.a.

Sources: Jian *et al.* (1996), Gundlach (1997) and Raiser (1998).

Notes
* Significant at the level of 1%.
** Significant at the level of 5%.
*** Significant at the level of 10%.

Table 5.5 β-convergence among the regions

Period	*Coastal*		*Central*	*Western*
	This study	*Raiser*		
1978–85	1.1	4.1%	2.3**	2.8
1985–92	1.4	3.3%	divergence	divergence
1978–92	1.4	3.5%	1.1	1.7
1978–97	1.4		2.2**	1.3
1953–97	divergence		0.9**	divergence
Five Year Plans (FYP)				
1st	divergence		1.3	2.8
2nd	1.0		divergence	divergence
3rd	divergence		1.1	divergence
4th	divergence		divergence	divergence
5th	0.6		0.8	0.6
6th	1.1		2.3***	2.3
7th	0.8		divergence	divergence
8th	2.2		4.4*	2.5

Source: Raiser (1998) and author's own estimates.

Notes
* significant at the level of 5%.
** significant at the level of 15%.
*** significant at the level of 20%.

evidence of convergence. Several conclusions were drawn from the comparison, as follows:

- According to this study, regional disparity has experienced considerable fluctuation in the past forty-five years. It peaked in the early 1970s. The bias of development strategy towards the industrial and urban sectors aggravated China's regional disparity in the pre-reform decades.
- Economic reforms in the late 1970s and early 1980s have generally contributed to a reduction in regional disparities according to this study. During the 1990s, while disparity within each region was declining, the gap between the coastal provinces and the rest of China widened. This is largely due to the bias of development policies towards the coastal region in the 1990s.
- This study argues that China's three autonomous cities, Beijing, Shanghai and Tianjin, are outliers in terms of per capita income. Excluding these cities, Chinese regional economies have shown modest disparities. Earlier studies comparing these cities to the provinces are likely to be biased and hence to result in misleading conclusions.

- International comparisons of regional disparities are affected by the quality of data and the choice of indicators. On the one hand, according to the estimates of the Gini coefficients, China's regional disparity is still low relative to other countries. On the other hand, if the GDP ratio of the richest over the poorest regions is compared, China has shown the worst regional disparity of both developing and developed countries. Thus, conclusions based on either indicator are misleading.
- China's regional economies have experienced different rates of convergence during the reform period (1978–97). In general, convergence was fast in the late 1970s and early 1980s. The two non-coastal regions have converged faster than the coastal economies.

While the findings in this chapter provide an alternative view on and hence fresh insight into the issue of regional disparities and convergence in China, there is still scope for further research in this area. For example, the present study could be extended to cover two more issues. First, the same techniques employed in this study could be applied to household survey data when they are available in the near future. This would make it possible to compare the findings from analysis of GDP statistics and household survey data, respectively. Second, the source of regional disparities in China is an important issue not covered in this study.

6 Growth and integration in South China

In the midst of the 1997 Asian financial crisis, three economies remained less affected. These were the economies of Hong Kong, Taiwan and mainland China, also called the Greater China economies by some researchers.[1] Why have these three economies so far avoided a crisis? This question deserves detailed investigation.

The objective of this chapter is to make a contribution by examining economic integration and its impact on productivity in the economies of Hong Kong, Taiwan, Guangdong and Fujian, which have been referred to as the Southern China Growth Triangle (Tang and Thant 1994). The existing literature has investigated complementarities, trade, and investment flows among the member economies.[2] Little work has been carried out to explain and compare growth and the role of productivity in these economies. This chapter attempts to fill the gap in the literature by focusing on regional integration and its impact on growth and productivity.

This chapter first presents some evidence of regional integration (Section 6.1). Then the general trend of productivity change among the member economies is examined (Section 6.2). This is followed by an econometric study of total factor productivity growth in the four regions (Section 6.3). Finally, the chapter is concluded with some summary remarks (Section 6.4).

6.1 Evidence of regional integration

Taiwan, Hong Kong, Guangdong and Fujian have been four of the most dynamic economies in the world (Table 6.1). On the one hand, Taiwan and Hong Kong, as two of the four East Asian Tigers, have been well known for decades. On the other, Guangdong and Fujian have sustained a double-digit rate of growth for two decades. Robust growth has narrowed the gap in the level of development among the four economies and accelerated regional integration. The latter has been vital to the continued growth of Taiwan's and Hong Kong's economies in the 1980s and 1990s despite prolonged recession in the industrialised economies. Regional integration is also important to economic development and reform in Guangdong and Fujian.

Several factors have contributed to the rapid integration of the four economies. These include geographical proximity, shared cultural and language

Table 6.1 Summary statistics of the Southern China economies

Indicator	*Hong Kong*	*Taiwan*	*Guangdong*	*Fujian*	*China*
Population (millions)	7	22	71	33	12,363
Area (1000 sq. km)	1	36	178	121	9,600
GDP (US$ b)	173	283	88	36	901
GDP pc (US$)	26,601	13,150	1,256	1,115	732
GDP pc (1985 ppp$)	19,074	11,863	3,449	3,061	2,016
GDP composition (%)					
Primary	0.1	2.6	13.5	19.2	18.7
Industry	15.5	33.5	49.9	43.1	49.2
Services	84.4	63.9	36.6	37.7	32.1
GDP growth rates (%)					
1978–87	8.4	8.7	11.5	12.8	10.1
1988–97	5.1	6.6	15.1	15.6	9.8

Sources: State Statistical Bureau (1998a), Council for Economic Planning and Development (1996), Statistical Yearbook (1998) and International Monetary Fund (1998).

Note: Unless stated, the figures refer to 1997 statistics.

background, China's open door policy in the past two decades and Taiwan's lifting of martial law in 1987. In addition, economic complementarities among the four regions have been the ultimate driving force of integration. The economies of Taiwan, Hong Kong, Guangdong and Fujian have gone through different stages of development, with the first two being more capital-, technology-, and skill-intensive. As a result, these four economies complement each other and their integration enhances competitiveness and self-sufficiency. Through close linkage with Hong Kong and Taiwan, Guangdong and Fujian can gain access to advanced technology, information and offshore capital markets. In the meantime, Hong Kong and Taiwan can take advantage of mainland China's cheap labour, land and other resources, and huge domestic markets.

It is evident from Figure 6.1 that during the past two decades the economies of Taiwan, Hong Kong and mainland China have moved closely. This has been possible through increasing trade and investment flows among the regions, in particular among the four economies considered in this chapter (see Table 6.2).[3] On the one hand, Hong Kong and Taiwan are now the main sources of foreign investment in and tourism to Guangdong and Fujian. On the other hand, Guangdong and Fujian have been important destinations of Hong Kong and Taiwan's exports in the past decade. In addition, Hong Kong was the second largest buyer of Taiwan's exports in 1997. These linkages have enhanced the interdependence of these economies and promoted their integration. Subsequently, integration has important implications for the productivity and growth performance among the member economies. This is to be examined in the following sections.

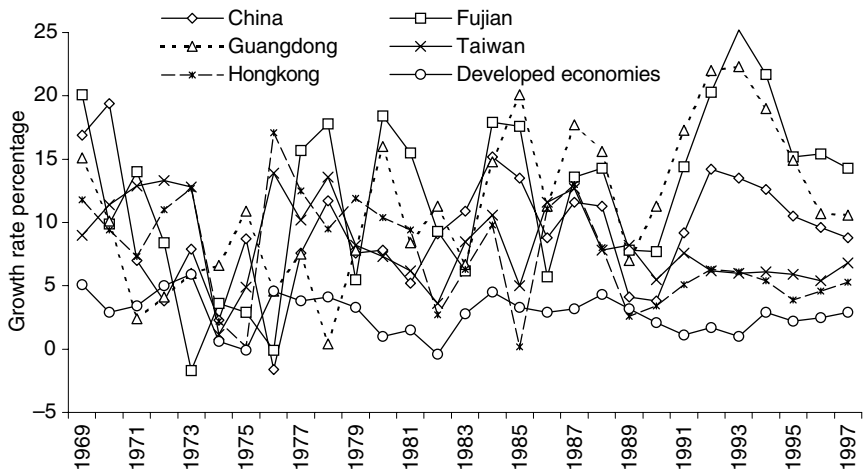

Figure 6.1 GDP growth rates of selected economies, 1969–97

Source: See Table 6.1.

Table 6.2 Indicators of regional integration in 1997

	Taiwan	*Hong Kong*	*World*
Guangdong			
Exports to	1.4	29.2	74.6
Imports from	10.5	4.6	55.6
Investment from	0.5	9.8	14.2
Tourists from	1.3	42.1	45.5
Fujian			
Exports to	n.a.	4.9	11.6
Imports from	n.a.	4.1	7.9
Investment from	n.a.	2.3	4.2
Tourists from	0.3	0.5	1.2

Sources: Guangdong Statistical Bureau (1998) and Fujian Statistical Bureau (1998).

Note: The units are US$ billion and million persons.

6.2 Productivity trend

The trend of productivity movement can be investigated in two forms, i.e., partial and total factor productivity indexes. Partial productivity indexes, i.e., labour and capital productivity, are often preferred by researchers for their simplicity of computation. Total factor productivity, however, has the advantage of taking all

factor inputs into consideration. For the purpose of comparison, both partial and total factor productivity indexes are examined in this chapter.

Data issues

To examine the trend of productivity movement, the production process is assumed to involve one output and two inputs. Output takes the value of GDP in each region. The two inputs are labour and capital. Labour represents the number of persons employed. Capital takes the value of capital stock in each economy. The measurement of capital stock is controversial as researchers often have to derive their own estimates due to the paucity of data available. In this chapter, capital stock is estimated using the backcasting approach discussed in Chapter 2. According to this approach, given the rate of depreciation and the incremental capital at time t (ΔK_t), capital stock (K_t) at time t for each region can be estimated. ΔK_t is available for the period 1968–97 for Taiwan and Hong Kong and for the period 1952–97 for Guangdong and Fujian.[4] In the empirical analyses, capital stock and GDP are expressed in 1990 constant prices.

Labour and capital productivity

The indexes of labour productivity calculated in local currencies have shown rapid catch-up by Fujian and Guangdong to their counterparts, Hong Kong and Taiwan (see Figure 6.2). This observation is consistent with the now well-known conclusion that poor economies can exploit their advantages of backwardness and hence catch up with rich ones (Kuznets 1973, Wolff 1991). While Figure 6.2 can help us gain valuable insights into the performance of the four economies, a

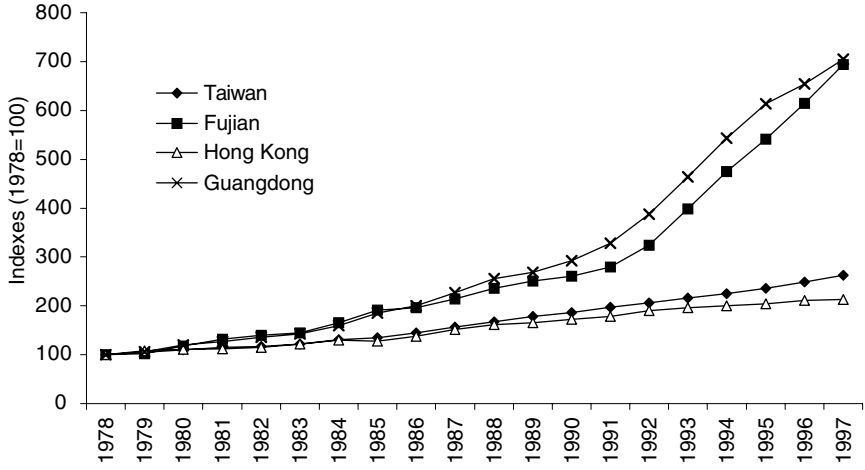

Figure 6.2 Labour productivity indexes, 1978–97

different picture is shown in Figure 6.3 which depicts the movement of labour productivity levels computed in terms of US dollars. It is apparent that labour productivity in Guangdong and Fujian has hardly changed in the past two decades. This is a puzzle. The problem lies in the use of official exchange rates. Chinese currency, the renminbi, has devalued by as much as 80 per cent during 1978–97, which has effectively offset the real growth in labour productivity during the same period.[5] This bias has raised the question of the accuracy of official exchange rates and hence led to the concept of purchasing power parity (PPP) rates or international dollar exchange rates.[6]

The use of PPP rates is vital for cross-economy comparisons. To derive a set of PPP rates for the four economies considered, Summer and Heston's (1991) estimates are employed and extended in this chapter.[7] As a result, all value-based variables can be expressed in terms of 'international dollar', and the level of labour productivity in the four economies can be compared to each other. Table 6.3 shows that Hong Kong's labour force has been the most productive one in the four regions. It is also clear that, in terms of labour productivity, Guangdong and Fujian have lagged behind but showed rapid catch-up with Taiwan and Hong Kong, in particular in the 1990s. As a result, relative labour productivity in the two mainland provinces increased significantly though the gap was still huge: workers in Hong Kong were still about six times as productive as their counterparts in Guangdong and Fujian in 1997.

The trend of productivity movement can also be examined by investigating capital productivity that is defined as the ratio of GDP to the value of capital

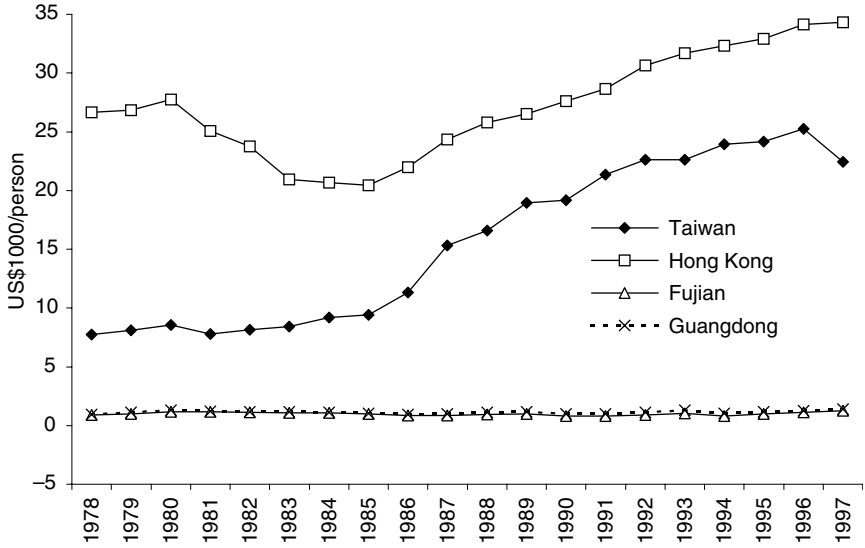

Figure 6.3 Labour productivity level, 1978–97

Table 6.3 Labour productivity

Region	*1978*	*1983*	*1988*	*1993*	*1997*
ppp$1000/person					
Hong Kong	26.4	32.3	42.9	53.7	58.3
Taiwan	12.2	14.6	19.8	25.9	31.4
Guangdong	2.7	3.5	4.9	7.7	10.3
Fujian	2.5	3.3	4.2	6.1	9.3
Indexes (relative to Hong Kong = 100)					
Hong Kong	100	100	100	100	100
Taiwan	46	45	46	48	54
Guangdong	10	11	12	14	18
Fujian	10	10	10	11	16

stock. GDP and capital stock can be expressed in either local or other currencies. As the same unit is used for both numerator and denominator, conversion is not a problem. Figure 6.4 presents the historical movement of capital productivity in the four economies over the past two decades. It is clear that capital productivity in the four regions has been declining and tends to converge over time.

Total factor productivity

With all variables being expressed in a common unit, (the international dollar), total factor productivity performance among the economies can then be

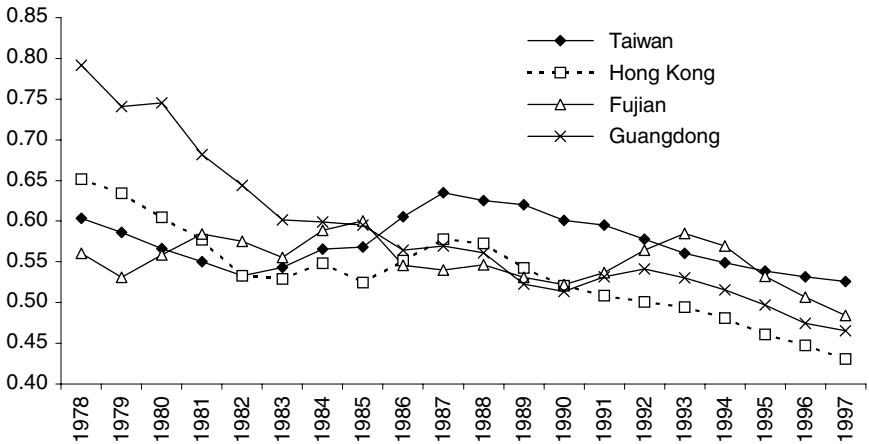

Figure 6.4 Capital productivity indices, 1978–97

computed and analysed. Following Solow (1957), total factor productivity is defined as the ratio of total output to the weighted average of all inputs. The weights are usually factor shares. Thus, the choice or determination of factor shares is the key to the computation of total factor productivity indices, and often very controversial.[8] In the existing literature, authors have used or derived various factor shares for the economies concerned. For example, Young (1995) estimated a capital share of 0.37 for Hong Kong and 0.29 for Taiwan (Table 6.4). Variations in the weights or factor shares used have naturally resulted in different TFP estimates.

To investigate the sensitivity of TFP estimates to the value of factor shares, Table 6.5 presents results under different scenarios. It is clear in this table that TFP estimates are very sensitive to the value of factor shares. Thus, researchers' conclusions based on inaccurate information of factor shares can be misleading.

However, several conclusions can be drawn from Table 6.5. According to the existing literature, it can be assumed that capital share for the four economies concerned ranges from 0.25 to 0.40.[9] Given this assumption, Table 6.5 shows that all four economies have achieved a significant growth in total factor productivity in the past two decades. It is apparent that, in contrast to the claim by Krugman (1994), productivity has played an important role in economic growth in the four regions. In particular, Guangdong and Fujian have outperformed Hong Kong and Taiwan in terms of TFP growth. This table also shows the negative impact on TFP of economic recessions in Hong Kong during the early 1980s and mid 1990s. According to the same table, it is also clear that TFP growth declines as capital share increases over time. Thus, it can be postulated that TFP growth in Guangdong and Fujian will eventually slow down and converge with the trend in Taiwan and Hong Kong as the economies narrow their gaps over time.

Table 6.4 Estimates of capital shares in selected economies

Economy	*Source*	*Capital shares*
Taiwan	Young (1995)	0.29
	Chen (1979)	0.40
Hong Kong	Young (1995)	0.37
	Chen (1979)	0.40
Mainland China	Maddison (1998)	0.40
Japan	Maddison (1998)	0.33
	Nishimizu and Jorgenson (1995)	0.40*
USA	Maddison (1998)	0.33
	Nishimizu and Jorgenson (1995)	0.40*

Source: As cited in the table.

Note: *Estimated average for the period 1952–1974.

Table 6.5 Capital shares and TFP growth rates

Capital share	*Hong Kong*	*Taiwan*	*Guangdong*	*Fujian*
1979–83				
0.20	2.42	2.88	4.83	6.35
0.25	1.98	2.56	4.14	5.95
0.30	1.54	2.24	3.46	5.54
0.35	1.10	1.92	2.77	5.14
0.40	0.66	1.60	2.08	4.74
0.45	0.22	1.28	1.39	4.33
0.50	–0.22	0.96	0.70	3.93
0.55	–0.65	0.63	0.02	3.53
0.60	–1.09	0.31	–0.67	3.12
0.65	–1.53	–0.01	–1.36	2.72
0.70	–1.97	–0.33	–2.05	2.32
0.75	–2.41	–0.65	–2.73	1.92
0.80	–2.85	–0.97	–3.42	1.51
1986–90				
0.20	5.06	5.78	7.25	4.68
0.25	4.74	5.50	6.60	4.19
0.30	4.41	5.21	5.94	3.71
0.35	4.09	4.93	5.28	3.22
0.40	3.77	4.65	4.62	2.74
0.45	3.45	4.36	3.96	2.25
0.50	3.13	4.08	3.30	1.77
0.55	2.81	3.80	2.64	1.28
0.60	2.49	3.51	1.98	0.79
0.65	2.17	3.23	1.32	0.31
0.70	1.85	2.95	0.66	–0.18
0.75	1.53	2.67	0.01	–0.66
0.80	1.20	2.38	–0.65	–1.15
1993–97				
0.20	1.77	3.62	9.80	12.68
0.25	1.46	3.26	8.97	11.66
0.30	1.14	2.91	8.14	10.64
0.35	0.83	2.56	7.30	9.62
0.40	0.52	2.20	6.47	8.61
0.45	0.21	1.85	5.64	7.59
0.50	–0.10	1.50	4.81	6.57
0.55	–0.41	1.14	3.97	5.55
0.60	–0.72	0.79	3.14	4.53
0.65	–1.03	0.43	2.31	3.52
0.70	–1.34	0.08	1.48	2.50
0.75	–1.66	–0.27	0.64	1.48
0.80	–1.97	–0.63	–0.19	0.46

6.3 Further analysis of productivity growth

To shed more light on the issue of productivity convergence, a stochastic frontier approach is applied to estimate TFP growth rates in the four economies.[10] The concept of frontier defines the existence of an unobservable function (the production frontier), which corresponds to the set of maximum attainable output levels for a given combination of inputs. The main feature of this approach is its unique specification that permits the distinction between the statistical noise and an error term associated with technical inefficiency.[11] In logarithmic form, this model may be presented as[12]

$$\log Y_{it} = \alpha + \beta_1 t + \beta_2 t^2/2 + (\gamma_1 + \gamma_2 t)\log L_{it} + (\eta_1 + \eta_2 t)\log K_{it} + e_{it} \tag{6.1}$$

where

$$e_{it} = v_{it} + u_{it}\ , \tag{6.2}$$

and α, β, γ, and η,'s are the parameters to be estimated; Y_{it}, L_{it} and K_{it} represent GDP; labour and capital of the i^{th} economy at time t; e_{it} is the error term combining a random term, v_{it}; and the term associated with technical inefficiency, u_{it}. The term v_{it} has the usual properties while u_{it} is assumed to be independent of v_{it} and non-positive. Given the specification in Equation (6.1), the corresponding degree of technical efficiency, TE_{it}, the ratio of the observed output, Y_{it}, to the maximum feasible output (that is, the frontier output), y_{it}, is

$$TE_{it} = Y_{it}/y_{it} = e^{u_{it}} \tag{6.3}$$

Manipulating Equations (6.1) and (6.2) gives the following growth accounting equation

$$\dot{Y}_{it} = (\beta_1 + \beta_2 t + \gamma_2 \log L_{it} + \eta_2 \log K_{it}) + (\gamma_1 + \gamma_2 t)\dot{L}_{it} + (\eta_1 + \eta_2 t)\dot{K}_{it} + \dot{TE}_{it} \tag{6.4}$$

where the dots indicate percentage changes. This equation implies that output growth can be decomposed into three components: technological progress; input growth; and changes in technical efficiency. This decomposition enriches Solow's dichotomy by attributing observed output growth to movements along a path on or beneath the production frontier (input growth), movement toward or away from the production frontier (efficiency growth), and shifts in the production frontier (technological progress).[13]

According to the above decomposition, total factor productivity growth ($\dot{TFP}_{it}$), defined as the growth in output not explained by input growth, is the sum of technological progress and changes in technical efficiency, that is

$$\dot{TFP}_{it} = \dot{TP}_{it} + \dot{TE}_{it}\ , \quad t = 1, \ldots, T\ , \quad i = 1, \ldots, N. \tag{6.5}$$

Equation (6.5) implies that, even without technological progress, productivity growth can still be positive as backward economies or regions close their gaps with the best practice output (i.e., improvement in efficiency). In contrast, the conventional growth-accounting method cannot distinguish between technological progress and changes in technical efficiency, yet the former can be assumed to be the consequence of innovation or adoption of new technology by best practice countries or economies, and the latter mainly due to the effect of catching up. These two are analytically distinct and may have quite different policy implications, as argued by Nishimizu and Page (1982).

The main problem raised by the estimation of models (6.1) to (6.4) is the computation of technical efficiency, TE_{it}, which requires a decomposition of the residual in Equation (6.1) into separate estimates of statistical noise and technical inefficiency, and the latter is both time-varying and economy-specific. It was not until the work by Jondrow *et al.* (1982) that this decomposition was made possible. After Jondrow *et al.*, many sophisticated techniques have been proposed to estimate technical efficiency in frontier models. Each of these techniques has its advantages and drawbacks.[14]

This chapter employs a time-varying efficiency approach proposed by Cornwell *et al*. (1990) and recently applied by Fecher and Pestieau (1993) and Wu (1995). Following this approach, the efficiency term, u_{it}, is specified as a quadratic function of time, t. The final estimation of the above-mentioned models is implemented in two steps.[15] In the first step, Equation (6.1) is estimated by standard panel data approaches with the residuals saved.[16] The estimation results are reported in Table 6.6. The estimates of most coefficients are statistically significant at the 1 per cent level. In the second step, this estimated residual variable is regressed against t and t^2, including a constant term, and the fitted value from this regression gives an indicator of technical efficiency.[17] To be consistent with the concept of frontier, the estimated efficiency indicators are normalised so that they are non-negative with an upper bound of unity. With these efficiency estimates, the growth rate of total factor productivity is then computed as the sum of the rate of technological progress and the rate of technical efficiency change.

The estimation results in the form of indices are presented in Table 6.7. Several observations are worthy of attention.

First, it is found that all four economies have achieved significant growth in total factor productivity. The estimates for Hong Kong and Taiwan are compatible with the findings by Nadiri and Son (1999) and Young (1995). While no previous studies on Guangdong and Fujian are available, the estimates of TFP growth for these two mainland regions are close to the findings on China by Borensztein and Ostry (1996) and Hu and Khan (1997). It is also found that total factor productivity in Guangdong and Fujian has grown much faster than in Hong Kong and Taiwan since the late 1980s. Thus, as discussed in the preceding section, Guangdong and Fujian have exploited the advantage of being backward and forged ahead of their advanced counterparts in terms of productivity performance.

Table 6.6 Production function estimates

Variable	*Coefficient*	*Standard error*
log(Capital)	0.4705*	0.0579
log(Labour)	0.5295*	0.0579
log(Capital)•Time	–0.0047*	0.0012
log(Labour)•Time	0.0047*	0.0012
Time	–0.0078	0.0070
Time•Time	0.0008*	0.0002
Estimated fixed effects for		
Hong Kong	–2.1531*	0.1819
Taiwan	–2.5518*	0.2319
Guangdong	–3.3101*	0.3143
Fujian	–3.4137*	0.3201
R-squared	0.9941	

Notes
The value of the standard errors is in parentheses.
*indicates significance at the level of 1%.

Table 6.7 TFP, efficiency and technological progress indexes

Index/Region	*1979*	*1983*	*1988*	*1993*	*1997*
Technical efficiency					
Hong Kong	1.0119	1.0054	0.9973	0.9893	0.9830
Taiwan	1.0161	1.0103	1.0031	0.9959	0.9903
Guangdong	0.9786	0.9872	0.9979	1.0088	1.0176
Fujian	0.9928	0.9973	1.0016	1.0060	1.0095
Technological progress					
Hong Kong	1.0100	1.0149	1.0220	1.0282	1.0335
Taiwan	1.0133	1.0188	1.0260	1.0323	1.0374
Guangdong	1.0214	1.0259	1.0320	1.0377	1.0421
Fujian	1.0204	1.0259	1.0326	1.0392	1.0428
Total factor productivity					
Hong Kong	1.0220	1.0204	1.0192	1.0173	1.0159
Taiwan	1.0296	1.0293	1.0292	1.0281	1.0273
Guangdong	0.9996	1.0128	1.0299	1.0468	1.0605
Fujian	1.0141	1.0231	1.0321	1.0455	1.0527

Note: The figures indicate indexes relative to the preceding years. Thus, a number greater than one implies a positive growth. A number smaller than one implies a decline.

Second, according to Table 6.7, all four economies have shown a positive rate of technological progress in the past two decades. This factor might be the driving force for sustained growth in the four regions. Once again, the two mainland regions have outperformed their neighbours and hence shown catch-up to Hong Kong and Taiwan.

Third, Table 6.7 also shows that efficiency improvement (i.e., catch-up) contributed positively to productivity performance in Hong Kong and Taiwan in the 1980s and in Guangdong and Fujian in the 1990s. In general, Hong Kong and Taiwan performed much better in the late 1970s and early 1980s than in the late 1980s and the 1990s. In contrast, Guangdong and Fujian performed much better in the 1990s than in the 1980s. In addition, the estimates of technical efficiency show that Hong Kong and Taiwan were producing closer to their best-practice outputs in the 1980s (i.e., the relatively higher level of technical efficiency) but they lost to their neighbours and competitors, Guangdong and Fujian, in the 1990s (i.e., the relatively lower level of technical efficiency).

Finally, TFP performance over time has been relatively stable in Taiwan, declining in Hong Kong and rising dramatically in Guangdong and Fujian. These trends are consistent with the performance of the economies in the past decades, i.e., sustained growth in Taiwan, stagnation in Hong Kong and rapid growth in Guangdong and Fujian. This pattern of changes has led to productivity catch-up and hence convergence among the economies considered.

While the gap in the level of economic development has provided the pre-condition for catch-up and convergence, other factors are important too, such as high growth in investment (Abramovitz 1979). Evidence from the OECD economies has shown that there are positive interactions between capital accumulation and technological advance and that TFP convergence is directly associated with the growth in capital–labour ratios or capital intensity (Wolff 1991). According to Table 6.8, as expected, Hong Kong has the most capital-intensive economy among the four, with Taiwan standing in the middle. In general, the difference in capital intensity among the members has decreased over time with the exception that Taiwan's capital–labour ratio declined relative to Hong Kong's in the 1980s, probably due to the negative impact of the second oil shock on the Taiwanese economy.

However, in comparison with other industrialised economies, capital–labour ratios in the four economies have recorded relatively high rates of growth in the past two decades. For example, the growth rates of capital–labour ratios in Taiwan and Hong Kong are comparable with these in Japan (7.1 per cent) and Germany (5.7 per cent) but much higher than these in the United States (2.4 per cent) and the UK (3.6 per cent) during the period 1950–79 (Wolff 1991). Thus, on the one hand, strong growth in capital intensity has helped Taiwan and Hong Kong to narrow their gaps with the developed world in the past decades. On the other hand, rapid capital accumulation enabled Guangdong and Fujian to catch up with their rich neighbours, Taiwan and Hong Kong.

Table 6.8 Estimates of capital–labour ratios

Ratio/Region	*1979*	*1983*	*1988*	*1993*	*1997*	*1979–87*	*1988–97*
Capital–labour ratio (ppp$1000 per worker)							
Hong Kong	44.6	61.0	75.0	108.7	139.7	58.2	105.8
Taiwan	22.2	26.9	31.7	46.2	59.8	26.4	44.9
Guangdong	4.9	5.9	8.9	14.6	22.1	6.1	14.6
Fujian	3.5	6.0	7.8	10.5	19.3	6.2	11.6
Capital–labour ratio (Hong Kong = 100)							
Hong Kong	100	100	100	100	100		
Taiwan	49.8	44.1	42.3	42.5	42.8	45.7	42.3
Guangdong	8.9	9.6	11.8	13.4	15.8	10.3	13.5
Fujian	11.0	9.7	10.4	9.6	13.8	10.7	10.7
Growth rates							
Hong Kong	9.8	6.4	7.9	4.5	8.0	6.1	7.2
Taiwan	10.3	1.2	10.4	8.2	6.7	4.1	7.6
Guangdong	14.4	9.5	9.6	18.4	6.3	10.0	10.6
Fujian	8.7	4.4	5.0	14.5	14.2	5.8	10.2

6.4 Summary remarks

In summary, empirical evidence has shown rapid integration among the economies of Taiwan, Hong Kong, Guangdong and Fujian in the past two decades. As a result, these economies have become interdependent. This increasing link not only sustained economic growth in Hong Kong and Taiwan in the difficult 1980s and 1990s, but also greatly promoted economic reform and growth in mainland China, particularly in Guangdong and Fujian in the past decade.

It is found that, in terms of growth and productivity performance in the past two decades, Guangdong and Fujian have shown rapid catch-up with their neighbours, Taiwan and Hong Kong. This phenomenon has resulted from the 'advantages of backwardness' of mainland China. In addition, strong growth in investment has been an important stimulus for TFP growth and hence a driving force for convergence among the four economies. It can be projected that as gaps between the four regions narrow over time, economic links will increase in level of sophistication as well as scope of operation.

Although the above findings can help gain insight into growth and productivity performance in Hong Kong, Taiwan, Guangdong and Fujian, there is scope for further investigation. For example, it would be interesting to compare the four economies as a bloc with other economic blocs such as the OECD and hence to

examine whether the Southern China group has shown catch-up to the world frontier. In addition, this study could also be extended by the application of different approaches in modelling frontier production functions and in deriving the capital stock series.

Part III

Growing through deregulation at the industry level

Part III is distinguished from Parts I and II by examining growth at the industry level. The telecommunications and energy sectors are chosen for the case studies (Chapters 7 and 8 respectively). In the 1980s, these two sectors were the bottlenecks of the economy. Dramatic changes have, however, taken place in these sectors in the 1990s. As a result, rapid growth has accompanied economic reform. Chinese people nowadays receive much better services in telecommunications. China's energy sector has been in transformation as well in the past decade. It has to meet the challenges of increasing environmental awareness and burgeoning demand due to economic growth. Chapters 7 and 8 document the process of reform, the impact on growth and possible policy implications in the telecommunications and energy sectors.

7 Deregulation and growth in the telecommunications industry

In the 1980s and 1990s, China's telecommunications sector like the rest of the Chinese economy has undergone dramatic changes in terms of the regulatory environment, infrastructure development and services. As a result, the Chinese telecommunications industry has expanded significantly and is now the world's second largest in terms of telephone lines (ITU 2000).

This chapter aims to present an overview of the current situation and reform in the Chinese telecommunications sector. Section 7.1 briefly reviews the historical growth of China's telecommunications sector. It particularly focuses on the factors underlying China's recent growth. Section 7.2 describes the organisational structure and reforms in the telecommunications sector. Section 7.3 examines the main players and competition in the market. Section 7.4 looks at the conditions of ownership and privatisation in China's telecommunications industry. The growth outlook for the telecom sector is discussed in Section 7.5. Finally, Section 7.6 presents concluding remarks.

7.1 Growth in China's telecom sector

China's telecommunications industry began with the construction of the first submarine cable by a British company in 1870 and the first land line by the Chinese army in 1879. Services in telegraphs, telephones and wireless communications were gradually introduced into China and for a long time were dominated and controlled by foreign providers (He 1997). Given this background, after taking office in 1949, the government of the People's Republic of China kept a tight control on the construction and operation of the telecommunications networks. Growth in this sector during the period 1949–79 was modest for various reasons but the situation has changed since China's economic reform programme was initiated in 1979. As a result, China's telecommunications industry has grown steadily over the past two decades (Figure 7.1). This growth has been particularly robust and well ahead of China's GDP growth in the past ten years.

Several factors have contributed to the fast expansion of China's telecommunications sector. First, telecommunications growth in recent years has been demand-driven. Since the implementation of economic reforms in the late 1970s, the Chinese economy has achieved an average annual rate of GDP

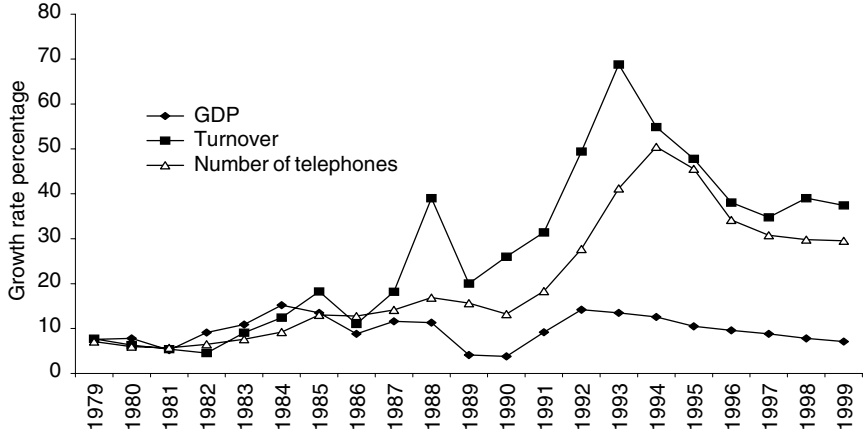

Figure 7.1 Growth in GDP and telecommunications services

Source: State Statistical Bureau (2000a).

Note: The lines represent the percentage rate of growth in GDP, turnover and the numbers of telephones.

growth of about 9.6 per cent (1979–99).[1] This growth has led to a dramatic expansion in economic activities and hence a great increase in demand for telecommunications services. In particular, over the past two decades, economic liberalisation has brought Chinese people greater freedom to move around and obtain work away from their hometowns. For example, millions of peasants have found jobs in the cities. In addition, international traffic of telecommunications has increased rapidly due to the arrival of offshore investors and tourists. All these developments have required an expanded system to meet the demand for business and personal communications.

Second, over the past two decades, Chinese policy-makers have increasingly recognised the importance of the telecommunications sector in economic development. In particular, they have learnt from international experience. For example, government officials are well informed of international research, e.g., the study by Hardy (1980), which shows that telecommunications contributed directly to growth in GDP. A Chinese government report also shows that the marginal contribution to the national economy from investment in information resources is about sixteen times greater than that from investment in other sectors (EIU 1997). These research findings convey a message that the telecommunications sector contributes directly to economic growth.

Traditionally, the role of the telecommunications sector is to serve the military as well as the elites in society. As economic activities increase, the Chinese telecommunications sector is required to provide services to people from all walks of life. In addition, as China's economic growth took off in the late 1970s, the telecommunications sector together with energy and transport sectors was

identified as the main bottleneck in the economy and hence designed as the area for priority development (Yu *et al.* 1999, p. 479). These factors have resulted in government policy changes and led to an investment boom in the telecommunications sector (Figure 7.2).

Finally, recent growth in China's telecommunications sector is also driven partly by deregulation and subsequent emergence of competition in this sector. The presence of several domestic carriers and participation of foreign providers (legally or illegally, e.g., call-back services and Internet telephony) has brought about an era of great expansion as the major players compete for market share. As a result, competition has significantly lowered the cost of access to telecommunications services. For example, the installation fees to fixed-line services were adjusted twice in 1999 and on average fell from about 2571 yuan (or US$321) in 1995 to 500 yuan (US$62) in 1999. Mobile phone services and access to the Internet have also become more affordable. The price changes boosted consumer demand dramatically and hence stimulated growth in the past decade.

7.2 Organisational structure and reforms

Associated with the rapid growth in China's telecommunications sector are reforms and structural changes. Before 1998, several government departments were responsible for the development and policy-making in China's telecommunications sector (Figure 7.3). The Ministry of Posts and Telecommunications (DGT), was the major player and owned the bulk of China's fixed lines. Private

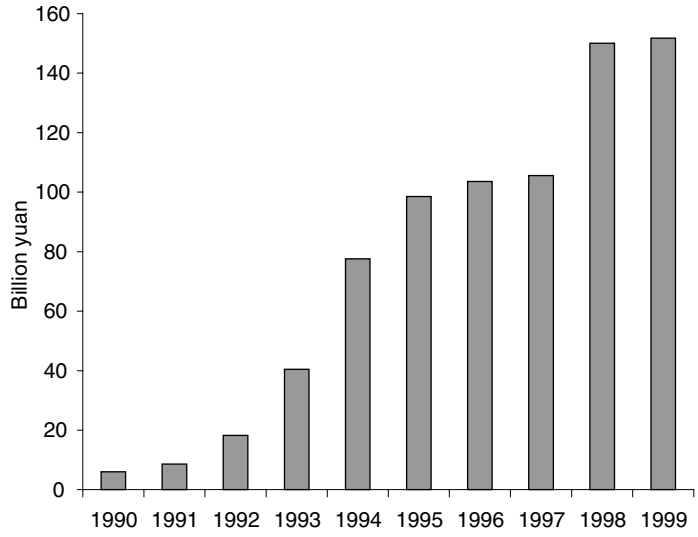

Figure 7.2 Investment in China's telecommunications sector, 1990–99

Sources: State Statistical Bureau (2000a) and Harwitt (1998).

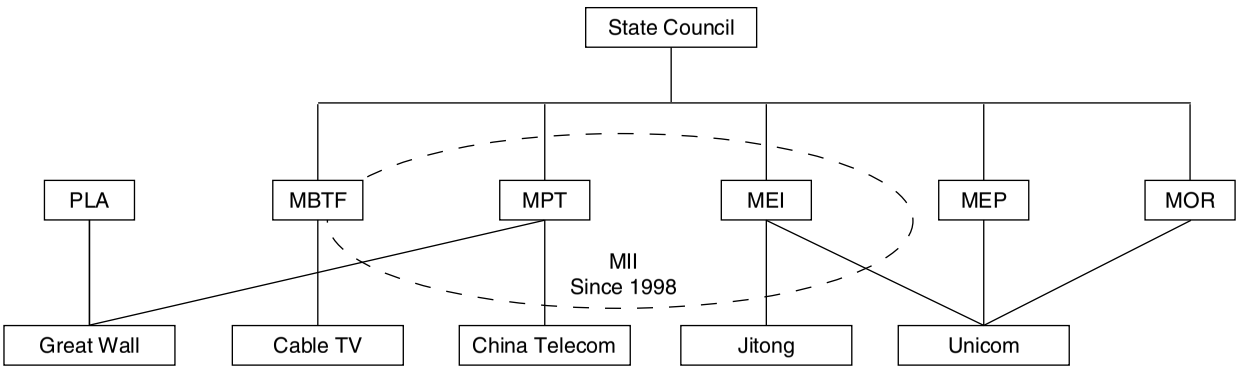

Figure 7.3 Organisational structure of China's telecommunications sector

Source: Author's own work.

Notes
PLA: People's Liberation Army. Great Wall: China Telecom Great Wall Corporation. MBTF: Ministry of Broadcasting, Television and Films. Cable TV: various cable TV networks. MPT: Ministry of Posts and Telecommunications. MEI: Ministry of Electronic Industry. MEP: Ministry of Electric Power. MOR: Ministry of Railways. Unicom: United Telecommunications Corporation. Jitong: Jitong Telecommunications Corporation. China Telecom: former Directorate General of Telecommunications. MII: Ministry of Information Industry. The former Ministry of Petroleum also maintained a small telecom network for private access.

networks were also owned and operated by other government departments such as the Ministry of Railways (MOR), Ministry of Electric Power (MEP), Ministry of Defence (MOD, via the People's Liberation Army) and Ministry of Petroleum (MOP). Though the DGT, later known as China Telecom (China Telecommunications Co. Ltd.), was separated from the MPT in 1994, the two entities still worked together. As a result, the MPT could not act effectively as an independent and transparent regulator. The situation was similar to the cases of AT&T in the USA and British Telecom before liberalisation in these countries. China Telecom was the only provider owned by the government, i.e., the regulator. The industry was, however, under tremendous pressure to deregulate and allow new entrants. As an experiment, in 1994 the authority approved the establishment of a second national carrier, China United Telecommunications Corporation (Lian Tong or Unicom). One of the objectives of establishing Unicom was to utilise the excess capacity in the private telecommunications networks owned by the MOR and MEP to provide services in mobile phones, paging, IP telephony and data communications. The emergence of Unicom presented a direct challenge to the monopoly of China Telecom. The majority shareholders of Unicom include several government organisations e.g., the Ministry of Electronic Industry (MEI), MOR, MEP and China International Trade and Investment Corporation (CITIC). Since the MPT embraced both regulatory and operational responsibility, Unicom (as an entity outside the MPT) has experienced major problems in interconnections with China Telecom, the main owner of fixed lines. In addition, as a new entrant Unicom was too small to compete with its giant rival, the old China Telecom.[2]

However, following restructuring of the administrative system of the central government in 1998, the organisational structure of China's telecommunications sector has changed. The MPT, MEI, and the State Radio Regulation Commission were merged to form the present Ministry of Information Industry (MII). The aim of the bureaucratic restructuring is clearly to consolidate the government's regulatory role, to separate regulation from operation and to create an environment for fair competition. One example is that since the restructuring, Unicom and China Telecom fall under the same umbrella of the MII. The two national carriers may now be able to compete on the same level-playing field. Under the new administrative system, MII is the sole regulator responsible for price setting, licensing and other regulatory matters.

The overhaul of the bureaucratic system was accompanied by reform of the telecommunications enterprises. One of the main initiatives was to break up China Telecom's four divisions of services into separate entities. As a result, four independent companies were formed. They are responsible for the fixed line, mobile, paging and satellite communication services, respectively. The fixed line services maintain the name China Telecom (hereafter the new China Telecom vs the old China Telecom). The new China Telecom was officially incorporated on 17 May 2000.[3] The mobile service department of the old China Telecom became China Mobile (China Mobile Communications Group) which was formally established on 16 May 2000.[4] A new company, China Satellite (China Satellite

Communications Group), which will provide satellite telecommunications services, was also approved by the State Council. The paging arm of the old China Telecom has merged with Unicom. Although the split companies will operate in their respective sectors, they will eventually be allowed to enter each other's business sphere.

The objective of this reform initiative is to break the monopoly of the old China Telecom and hence to promote competition among providers. In particular, after the restructuring, the new China Telecom, China Mobile and Unicom are comparable with each other in size and hence are more equal rivals. An analysis of the major players and their roles in China's telecommunications sector is presented in the next section.

7.3 Major players and competition

The major players in China's telecommunications sector are the three giants (i.e., the new China Telecom, China Mobile and Unicom) as well as a few new, small firms. The analyses here focus on service providers only. In terms of market shares, the three big players have dominated the sector. Other minor players include Jitong, Great Wall, China Satellite and Netcom (Table 7.1). At the end of 2000, two new companies were added to the sector. One was Shanghai Xintian Telecommunications Ltd, jointly owned by China Telecom (Shanghai), Shanghai Information Investment Ltd and AT&T. The latter has an equity of 25 per cent. The other company was Railway Telecommunications Ltd. The business activities of both companies involved value-added services. By the end of 2000, in terms of shares over total revenues in the sector, China Telecom, China Mobile and Unicom accounted for 57.7 per cent, 34.5 per cent and 7.7 per cent, respectively.[5]

Competition in fixed-line services has so far been limited as the new China Telecom (hereafter China Telecom) is still the overwhelmingly dominant provider in the market. Unicom is the second provider but its service through interconnection with China Telecom has been problematic. As a result, Unicom has been building its own fixed-line network though capacity is still limited.

Table 7.1 Major players in China's telecommunications sector (end of 2000)

Service	*Player*
Fixed line	China Telecom, Unicom and some local cable TV networks
Paging	Unicom and many other providers
Mobile	China Mobile, Unicom, Great Wall and potential entrants (China Satellite, China Telecom)
IP telephony	Unicom, China Telecom, Netcom, Jitong and China Mobile
Data	China Telecom, Unicom, Netcom, Jitong, China Mobile and potential entrants (e.g., the cable TV networks)

With further deregulation, the situation in fixed-line services will change. One possibility will be the emergence of joint services by Unicom and cable TV networks. The latter are at present not permitted to provide telecommunications services. In terms of the length of fixed lines, the cable TV networks can match China Telecom. At the end of 1998, the cable TV network had over 77 million subscribers, with a density greater than that of China's telephone subscription during the same period (Duan 2000). In particular, cable TV networks have access to a large pool of households. However, cable TV networks are owned and operated by hundreds of entities, and are mainly suitable for one-way communications. There are also problems with interconnections as many networks are not connected with each other. At present, some small networks have been expanded to provide telecommunications services to local communities. For example, the Broadcast Bureau in Hunan created a company that linked fourteen of the province's largest cable-TV stations into a single network (Lawrence 1999a). It is now upgrading the new, unified network to handle two-way transmissions and eventually interactive data services. If regulatory barriers are removed, it is expected that more local cable TV networks will extend their services into the telecommunications sector. For instance, Unicom may upgrade some cable TV networks to provide voice and data communication services. The target of Unicom is eventually to have a market share of 20 per cent in long-distance calls via its fixed lines. However, Unicom's expansion in local call services is very slow partly because the return to local calls and other services is very low. Unicom currently focuses on providing services to large clients (e.g., big companies or government departments) and provides local-call services in three cities only. It can be projected that the dominance of China Telecom in fixed-line services will continue in the near future.

China's paging service sector, the largest in the world, is the most competitive area in the telecommunications industry (Table 7.2). The provision of paging services was deregulated in 1993. It was estimated that there were more than 2000 licensed providers in 1998 (X. Wan 1998). Unicom has a market share of about 50 per cent. This sector is now experiencing merging and bankruptcies. The direction of further growth is to provide two-way paging and data communications services. For example, Unicom is providing two-way paging services in Shanghai.

In the area of mobile services, the market is divided between the two main players, China Mobile and Unicom. China Mobile has a nationwide GSM network. Currently, Unicom has a licence to build a nationwide CDMA network. In 1999, Unicom had a market share over 14 per cent (Yang 2000). This figure rose to 22 by the end of 2000 and is expected to reach 35 by 2005.[6] The third provider is China Great Wall Communication Company (Great Wall) which was jointly founded by the former MPT and the People's Liberation Army (PLA). It was intended to build a CDMA network in China. As the PLA has been banned from business activities, the future of Great Wall is uncertain. It will probably remain a small player in the market (In early 2001, it was reported that Unicom was in the process of taking over Great Wall.)

Table 7.2 China's telecommunications indicators (million subscribers)

Year	*Telephone*	*Mobile*	*Paging*	*Internet users*
1990	6.85	0.02	0.44	
1991	8.41	0.05	0.87	
1992	11.47	0.18	2.22	
1993	17.33	0.64	5.61	
1994	27.30	1.57	10.33	0.01
1995	40.71	3.63	17.39	0.04
1996	54.95	6.85	25.36	0.16
1997	70.31	13.23	29.69	0.52
1998	87.42	23.86	37.83	2.10
1999	108.81	43.24	47.18	8.90
2000	144.41	85.26	48.64	22.50
2001	180.37	145.22	36.06	36.57
2002*	209.06	195.83	20.90	45.87

Sources: State Statistical Bureau (2000a, 2002), CNNIC (2000, 2002) and the web site of the Ministry of Information Industry.

Note: Figures at the end of October 2002.

By the end of 2000, the total number of mobile phone users in China amounted to about 85 million, almost double the figure in 1999 (Table 7.2). China is now the world's largest mobile phone market, with more than 200 million mobile phones by the end of 2002. Although the two national carriers have dominated the market, competition between them has already lowered the cost of mobile phone services considerably. Two other licence holders, China Satellite and China Telecom, are also providing services in this area. It can be predicted that competition will be intense in China's mobile phone sector. Currently, Unicom, China Mobile and China Telecom are aggressively promoting their wireless internet services under the wireless application protocol (WAP).

Data communications are mainly provided by four networks, Chinanet (China Telecom), Uninet (Unicom), ChinaGBN (Jitong) and CNCNET (China Netcom Corp.). Each network has its own advantages. While China Telecom has an existing large customer base, Unicom's network is better positioned in terms of technology and network structure. In the meantime, Jitong (Jitong Communications Corporation) established by the former MEI and 30 other SOEs and research institutes in 1993 is working towards expanding its current network capacities and speed. The newest entrant, CNCNET, is however exploiting services through broadband cable facilities. The owner of CNCNET is China Netcom Corp. which was founded jointly by the Chinese Academy of Sciences, the Ministry of Railway, the State Administration of Radio, Film and Television (SARFT) and Shanghai Municipality. According to a report by Lawrence

(1999b), CNCNET will be based on IP (Internet protocol) technology to provide high-speed voice and data services. With the SARFT on its board, China Netcom Corp. may be able to use the cable TV lines to link customers with its high-speed networks. In addition, there are two free education networks, i.e., CERNET (Chinese Education and Research Network) and CSTNET (Chinese Science and Technology Network). In terms of capacity, ChinaNet and CNCNET are the largest (Table 7.3).

As for Internet telephony, five companies are licensed, (Unicom, Netcom, Jitong, China Mobile and China Telecom). Unicom has a market share of 50 per cent. The rest is shared among other providers. Netcom as a new entrant is leading the development of broadband network for data communications. By the end of 2000, China had about 22 million registered Internet users (Table 7.2). The figure is expected to reach 100 million within five years (Weiss 2000). Currently, the five providers have a total capacity of 56 megabytes for Internet telephony. It has been reported that 10 per cent of China's international voice calls were made through IP telephony in 2000 and that this figure would jump to 35 per cent within three years (Masud 2000).

7.4 Ownership and privatisation

China's telecommunications sector has moved away from state ownership and monopoly to state control through shareholding and competition. This transition in ownership started with the partial float of the old China Telecom in both domestic and offshore stock markets. The second national carrier, Unicom, was also listed in the stock markets. The state through various government departments and SOEs still controls these two national carriers. Though value-added services have been deregulated internally, participation of offshore

Table 7.3 Capacity of China's data communications networks, 31 July 2002

Name	*Capacity (megabytes)*	*Operator*
ChinaNet	6,452	China Telecom
CNCNET	2,870	China Netcom Corp
UNINET	693	Unicom
CERNET	257.5	State Education Commission
CMNET	247	China Mobile
ChinaGBN	148	Jitong
CSTNET	55	Chinese Academy of Sciences
CGWNET	n.a.	China Great Wall
CSNET	n.a.	China Satellite
Total	10,576.5	

Source: CNNIC (2002).

investors and service providers in China's telecommunications sector has to date been limited due to government regulations. Under current regulations, foreign companies are allowed to sell advanced equipment to China and to create joint ventures to manufacture telecommunications products. Large companies such as AT&T, Motorola, Siemens and NEC have taken advantage of this policy. Some products of these companies, (e.g., Motorola mobile phones), actually dominate the market. Offshore investors are, however, prohibited from direct provision of services. To circumvent some of these rules, Unicom devised a unique joint venture scheme called 'Foreign-Chinese-Chinese (FCC)'. Within this framework, a separate Sino-foreign joint venture can team up with Unicom to establish a new entity. At one stage, foreign equities from France Telecom, Sprint, Deutsche Telekom, Bell Canada and NTT International amounted to a significant proportion of Unicom's total shares. This FCC model was however abandoned in mid 1997 due to the central government's intervention. Despite this, it is reported that some foreign companies are still providing services to Chinese enterprises, such as establishing and maintaining local intranets (Aldrich and Rooth 1999). Though information concerning foreign ownership is limited, offshore companies have apparently been involved in the businesses of China's main telecom service providers. It is reported that Unicom has set up a joint venture with Hong Kong's Hutchison Whampoa group which owns 2 per cent of Unicom (Dodgson 2000). According to the same source, China Mobile will team up with UK-based Vodafone and Netcom with Singapore Telecom.

Another form of foreign participation is through shareholding. Both China Mobile and Unicom are partly floated. China Mobile (originally as a subsidiary of the old China Telecom) initially offered US$4.2 billion worth of its shares on the New York Stock Exchange in October 1997. Its second share offer in 1999 raised a fund of US$2.6 billion. Unicom was listed simultaneously in New York and Hong Kong Stock Exchanges on 21 June 2000, raising capital of US$6.4 billion. As a result, Unicom is now 20 per cent owned by the public. The new China Telecom was also listed in New York and Hong Kong Stock Exchanges in 2002. Another company, Jitong, will also list in offshore stock exchanges. The current ownership condition will thus change over time. In particular, with China's commitment to WTO rules, China will have to allow foreign companies to hold shares up to 50 per cent. However, apart from the deal associated with China's WTO membership, full privatisation of state-owned enterprises (SOEs) has not been raised as a reform option yet.

7.5 Growth outlook

Although already being one of the largest in the world, China's telecommunications sector will continue to expand in coming decades. This growth prospect is determined by several factors. First, China's level of economic development is still far behind that of the developed world. The current trend of robust economic growth will continue for at least another decade. Growth-driven

demand for telecommunications services will increase continuously. According to the report by Masud (2000), the number of telephone lines in China will increase from 160 million in 1999 to 370 million in 2010 and 1 billion in 2020. The number of mobile phone subscribers is expected to reach 250 million by 2004 (Li 2000).

Second, though great in aggregate, China's telecommunications sector is still small on a per capita base. It is still a long way to match its counterparts in the developed economies such as the USA and Japan (Table 7.4). This gap implies a huge growth potential for China's telecommunications sector.

Third, development in China's telecommunications sector is uneven. There are both regional and rural–urban imbalances. In general, the urban areas are much better developed than the rural areas. In 1999, the teledensity of 19.2 per cent in urban China was much higher than that of 3.9 per cent in rural China (State Statistical Bureau 2000). In addition, the central and western regions lag behind their coastal counterparts (Table 7.5).

Finally, further deregulation and subsequently increasing competition will lead to an expansion in demand. Pricing in China's telecommunications sector is still controlled by the government. As a result, the cost of services is still high relative to international prices. For example, the cost of international calls is so high in China that some foreign companies take risks to operate illegal call-back services in the big cities such as Shanghai and Beijing. China Telecom recently changed its practice of charging local calls per three minutes. But mobile phone

Table 7.4 Telecommunications indicators in selected countries, 1999

Country	*Phone lines*[a]	*Mobile*[b]	*Internet*[c]	*PCs*[d]	*GDPpc*[e]
Bangladesh	0.30	0.06	2.36	0.10	265
India	2.20	0.12	20.04	0.33	435
Viet Nam	2.58	0.24	12.71	0.89	312
Sri Lanka	2.84	0.94	34.87	0.56	851
Philippines	3.44	2.38	67.16	1.69	894
Thailand	8.35	3.25	131.46	2.27	1,846
China	8.59	3.41	70.25	1.22	768
Malaysia	20.31	10.11	687.13	6.87	3,333
Japan	49.40	44.94	1,446.58	28.69	33,231
USA	66.10	31.15	3,982.36	51.05	32,198
Asia	8.01	4.44	140.88	2.52	2,259
World	14.89	8.05	439.77	6.78	5,179

Source: ITU (2000).

Notes
[a] number of lines per 100 inhabitants. [b] number of subscribers per 100 inhabitants.
[c] number of users per 10,000 inhabitants. [d] number of PCs per 100 inhabitants. [e] 1998 figures in US dollars.

Table 7.5 Telecommunications indicators by regions, 1998

Region	*Teledensity*		*Mobiles*	*Pagers*	*Lines*	*GDPpc US$*
	Urban	*Rural*				
			Coastal			
Beijing	39.3	10.6	9.8	2.4	50.0	2228
Tianjin	29.8	5.5	6.5	6.0	33.3	1698
Hebei	23.7	3.8	2.0	4.9	13.9	783
Liaoning	19.9	6.3	3.6	9.7	19.1	1110
Shanghai	36.1	26.2	9.8	6.1	48.0	3414
Jiangsu	21.8	10.0	2.6	5.6	24.0	1215
Zhejiang	31.3	7.3	3.8	4.7	21.2	1355
Fujian	32.6	6.7	5.3	n.a.	19.8	1224
Shandon	16.9	3.5	2.1	3.4	11.9	983
Guangdong	28.5	6.8	5.1	5.2	19.7	1352
Guangxi	17.9	1.2	1.5	4.7	8.5	567
Sub-mean	27.1	8.0	4.7	4.8	24.5	1448
			Central			
Shanxi	16.0	2.4	2.0	3.3	12.5	615
Inner Mongolia	14.2	4.1	2.0	3.3	15.0	617
Jilin	17.4	4.2	2.6	4.9	16.0	718
Heilongjiang	18.4	4.3	3.7	5.1	18.0	910
Anhui	17.4	2.5	1.3	3.3	9.7	556
Jiangxi	18.0	2.6	1.6	4.4	12.2	536
Henan	20.6	3.1	2.1	3.6	13.0	565
Hubei	18.1	3.6	1.7	4.0	12.1	760
Hunan	19.1	2.5	1.6	4.2	9.4	599
Hainan	20.6	1.7	3.2	9.1	10.8	710
Sub-mean	18.0	3.1	2.2	4.5	12.9	659
			Western			
Chongqing	20.2	1.8	1.6	3.0	11.2	569
Sichuan	16.4	1.2	1.4	3.3	8.7	512
Guizhou	14.6	0.5	0.8	2.6	6.2	281
Yunnan	29.2	2.8	2.3	7.0	16.7	526
Tibet	24.5	0.1	2.6	3.6	33.9	449
Shaanxi	20.4	1.8	1.5	3.0	11.5	476
Gansu	19.6	1.5	1.3	4.2	14.7	420
Qinghai	18.1	2.5	2.0	3.3	17.9	529
Ningxia	23.3	2.8	1.8	6.6	23.9	515
Xinjing	16.7	8.7	1.8	4.8	24.9	778
Sub-mean	20.3	2.4	1.7	4.1	17.0	505

Source: State Statistical Bureau (1999a, 1999b)

Note: All indicators but GDP per capita represent numbers per 100 persons.

calls are still double-charged. Further changes can be speculated. For instance, the prices of telecom services will continue to fall as the market becomes more competitive over time. These changes together with other factors described will be the driving forces behind the growth of China's telecommunications sector.

However, growth in China's telecommunications sector is still subject to some constraints and uncertainties. First, China's Telecommunications Act was promulgated in September 2000. This was the first legal document specifying a complete set of regulations to protect fair competition and ensure universal service obligations and efficient allocation of resources. The question is how effectively it will be enforced. Second, the MII is still the majority shareholder of the key players in the telecommunications market. Whether the MII can completely stay away from the operation of these companies is a question that could affect the independence and transparency of its regulatory role. Third, recent regulations towards foreign investment have been characterised by frequent changes and ambiguities. These confusions give pause to some foreign participants. Finally, the dominant owner and operator of fixed lines, China Telecom, is heavily indebted. Many of its local branches are operating in the red due to overstaffing and poor management. The future performance of China Telecom will affect infrastructure development and provision of services in the telecommunications industry. To overcome the problems with China Telecom, the giant company was further restructured to two independent providers in early 2002. This relatively new development will definitely bring about more changes in China's telecommunications industry in the near future.

7.6 Concluding remarks

To sum up, China's telecommunications sector has experienced dramatic growth over the past decade. This growth has largely been driven by increasing consumer demand and deregulation. Currently, China's telecommunications sector is dominated by three main providers. Some degree of competition exists in the industry. Certain areas (paging, mobile phones and data communications) are more deregulated and more competitive. But deregulation by and large is incomplete. Telecom legislation is still in its infancy and has for a long time been mainly supported by fragmented administrative decrees. The first Telecommunications Act was as recent as September 2000. Its enforceability is yet to be tested. Many other issues such as property rights, foreign participation and interconnection remain unresolved. Some problems such as private ownership are associated with the transitional nature of the Chinese economy. Others (e.g., interconnection) are industry-specific. At present, competition mainly occurs in wireless and other value-added services. In particular, there is little competition in the fixed-line service sector. Mandatory interconnection was not effectively enforced in the past. Interconnection has become the bottleneck in the industry. These problems are yet to be solved in the near future. It is anticipated that recent reforms and China's WTO membership

will lead to further deregulation and growth in this sector. Thus, the growth outlook for the Chinese telecommunications sector is bright. This growth will boost China's overall economic growth and create opportunities for global telecommunications trade.

8 Deregulation and growth in the energy sector

Over the past two decades dramatic changes have taken place in the Chinese energy sector. In the 1980s when economic growth took off immediately after the spate of reform initiatives, China's energy sector suffered from severe supply shortage. The then energy policy focused on promoting the growth of coal production. As a result, the coal industry expanded rapidly. In particular, the township and village-run mines emerged as the major force in coal production. However, since the late 1980s, the policy focus has shifted to the development and reform of the electricity sector. One of the main changes was that the non-state sector was allowed to enter the market. The build-operate-transfer (BOT) model was adopted in the mid 1980s, for instance. By 1999, about US$15 billion of private funds had been invested in China's power sector (World Bank 2000). These changes have led to a great expansion of the capacity for electricity generation in China. By the late 1990s, China's electricity supply could almost meet the demand, and there was even a surplus in some regions. In the meantime, China has increased its oil imports as well as domestic production of natural gas. Currently, China's energy sector is characterised by (1) oversupply of coal, (2) rapidly growing electricity-generating capacity, (3) a net oil-importing industry and (4) an expanding natural gas sector. These new developments together with China's recent entry into the World Trade Organization will affect China's energy policy in the twenty-first century.

The objective of this chapter is to present a review of the key factors that may affect China's national energy policy in the near future. Section 8.1 discusses the regulatory changes in the Chinese energy sector. This is followed by a review of pricing practices and reforms in Section 8.2. The relationship between the environment and China's energy policy is discussed in Section 8.3. The issues associated with energy production and consumption are examined in Section 8.4. Section 8.5 sheds some light on the outlook for energy demand in China, in particular in Guangdong. Finally, some summary remarks are presented in the concluding section.

8.1 Regulatory changes

In March 1998, China's central administration was radically restructured. The objective was to improve administrative efficiency and strengthen the government's regulatory role by relinquishing it from business operations. In the energy sector, several former government ministries were restructured. Their commercial arms were separated from their regulatory bodies and eventually corporatised. The regulatory functions of the former ministries are now allocated to the State Development Planning Commission (SDPC), State Economic and Trade Commission (SETC) and Ministry of Land and Natural Resources (MLNR).

The SDPC is based on the old powerful State Planning Commission. But its power has been reduced and its control over the energy sector considerably weakened. It is now mainly responsible for long-term planning, project approval and pricing. The SETC merged six former state ministries including coal, electric power, petroleum and chemical industries, metallurgical industry, machine-building industry and internal trade. The power and authority of the SETC has been greatly increased since the restructuring. Through its State Administration of Petroleum and Chemical Industries (SAPC), State Administration of Coal Industry (SACI) and Department of Electric Power (DEP), the SETC is now the main regulatory body in the energy sector (Figure 8.1). The MLNR, newly created in 1998, is responsible for the planning, management, protection and sustainable use of all natural resources (IEA 2000). It also handles licensing for exploration and production.

The administrative restructuring was followed by reform of the enterprise sector. The oil and gas sector is now dominated by three state-owned enterprises, i.e., China National Petroleum Corporation (CNPC), China Petroleum and

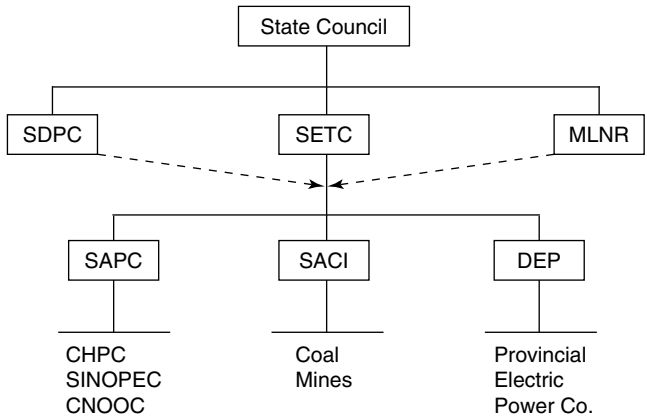

Figure 8.1 Regulatory structure of the energy sector

Source: Author's own work.

Chemical Corporation (SINPEC) and China National Offshore Oil Corporation (CNOOC). CNOOC is responsible for all offshore operations. Its products are treated as imports in the domestic market. The Chinese market is divided between CNPC and SINPEC. CNPC controls oil and gas fields, refineries and petrochemical plants in 12 provinces in north and west China. SINPEC concentrates on oil production and refining operations in 19 provinces in eastern and southern China. Since 1998, CNPC and SINPEC have been competing for retail market shares.

The electric power sector is the responsibility of the DEP under the SEPC. China State Power Corporation (CSPC) acts as a holding company for state assets in the power sector. The corporation is working on a set of proposals to restructure the industry. The preferred reform strategy is a vertical separation of the generation, transmission and distribution functions. The final package is yet to be announced.

The regulator of the coal sector is the SACI. The SACI, established in 1998, replaced the old Ministry of Coal Industry and used to control about 40 per cent of China's coal production (1996 statistic reported in Section 8.4). Since 1999, mines owned by the SACI have been transferred to the provincial authorities, leaving the SACI as a purely regulatory body within the government. To serve as a bridge between the government and the coal firms, the China Coal Industry Association (CCIA) was established in March 1999. The CCIA is expected to play an important role in promoting market reforms and drafting industrial regulations. These regulatory changes have important implications for China's energy production and consumption which is the topic of Section 8.4.

8.2 Pricing practices and reforms

China's energy policy is also affected by consumer income and pricing practices. Although the prices of water and fuel have been raised significantly in recent years, they still account for a relatively small share of consumers' total expenditure (Table 8.1). This implies that there is scope for consumers to accept relatively more expensive fuels than the traditional coal. Thus, many local authorities are confident that consumers can afford more price hikes, which helps the underlying changes in energy structure, i.e., the shift towards the use of cleaner energy, e.g., liquefied petroleum gas (LPG), liquefied natural gas (LNG) and natural gas (NG).

Currently, China's energy prices are still controlled by the state. But significant changes have taken place in energy pricing practices. These changes began with the introduction of 'dual-track' pricing in the 1980s. Under the 'dual-track' system, a portion of energy products could be sold at higher (unplanned) prices in the free market. In the 1990s, more drastic measures have been implemented towards price liberalisation. These deregulation initiatives have been introduced into all energy sectors, (i.e., coal, oil, electricity and natural gas).

Table 8.1 Household expenditures in urban China (percentage shares)

Item	*1995*	*2001*
Food	49.9	39.2
Clothing	13.5	10.0
Daily necessities	8.4	8.8
Health care	3.1	6.4
Transport and telecommunications	4.8	7.9
Recreation, education, etc.	8.8	12.6
Housing	2.9	4.0
Water, fuels, etc.	4.2	6.0
Others	4.3	5.2
Total	100	100

Sources: State Statistical Bureau (2000a, 2002).

Coal

China is the world's largest coal producer, with an output of 1.1 billion tons in 2001 (State Statistical Bureau 2002). Coal production has been severely affected by pricing practices in the past decades. As a result, coal pricing has been changing over time. It has gone through two stages:

> *Stage I (1983–90)* A 'dual-track' system was introduced to replace complete government price control before 1983. For example, the 'unplanned' coal price ranged from 80 yuan/ton in 1987 to 136 yuan/ton in 1991 while the controlled price ranged from 36 yuan/ton to 61 yuan/ton during the same time (APERC 2000).[1] However, the 'unplanned' prices were used as references by the government to set the controlled prices. Thus the market was beginning to influence coal pricing.
>
> *Stage II (1993 onwards)* With sufficient coal supply, complete price liberalisation was initially trialled in eastern China and then introduced to the rest of the country. The coal price has since been market driven.

Coal price liberalisation has led to (a) a reduction in government subsidies to the coal sector and (b) improvement in management (for producers) and energy efficiency (for end users).

Oil

The prices of oil and petroleum products in China are still highly regulated by the government. The market mechanism plays only a limited role under the 'dual track' price system introduced in the early 1980s. Under that system, producers

were allowed to sell their above-quota products in the market and the regions could import petroleum products using their own foreign exchange reserves. As a result, both domestic production and imports expanded rapidly. However, the huge gap between the domestic and world prices led to excessive imports in some regions and a surge of speculative and smuggling activities. To overcome these problems, on 1 May 1994 the dual-track pricing system was abandoned and the central government again took tight control of price-setting and imports.

However, as oil imports increased and hence international competition grew, the demand for price liberalisation became stronger, which resulted in major reform during June 1998. Since then, the domestic price of crude oil has been set according to the world price. In the meantime, the central government sets regional prices of refined oil products according to prices in the Singaporean oil market. A consequence of the 1998 reform is that regulated prices have moved very close to international prices. In addition, CNOOC's products have been treated as imports and sold in the domestic market according to the world prices.

Electricity

The price of electricity has been regulated by the government but has risen rapidly in recent years. Several factors have contributed to this increase. Due to the shortage of electricity supply in the 1980s, investment-recovery pricing practice was introduced. As a result, the price of electricity in some plants was very high. Also, in the 1990s, the government removed its subsidies to electricity consumption in the agricultural sector, which led to an increase in electricity prices in the rural sector. As the supply and demand situations have changed since the late 1990s, the Chinese government is moving rapidly to deregulate the electricity sector. Currently, the focus of the reforms is to separate (a) regulation from business functions and (b) generation from transmission (State Development Planning Commission 2002). The first phase of deregulation will involve the regrouping of current power plants into four or five corporations and the formation of six grid companies (south, north, northeast, northwest, eastern and central). The second phase of deregulation will involve liberalising supply prices from the generators. However, reform of the retailing sector has not yet been on the agenda.

Natural gas

Among the energy sectors, the natural gas industry has been highly regulated by the government. This reflects to some extent the status of natural gas as an energy option in China. The natural gas sector has for a long time been ignored by Chinese authorities. The currently modest production of natural gas has been reserved mainly for fertiliser producers. As a result, the price of natural gas has for a long time been kept low. For example, in 1995, the price of natural gas in Sichuan varied from 470 yuan per thousand cubic meters for fertiliser factories to 670 yuan for commercial users (Huo 1999).[2] Government subsidies were also provided to the residential sector. With the removal of subsidies recently, prices

have increased but are still below international prices. As the LNG project in Guangdong is under way and the West–East Gas Pipeline is still being actively pursued, further liberalisation in the natural gas sector is to be expected.

8.3 Environment and energy policy

Environmental awareness is becoming a critical factor in determining energy policies in China. As the Chinese people become more affluent, they demand better quality of life and hence become more aware of environmental problems. For example, air pollution has recently become the main concern of urban residents. As a result, in many Chinese cities, the air quality is monitored and reported every day. Environmental damage also affects the growth of agriculture and forestry. It is estimated that the direct cost of environmental damage in the 1990s amounted to 7 per cent of China's GDP as cited in ERI (2000). As a result, environmental concern has become a key parameter in China's energy policy-making.

One of the main pollutants is sulphur dioxide (SO_2). China's total SO_2 emission increased dramatically in the 1990s. It amounted to 23 million tons in 1997, the largest single source of SO_2 emission in the world. This figure was expected to reach 24.6 million tons by the end of 2000 (Li *et al.* 2000). A consequence of SO_2 emissions is widespread acid rain that affects 40 per cent of China's territory. It is even argued that China's SO_2 emissions are responsible for acid rain in neighbouring Japan and South Korea. Several factors have contributed to China's rising SO_2 emissions.

It is reported that 75 per cent of China's air pollution is due to the burning of fuel (ERI 2000). Coal as a source of primary energy accounts for the dominant share of China's total consumption. Though this share has declined recently, it is still too high relative to other countries (Table 8.2). Thus, a change in energy structure is vital to the reduction of air pollution and hence improvement in quality of the environment. In addition, only 22.2 per cent of China's coal has is washed. About 90 per cent of coal is consumed as raw fuel i.e., not washed. In particular, stack removal of SO_2 has hardly been practised in China as yet.

Another environmental problem associated with energy consumption is Carbon dioxide (CO_2) emission. Though China's CO_2 emission is low on a per capita basis, China is already ranked the world's second largest producer of CO_2, behind the USA. China's CO_2 emission is expected to exceed that of the USA during 2020–30.

To rationalise the energy structure and hence protect the environment, the central government and local authorities have implemented various policy measures. For example, many regions have initiated the so-called 'clear water, blue skies' project. The goal of this project is to clean and protect air and water in China. However, the standard of environmental quality varies among the regions. The coastal regions, in particular the coastal cities, have often imposed much higher standards than the national averages. Some of the common measures can be summarised as follows:

Table 8.2 Energy structure in selected economies (percentage shares)

Energy	*1999*		*1996*					
	China	*GD*	*China*	*USA*	*Japan*	*India*	*Russia*	*Korea*
Coal	67.1	54.3	74.6	24.2	17.6	56.9	19.7	19.2
Oil	23.4	32.8	18.0	39.1	53.8	31.9	21.1	61.6
Natural gas	2.8	0.3	1.8	26.7	11.9	7.9	52.4	7.4
Other	6.7	12.6	5.6	10.0	16.7	3.3	6.8	11.8
Projections for the year 2010								
Coal	65.1	40						
Oil	19.6	30						
Natural gas	6.6	10						
Other	8.7	20						

Sources: Keii (2000), State Statistical Bureau (2000b) and Guangdong Statistical Bureau (2000).

- China aims to reduce its SO_2 emission in 2010 to the level of 2000.
- New mines are prohibited from the producing of coal with sulphur content greater than 3 per cent. Existing mines producing coal with sulphur content over 3 per cent have the options of closure, reduction in production or installation of coal-washing equipment.
- Coal-fired power plants have to reduce SO_2 emissions and eventually install desulphurisation equipment by 2010.

China's energy consumption per unit of GDP is about four times as great as that in the USA (Li *et al.* 2000). Thus, there is great scope for improvement in energy efficiency. In addition, the goals of environment protection and energy conservation may also be achieved through the development of less energy-intensive industries.

The consumption of coal is responsible for about 90 per cent of China's SO_2 emission. In 2001, coal still accounted for 67 per cent of China's total consumption of primary energy (State Statistical Bureau 2002, p. 126). To reduce SO_2 emissions and hence protect the environment, the Chinese government is actively promoting the policy of replacing coal by oil, natural gas and renewable energy. As a result, within ten years China's energy structure will be more rational with natural gas and renewable energy becoming increasingly important sources of energy.

8.4 Production and consumption

The energy sector has been regarded as one of the strategic industries affecting the Chinese economy and people's livelihood. Therefore, energy production and

consumption in China, as in the rest of the world, has for a long time been tightly controlled by the government. This background is reflected in the current ownership and control structure of China's energy production and consumption despite the institutional reforms of the past two decades. In general, state ownership still dominates the industry but it varies across different sectors. The coal sector has the greatest participation of non-state producers. In fact, in some years, the township, village and private (TVP) mines account for more than 50 per cent of total coal production (see Table 8.3). With the closure of many small mines in the late 1990s, however, output share of the state sector has increased substantially. In the electricity sector, there are some independent power producers (IPPs). Their market share is still small but rapidly rising. However, non-state investors play only a minor role in the oil and gas sectors, which partly reflects the capital- and skill-intensive nature of these industries.

Coal

In August 1998, there were 94 large state-owned coal companies, 2,500 local government owned mines and 75,000 township and village-run small mines (IEA 1999). The output share of the state sector declined to its lowest level in the mid 1990s, a reflection of strong growth of the non-state sector in the 1980s and early 1990s. By September 2000, however, about 30,000 small mines were forced to close due to environmental and safety concerns.[3] In the meantime, the 94 large state-owned companies previously controlled by the central government were transferred to provincial authorities. As a result, by the end of 2000 there were 2,098 state-owned mines and 20,237 non-state-owned mines (Editorial Board 2001).

Another form of non-state ownership is foreign investment and equities. During 1996–2000, over US$1 billion foreign capital was invested in China's coal sector (Editorial Board 2001). But the bulk of foreign funds came from bilateral loans. It is thus clear that the coal sector is not attractive to offshore investors. In addition, a few coal companies are also listed in domestic and offshore stock exchanges. Therefore the non-state sector can also hold equities of the listed state-owned enterprises (SOEs).

Table 8.3 Output and employment shares (%) in the coal sector, by ownership

Owner	*Output*			*Employment 1996*
	1996	*1998*	*2000*	
Central government	39.1	54	84	66
Local governments	9.1			14
Townships and villages	44.7	44	16	20
Individuals	7.0			

Sources: IEA (1999) and Editorial Board (2001).

The non-state sector produced about 16 per cent of the coal output in 2000 (see Table 8.3). Over 70 per cent of China's coal is used for electricity generation and industrial consumption (Table 8.4). The shares of residential and transport use have been declining rapidly, which reflects the concern about air pollution in the urban areas. China is also a net coal exporter.

Oil

In 2001, China produced 165 million tons of crude oil and imported about 82 million tons (State Statistical Bureau 2002). The imported oil accounts for about a half of China's total consumption. Since 1993, the share of imported liquefied petroleum gas (LPG) in total supply has risen from 14 per cent in 1993 to 44 per cent in 1998 (State Statistical Bureau 2000a). Residential consumption accounted for 65 per cent of total LPG supply in 1998 (Table 8.4). Foreign investors have mainly been involved in exploration. Shell is an exception. It has been permitted to build and operate petroleum stations in China. PetroChina was floated on the Hong Kong and New York stock markets in early 2000, which raised about US$3 billion of capital. PetroChemical was listed in the stock exchanges in Hong Kong, London and New York in October 2000, raising more than US$3.7 billion of capital. The third SOE, CNOOC, was also listed on Hong Kong and New York stock exchanges in early 2001, raising about US$1.25 billion. Thus, foreign investors can be involved in the oil sector by shareholding.

Table 8.4 Final energy consumption by sector, 1998

Sector	*Total (mtce)*	*Coal (mt)*	*Oil (mt)*	*LPG (mt)*	*NG (bcm)*	*Electricity (twh)*
Agriculture	57.9	19.2	12.9	0.0	0.0	62.4
Industry	944.1	1149.5	108.7	2.2	17.2	840.6
Construction	16.1	6.1	2.9	0.0	0.0	18.9
Transport/telecoms	82.5	13.9	42.5	0.0	0.4	25.6
Trade/catering	25.5	9.5	4.3	0.4	0.3	29.3
Residential	143.9	88.8	9.8	7.7	2.4	132.5
Others	52.1	7.8	17.0	1.5	0.0	50.7
Total	1322.1	1294.9	198.2	11.9	20.3	1159.8

Source: State Statistical Bureau (2000b).

Notes
mtce: million tons coal equivalent;
mt: million tons;
bcm: billion cubic meters;
twh: terawatt hours or one billion kilowatt hours.

Electricity

China generated 1,239 twh of electricity in 1999, with thermal power plants having a dominant share (State Statistical Bureau 2000b). Production increased to 1,478 twh in 2001 (State Statistical Bureau 2002). Industrial consumption still accounts for the lion's share which is however declining. The rapidly growing area is residential consumption. Its share of total electricity consumption doubled during 1987–97 (APERC 2000). Since 1979, about 10 per cent of total investment in the power sector came from abroad in the forms of foreign investment and soft loans. This figure is expected to reach 20 per cent in the near future (X. Li 1999). By mid-1998, 24 foreign-invested plants with a combined capacity of 4.9 gigawatts (gw) or billion watts were in operation and another dozen plants with a combined capacity of 9 gw were under construction (Blackman and Wu 1999).

Natural gas

Natural gas amounted to only 3.4 per cent of China's total primary energy supply in 2001 (State Statistical Bureau 2002). In 1999, China produced 25.2 bcm of natural gas, about 40 per cent of which was produced in Sichuan province. So far the industrial sector has been the dominant use of natural gas followed by the residential sector (Table 8.4). Both production and consumption have been tightly controlled by the government. This situation will however change in the near future. The Guangdong liquefied natural gas (LNG) project will allow 35 per cent foreign ownership. Foreign investors are also encouraged to participate in the massive West–East Gas Pipeline project. In late 1999, China lifted the ban on foreign investment in town-gas pipeline construction. It can be expected that foreign investors will play an important role in China's natural gas sector. However, as in the other energy sectors, foreign participation in the retailing businesses is still prohibited with the exception of owning and managing petroleum stations. But this situation is going to change with China's entry into the WTO.

8.5 Demand outlook

China's primary energy consumption reached 1.32 billion tons coal equivalent (btce) in 2001 (State Statistical Bureau 2002, p. 126). Though China's energy demand has been declining in the past five years, its long-term trend is still to increase. In particular, energy consumption in Guangdong will continue to grow in the near future. This growth prospect is determined by several factors.

First, the Chinese economy is still at the stage of rapid expansion. A growth rate of about 7 per cent will be maintained in the next two decades (World Bank 1997a). Currently, China is heading to its next cycle of high growth following the downturn in the late 1990s. The growth rate in the coming decade is projected to be 6.9 per cent (World Bank 1997a). This growth will boost China's energy consumption to a higher level.

Second, though great at aggregate level, China's energy consumption per capita of 1,034 kilograms coal equivalent (kgce) in 2001 was still very small relative to that in the developed economies, e.g., 11.5 tons coal equivalent (tce) in the US and 5.1 tce in Japan in 1995 (State Statistical Bureau 2000a, 2002). This difference implies great growth potential for energy demand in China.

Third, energy consumption in China is highly unbalanced between rural and urban sectors as well as across Chinese regions. In 1996, urban residential energy consumption of 261 kgce per capita was twice as great as rural consumption per head (96 kgce). In the same year, on a per capita basis, China's developed regions, e.g., Beijing, Shanghai and Guangdong consumed three times as much electricity as the less developed provinces, e.g., Guizhou, Yunnan and Qinghai (Table 8.5). Over time, rural consumers will catch up with their urban counterparts and poor areas with rich regions. This catching-up effect will also affect China's overall energy demand in the future.

Table 8.5 Final energy consumption in 1996 (physical quantity per capita)

Region	*Coal (kg)*	*Oil (kg)*	*Gas (cm)*	*Electricity (kwh)*
Developed regions				
Beijing	282.9	27.9	6.0	172.8
Tianjin	202.0	10.7	8.5	178.7
Shanghai	110.0	21.5		245.2
Jiangsu	46.4	6.1		117.6
Zhejiang	34.3	13.4		153.9
Fujian	50.1	10.0		129.3
Shandong	32.1	4.1	7.1	102.3
Guangdong	26.0	43.8		178.2
Developing regions				
Anhui	61.8	2.0		60.6
Guangxi	6.4	7.6		72.6
Guizhou	319.1	4.6		40.1
Yunnan	133.9	0.5		52.6
Shaanxi	146.1	3.6		61.2
Gansu	194.1	1.5		67.7
Qinghai	255.9	17.2		51.6
Ningxia	156.3	5.2	0.8	82.7

Source: State Statistical Bureau (1998b).

Notes
cm: cubic meters;
kwh: kilowatt hours.

Finally, China's future demand for energy is also determined by the growth of several energy-intensive sectors, e.g., automobiles and air-conditioners. The number of motor vehicles has increased from 5.5 million in 1990 to 18.0 million in 2001 (State Statistical Bureau 2002, p. 130). In the meantime, the ownership of air conditioners in Chinese households has increased from 11.6 per cent in 1996 to 35.8 per cent in 2001 (State Statistical Bureau 2002, p. 94).

The objective of this section is to present a survey of China's energy demand projections reported in various sources and hence to gain insight into China's energy demand prospects in the coming two decades.

China's total energy consumption is projected to increase from 1.32 btce in 2001 to 1.64 btce in 2005 and 2.22 in 2015 (Shi and Zhao 1999, p. 141). The implied average annual rate of growth is 5.1 per cent during 2001-05 and 3.1 per cent during 2005–15. These rates will vary across regions as well as sectors. The coastal regions will continue to be the leading energy growth regions. Transportation and residential sectors will likely be the sectors contributing to China's increased energy consumption in the future.

China's rising energy consumption will boost domestic demand for coal, petroleum products, electricity and natural gas. Due to the change in energy structure, growth will be biased towards cleaner energy such as natural gas. The demand for coal will continue to grow modestly as coal is still the cheapest fuel in China. The International Energy Agency projects that coal demand will increase annually at 3.1 per cent in the next two decades (IEA 1999). Keii (2000) derives a more modest annual rate of growth (2 per cent) for coal consumption in the coming decade. According to Keii's projection, China's demand for coal will reach 1.3 billion tons in 2010. However, the share of coal as a primary energy source against total energy consumption will decline over time. By 2010, coal will account for about 65 per cent of China's primary energy (see Table 8.4).

China's demand for natural gas is projected to be around 100 billion cubic meters (BCM) in 2010 and 200 BCM in 2020 (Table 8.6). The implied annual rate of growth in the first two decades of the twenty-first century is about 9 per cent according to Han *et al.* (2000) and 11 per cent according to Zhou (1999). In addition, according to both sources, growth in demand will be much greater in the first ten years.

The projected growth in the consumption of oil and electricity is modest. For example, Han *et al.* (2000) estimated an annual rate of growth of 4 per cent for crude oil consumption and 5 per cent for electricity demand during 2000–20. Obviously, the fastest growth area is natural gas. The two largest users of natural gas will be the residential and power generation sectors. Demand in these sectors is projected to grow at a rate greater than 20 per cent during the period 2000–10 (Table 8.6). This growth can only become possible with overseas supplies. Han *et al.* (2000) estimated that China's imports of natural gas would reach 35 bcm in 2010 and 75 bcm in 2020. Given the projected rate of growth and the stagnation of domestic production of oil, China will also have to rely on offshore sources to meet the demand. Han *et al.* (2000) predicted that China oil imports would

Table 8.6 China's energy projections

Author	*Natural gas*			*Crude oil*		*Electricity*	
	1997 bcm	*2010 bcm*	*2020 bcm*	*2010 mt*	*2020 mt*	*2010 bkwh*	*2020 bkwh*
Zhou (1999): demand							
Total	19.56	96	204				
Power generation	2.19	35	81				
Residential	2.12	22	50				
Chemical industry	8.43	19	33				
Other industries	6.82	20	40				
Han *et al.* (2000): demand		118	220	296	379	2000	3400
Han *et al.* (2000): domestic production		75	135	190	200		
Y. Li (1999)		80					
Han *et al.* (2000): imports		35	75	106	180		

Source: As cited in the table.

increase from 57 million tons in 1999 to 106 million tons in 2010 and 180 million tons in 2020.

Energy demand in Guangdong will particularly be robust in the coming decades. Growth will be led by natural gas consumption, followed by demand for other energy, i.e., nuclear and renewable energy (See Table 8.7). As a result, energy structure in Guangdong will become more rational, with natural gas and renewable energy accounting for about 30 per cent of total consumption. Overall, Guangdong's energy consumption is expected to double in the coming decade.

8.6 Concluding remarks

China's energy sector has undergone dramatic changes in recent years. These changes have been driven by reforms and subsequent economic conditions. Environmental awareness has become an important factor propelling reforms and changes in the energy sector. It has been the driving force for changes in China's energy structure which is currently dominated by the use of coal. China is now under both internal and external pressures to increase use of cleaner energy, e.g., natural gas and renewable energy. In the meantime, cleaner energy becomes more affordable due to rising consumer income and changing energy pricing practice. In addition, the shift from coal use to the consumption of cleaner energy has been supported by price liberalisation and deregulation in the energy sector.

Reforms in the energy sector were accompanied by overhaul of the regulatory framework. The regulatory reform targeted separation of government's role in regulation from its business activities. The reform has passed through different

Table 8.7 Primary energy consumption in Guangdong in 1999 and 2010

Energy source	*Shares (%)*		*Quantity (mtce)*		*Annual growth rate (%)*
	1999	*2010*	*1999*	*2010*	
Coal	54.3	40	37.2	60.0	4.4
Crude oil	32.8	30	22.5	45.0	6.5
Other	12.8	20	8.8	30.0	11.8
Natural gas	0.3	10	0.2	15.0	48.1
Total	100	100	68.5	150	7.4

Sources: This chapter (Table 8.2), Guangdong Statistical Bureau (2000) and Yao (1999).

phases in the coal, electric power, oil and gas sectors. As a result, the coal and oil sectors are more liberalised. The reform package of the electric power industry was announced in April 2002. In terms of deregulation, the natural gas sector lags behind due to the historically minor role of this sector in China's energy industry. But over time, natural gas as a cleaner energy will play an increasingly important role in the Chinese economy. It is projected that demand for natural gas will lead the growth in China's energy consumption in the coming decades. China will consume more natural gas and eventually become an important buyer in the international market. Among Chinese regions, Guangdong will lead in the use of natural gas and other cleaner energy.

Though foreign participation in the Chinese energy industry has expanded, scope is still limited, particularly in the retail sector. China is now an official member of WTO. Further reforms and deregulation in the energy sector are anticipated. The Chinese government has committed itself to substantial reduction of tariffs, elimination of non-tariff trade barriers (e.g., import quota and business licensing) and phased participation of private and foreign providers in the wholesale and retail services (Zhang 2002). These trade liberalization initiatives will bring about both opportunities and challenges to the Chinese energy industry.

9 Conclusions

This book examined China's economic growth at the economy level, among the regions and in selected industrial sectors. This final chapter summarises and comments on the main findings in the core chapters (2 to 8). A summary of the main results is presented first. Then the chapter is concluded with some remarks on the growth outlook in China.

9.1 Main findings

The main findings in the core chapters are summarised in Table 9.1. There are three tasks in Chapter 2. It first reviews the literature on capital formation and economic growth in China. The literature is inconclusive and limited due to the lack of reliable data, in particular the capital stock statistics. The chapter then discusses and assesses three approaches towards the estimation of capital stock, i.e., the initial value, integral and backcasting approaches. The backcasting approach is employed to derive capital stock series which are used in other chapters. For the convenience of other researchers, the complete data series are presented in the appendix of this book. The final task in Chapter 2 is a brief analysis of the relationship between capital formation and China's economic growth. It is found that economic growth is closely associated with the increase in capital formation. This may indicate the important role of capital stock in China's economic growth, an issue to be investigated in other chapters of the book. There are however variations among the regions.

Chapter 3 examined the sources of economic growth. It applied the standard regression approach to investigate the impact of key economic and policy factors on growth among the Chinese regions. It is found that China's regional growth is positively affected by capital formation, infrastructure, productivity, human capital, foreign investment, economic reform and openness. These factors together with initial conditions accounted for 70–90 per cent of China's total growth. There is also evidence of conditional convergence among the regions. This trend of convergence was particularly strong in the 1980s. It is also found that convergence mainly occurred within China's three geographical regions, i.e., the western, central and coastal regions. There is little convergence between the three regions.

Table 9.1 Summary of the main findings

Chapter	*Method*	*Findings*
2	Perpetual inventory	Close association between capital formation and economic growth but considerable regional variation.
3	Regressions	Eight factors account for 70–90% growth; evidence of conditional convergence within the regions and no convergence between the regions.
4	Growth accounting	Factor inputs account for 57.7% of growth; productivity accounts for 13.5% of growth; China's growth is sustainable; findings are robust according to sensitivity analysis.
5	Indices of disparity	Little change in regional disparity in the absence of the three large cities; evidence of convergence within the central and western regions.
6	South China integration	Guangdong and Fujian are rapidly catching up with Hong Kong and Taiwan; evidence of regional integration and convergence.
7	Telecommunications	Growth outpaces that of the overall economy; demand, policy change and deregulation are the driving forces of growth; further growth due to low teledensity, rural–urban and regional gaps.
8	Energy sector	Coal sector is most deregulated followed by the petroleum sector; electricity reform package was out in late 2002; gas sector is less deregulated and less mature; growth will continue due to rising demand and consumption.

Chapter 4 introduced an alternative approach to account for China's growth. According to this approach, factor inputs, technological progress and technical efficiency, respectively, accounted for 57.7, 12.3 and 1.2 per cent of China's growth during 1982–97. The sum of the last two items is equal to the contribution of total factor productivity. Thus, productivity has on average contributed 13.5 per cent of China's growth in the 1980s and 1990s. This finding provides statistical support for China's sustained growth in the future. In addition, sensitivity analysis also shows that the findings in this chapter are robust. They are not sensitive to the choice of the rate of depreciation and the value of initial capital stock.

Chapter 5 dealt with China's regional disparity and convergence. Regional disparity in China has recently become the focus of academic research and policy-making. This chapter contributes to the current debate. It first presents a review of the literature. It is found that researchers do not agree with each other

on the conditions of regional disparity in China. Their work is constrained due to data limitations and inconsistent goals. In this chapter, several indices of regional disparity are estimated and the results are compared to previous studies. A major distinction in this study is its separation of the three municipal cities, namely Beijing, Shanghai and Tianjin, from the provincial regions. It is found that, in the absence of the three cities, regional disparity in China has changed little during the reform period. Previous measures of regional disparity mainly picked up the gap between largest cities and the provinces. The latter are less urbanised than the cities. With the exclusion of the three cities, China's regional disparity is internationally compatible. In addition, this chapter also found evidence of convergence within the three regions (western, central and coastal). This finding is consistent with observations from Chapter 3.

The southern China economic region has emerged as a major economic centre in Asia in the 1980s and 1990s. Chapter 6 compiled and estimated a database for the four regional economies, i.e., Guangdong, Fujian, Hong Kong and Taiwan. The database is employed to compare economic performance among the regions. It is found that the two mainland regions, Guangdong and Fujian have shown rapid catch-up with their affluent neighbours, Hong Kong and Taiwan. As a result, the gap between the four economies has been narrowing over time. This has become the driving force for economic integration in the region. With mainland China and Taiwan becoming official WTO members in late 2001, economic integration will be accelerated in the near future.

Chapter 7 presents a case study of the telecommunications industry which has far outpaced the growth of the Chinese economy. Several factors have contributed to this growth. They include burgeoning demand for services, changes in government policy and deregulation in telecommunications. In particular, deregulation has become the main driving force for the growth in China's telecommunications. Since the early 1990s, the Chinese telecommunications sector has been transformed from state monopoly to a privately owned and operated system. Several independent large companies together with small providers compete for services in the market. Foreign traders and investors are also allowed to play a role in various forms though there are still restrictions. As China complies with WTO regulations, foreign participation will gradually increase in the near future. China is now the world's largest mobile phone as well as fixed line market in terms of numbers. However, China's teledensity is still a long way from matching the level in advanced economies such as the USA and Japan according to Chapter 7. There are also huge differences between the coastal and inland regions and between rural and urban areas. These factors imply that China's telecommunications sector will maintain high growth in the coming years.

The energy sector used to be the bottleneck of the economy. This was due to poor efficiency in domestic production and the pursuit of energy self-sufficiency. After two decades of reform, China has shifted to rely on diverse sources of energy supply. In 2001, about a third of China's crude oil comes from offshore sources. As a result, China is now an important trader in the international oil

market. China has also signed a 25 year contract to purchase LNG from Australia. Domestically, dramatic changes have taken place in coal, oil, gas and electricity sectors. In all sectors, production and trade have moved away from state monopoly to multiple players. The coal sector is most deregulated. It is followed by the petroleum sector. A major reform package for the electricity sector was announced in late 2002. More changes and deregulation initiatives are expected in the future. In the meantime, burgeoning demand and rising consumption will maintain the trend of growth in this sector.

9.2 Growth outlook

China's GDP is expected to achieve a rate of growth of 7.9 per cent in 2002. This rate is impressive given the economic performance in the USA and Japan during the same period. In the same year, China overtook the USA to become the largest recipient of foreign direct investment. With China being a WTO member for just a year, more foreign capital is expected to flow to the Chinese economy. The Chinese government is also injecting massive investment in the western part of the country. All these signs point to the direction of continuing growth at the current level in China. This optimistic view is shared by the Economic Analytical Unit (2002) and Asian Development Bank (2002).

There are however potential uncertainties associated with China's growth in the near future. First of all is rising unemployment. According to official statistics, unemployment was around 4 per cent (State Statistical Bureau 2002). The actual figure is much higher. As more foreign firms and products enter the Chinese economy, the situation is likely to become worse in the short run. Coupled with unemployment is the lack of a nation-wide social security network. Most unemployed are left alone and are receiving no financial assistance. This could be a threat to social stability in a society with a billion urban workers and farmers.

While telecommunications and energy industries have moved ahead to embrace the market and economic openness, China's banking and financial sectors are yet to be reformed. These sectors are still dominated by state ownership and often closely linked with the inefficient state-owned enterprises (SOEs). The latter are the main debtors of the former and can still borrow more from the former under its current system. Many SOEs are inefficient but politically sensitive to the risk of bankruptcy. Thus, the banking and financial sectors could hamper long-term growth prospects of the Chinese economy.

Appendix

This appendix presents the complete database derived and used in this study. The database contains three variables, namely, capital stock, gross domestic product and price index. They are defined as follows.

Capital stock

The capital stock series is derived using the backcasting approach (see Chapter 2 for details). It is based on the assumption that the rate of depreciation is 7 per cent. The series is expressed in 1952 constant prices and billion yuan.

Gross domestic product (GDP)

The GDP series is drawn from official publications, mainly *China's GDP Data 1952–95* (State Statistical Bureau 1997) and *Statistical Yearbook of China* (State Statistical Bureau various issues). It is expressed in 1952 constant prices and billion yuan.

Price indices

The price indices are derived using nominal GDP and real rate of GDP growth (see Chapter 2 for details). It is based on 1952 prices (100).

The three series are available for the nation and its thirty regions covering the period 1953–2000. Chong Qing became a municipality in 1997 and is included in Sichuan province in this study. Capital stock is listed in the K_i columns, price indices in the D_i columns and GDP in the GDP_i columns. 'i' is the regional code and takes values from 0 to 30. The regional codes are defined as follows

0 China	8 Heilongjiang	16 Henan	24 Yunnan
1 Beijing	9 Shanghai	17 Hubei	25 Tibet
2 Tianjin	10 Jiangsu	18 Hunan	26 Shaanxi
3 Hebei	11 Zhejiang	19 Guangdong	27 Gansu

4 Shanxi	12 Anhui	20 Guangxi	28 Qinghai
5 Inner Mongolia	13 Fujian	21 Hainan	29 Ningxia
6 Liaoning	14 Jiangxi	22 Sichuan	30 Xinjiang
7 Jilin	15 Shandong	23 Guizhou	

Capital	**K0**	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
1953	118	2.6	1.2	4.5	3.6	2.3	6.8	2.8	4.1	2.3	3.2
1954	132	3.4	1.7	5.2	3.9	2.5	8.3	3.4	4.8	2.7	3.9
1955	145	3.8	1.8	6.1	4.2	2.6	8.8	3.9	5.5	3.2	4.8
1956	161	4.7	1.8	7.0	5.0	2.9	9.7	4.3	5.7	3.2	5.7
1957	179	5.5	2.3	8.1	6.0	3.3	11.0	4.6	6.5	4.6	6.5
1958	211	7.0	3.2	10.6	7.8	4.8	14.3	5.3	8.4	6.7	7.5
1959	260	9.3	4.6	13.1	10.0	6.7	18.7	6.3	10.5	10.2	8.7
1960	299	11.6	5.4	15.6	11.8	8.3	23.3	7.1	12.8	13.2	9.9
1961	302	11.7	5.2	16.1	11.8	8.3	22.5	7.2	12.6	13.6	10.2
1962	296	11.3	4.9	14.9	11.2	8.1	20.6	7.1	12.1	12.4	10.1
1963	299	10.8	4.6	14.8	10.9	8.1	21.2	7.2	12.4	12.7	10.4
1964	310	10.7	4.8	15.0	10.8	8.4	22.1	7.4	12.7	13.5	11.2
1965	329	11.0	5.2	15.4	11.3	8.9	23.5	7.7	12.9	13.4	12.0
1966	358	11.5	5.7	15.7	11.8	9.3	24.4	8.0	13.0	15.2	13.3
1967	371	11.7	6.0	16.2	11.7	9.1	24.9	8.2	12.9	15.0	13.8
1968	383	11.8	6.3	16.8	11.6	9.0	25.5	8.4	12.7	16.7	14.3
1969	401	12.4	6.7	17.7	12.1	9.0	26.5	8.7	13.3	16.5	14.9
1970	444	13.1	7.3	19.4	12.8	9.4	28.4	9.3	14.1	17.6	16.5
1971	490	14.6	8.2	21.5	14.4	9.8	31.5	10.2	14.7	19.5	18.5
1972	530	15.4	9.3	23.3	16.0	10.2	33.4	11.0	15.4	22.5	20.4
1973	578	17.5	10.8	25.2	17.0	10.8	36.1	12.0	16.3	25.6	22.5
1974	625	19.4	12.8	27.3	18.1	11.5	39.4	13.0	17.4	29.3	24.5
1975	682	20.6	14.4	30.2	19.3	12.2	44.0	14.3	18.9	32.2	26.7
1976	728	20.9	15.6	32.7	19.9	13.0	48.4	14.9	20.3	33.7	28.8
1977	780	22.0	16.9	35.7	21.3	13.9	50.7	15.6	21.4	35.2	31.0
1978	854	24.1	18.3	39.7	23.0	15.2	54.5	17.5	23.7	38.5	34.6
1979	926	26.7	20.3	43.6	24.1	16.5	58.1	18.5	26.0	41.2	38.2
1980	998	29.7	22.3	46.4	25.2	17.2	60.2	19.7	28.1	46.6	42.1
1981	1062	31.9	23.1	47.8	26.0	17.8	61.7	20.6	30.9	52.9	45.9
1982	1136	33.3	24.8	51.2	27.5	19.1	64.2	21.9	34.9	60.9	51.7
1983	1224	36.6	27.0	55.7	29.9	21.0	68.3	23.4	39.8	66.3	57.8
1984	1336	42.1	29.7	61.8	34.0	23.6	75.9	26.0	45.3	75.3	67.0
1985	1487	57.1	35.4	70.4	39.6	26.9	86.6	29.8	52.0	94.2	79.1
1986	1649	67.5	41.4	78.3	44.9	29.7	99.0	33.4	59.2	116.5	94.1
1987	1819	81.1	45.9	85.8	50.8	32.5	113.2	37.8	66.6	137.9	110.1
1988	2014	95.2	52.9	94.9	56.1	37.0	130.3	42.6	73.8	166.4	128.9
1989	2202	110.6	58.3	104.8	61.1	41.3	145.4	47.3	81.1	193.0	144.7
1990	2377	124.8	62.8	115.8	66.2	45.6	160.6	52.9	88.8	212.9	161.7
1991	2571	137.1	68.5	127.2	69.9	50.0	176.8	58.3	95.4	230.0	181.0
1992	2818	153.6	76.7	141.6	75.5	56.8	195.6	63.7	102.8	256.2	212.8
1993	3202	178.3	86.9	161.3	82.8	66.1	224.0	70.3	111.1	292.6	254.2
1994	3600	212.0	98.8	184.4	91.0	74.5	251.8	78.7	119.8	346.2	298.1
1995	4029	253.4	111.7	213.1	97.7	82.5	276.1	87.1	129.9	413.1	347.3
1996	4464	282.3	125.8	247.3	105.1	91.7	298.2	99.2	141.4	492.9	397.8
1997	4909	313.3	141.9	287.5	114.1	101.0	320.7	108.8	152.7	568.8	448.5
1998	5374	348.2	158.4	333.8	130.0	111.4	344.4	119.7	168.3	637.7	509.1
1999	5853	387.2	174.0	381.7	143.0	122.2	368.1	131.6	180.6	700.0	574.8
2000	6369	421.4	191.3	430.8	156.7	134.2	395.6	143.4	192.1	766.3	646.2

Capital	K11	K12	K13	K14	K15	K16	K17	K18	K19	K20
1953	2.0	2.0	1.1	2.0	4.7	4.1	3.0	2.4	0.3	2.4
1954	2.3	2.3	1.4	2.1	5.7	4.6	3.3	2.5	0.4	2.7
1955	2.6	2.8	1.7	2.1	6.9	5.4	3.7	2.9	0.4	3.0
1956	2.9	3.2	2.4	2.3	8.1	6.2	4.3	3.2	0.5	3.4
1957	3.5	3.7	2.8	3.0	9.4	7.4	5.3	3.7	0.6	3.6
1958	4.7	4.7	3.7	4.0	11.0	9.6	6.8	5.2	0.7	4.1
1959	6.2	5.7	5.0	5.2	13.1	12.3	8.3	7.0	0.8	4.9
1960	7.2	6.5	6.2	6.9	14.7	13.9	9.5	8.4	0.9	5.5
1961	7.3	6.5	6.0	7.0	14.6	13.3	9.3	8.1	1.1	5.5
1962	7.3	6.2	5.6	6.9	14.3	12.6	9.0	7.6	1.3	5.5
1963	7.5	6.0	5.2	6.8	14.2	12.5	9.1	7.5	1.5	5.7
1964	7.8	6.2	5.3	6.8	14.3	12.6	8.9	7.8	1.8	5.8
1965	8.3	6.5	5.5	6.9	15.3	13.0	9.3	8.2	2.1	6.1
1966	8.8	6.8	5.9	7.2	16.6	14.0	9.7	8.8	2.4	6.6
1967	9.2	6.8	5.6	7.4	17.7	14.6	9.8	9.2	2.8	6.7
1968	9.5	6.8	5.4	7.6	18.5	14.8	9.8	9.5	3.3	6.9
1969	10.2	6.9	5.4	7.8	19.9	15.7	10.3	10.0	3.9	7.6
1970	11.0	7.4	5.9	8.8	21.5	17.7	12.1	11.3	4.6	8.3
1971	11.9	8.0	6.8	10.0	23.2	19.2	14.2	13.0	5.4	9.2
1972	13.0	8.7	7.5	10.7	25.1	20.6	15.2	14.2	6.3	10.0
1973	14.0	9.3	8.1	11.3	27.5	22.3	16.6	15.2	7.3	10.9
1974	14.9	10.0	8.4	11.7	28.5	24.0	17.7	15.9	8.6	11.8
1975	15.7	10.7	8.8	12.0	31.8	25.8	19.8	16.7	10.1	13.0
1976	16.4	11.3	8.7	12.4	35.2	26.9	21.9	17.3	11.8	14.1
1977	17.5	11.9	9.0	12.7	39.1	28.9	24.1	18.2	13.9	15.4
1978	19.0	12.5	10.3	14.0	42.9	30.7	25.4	20.0	16.8	16.7
1979	20.5	13.0	11.5	15.5	46.4	32.7	26.7	21.4	19.4	17.7
1980	22.8	13.6	12.9	16.7	50.6	34.9	27.5	22.5	22.4	18.8
1981	25.1	13.9	14.3	17.6	54.0	37.3	28.7	23.5	26.5	19.9
1982	27.8	15.1	15.8	18.8	58.8	39.2	30.9	25.0	31.2	20.8
1983	30.2	16.7	17.4	20.0	64.1	43.7	33.1	26.7	35.7	21.7
1984	35.0	19.3	19.4	21.8	71.5	48.7	36.7	28.4	41.1	22.7
1985	42.0	22.8	22.3	24.1	81.3	55.2	42.0	31.5	49.8	25.0
1986	50.4	26.8	25.9	26.8	91.6	61.2	47.1	35.3	58.4	27.6
1987	60.2	30.5	29.8	29.7	105.3	68.3	52.4	39.7	68.1	30.1
1988	70.7	34.2	33.7	33.6	120.2	77.5	58.9	44.7	79.9	32.7
1989	79.2	37.4	37.3	37.0	135.2	86.5	63.1	48.3	91.8	34.6
1990	84.7	40.7	40.9	39.4	150.8	95.0	68.6	51.5	103.9	35.9
1991	93.1	43.7	45.5	42.3	170.9	104.4	74.1	55.6	117.7	38.0
1992	108.1	48.1	52.0	47.3	196.8	117.2	81.3	61.5	141.1	42.7
1993	132.1	55.1	62.9	53.9	231.1	130.6	91.3	69.0	176.1	49.7
1994	158.7	64.1	78.5	60.7	266.9	145.1	104.8	78.1	215.7	57.4
1995	195.1	74.8	96.8	67.9	306.1	163.3	121.1	89.0	257.1	66.6
1996	233.4	87.0	117.4	75.4	351.7	183.6	139.1	99.8	298.1	75.0
1997	273.9	99.9	140.3	84.9	404.5	206.6	161.3	112.0	335.8	83.2
1998	319.2	113.3	166.4	95.1	462.3	232.5	186.2	125.7	378.5	92.6
1999	363.6	125.6	194.0	105.9	523.5	259.6	214.3	139.4	424.4	102.0
2000	408.1	138.6	222.2	116.2	593.4	288.1	243.0	154.5	470.1	111.8

Capital	K21	K22	K23	K24	K25	K26	K27	K28	K29	K30
1953	0.4	4.1	1.5	2.2	0.0	2.4	5.4	0.8	0.6	1.4
1954	0.5	5.1	1.7	2.5	0.1	2.9	5.9	0.9	0.7	1.6
1955	0.5	5.9	1.7	2.7	0.1	3.3	6.6	1.0	0.7	1.8
1956	0.6	6.8	1.9	3.0	0.1	3.8	7.2	1.4	0.8	2.0
1957	0.7	7.9	2.2	3.3	0.1	4.1	7.8	1.6	0.8	2.2
1958	0.7	9.7	3.2	4.0	0.1	4.7	8.1	1.7	1.0	2.7
1959	0.8	12.4	3.8	5.0	0.1	6.1	8.9	2.1	1.4	3.3
1960	0.9	14.1	4.2	6.0	0.1	7.3	9.6	2.6	1.8	4.1
1961	1.0	13.2	4.0	6.0	0.1	7.2	9.9	2.5	1.8	4.4
1962	1.1	12.0	3.7	5.7	0.1	6.8	10.1	2.3	1.7	4.4
1963	1.2	11.7	3.7	5.7	0.1	6.6	10.3	2.2	1.7	4.6
1964	1.4	12.0	3.8	5.8	0.2	6.8	10.7	2.1	1.8	4.9
1965	1.5	13.7	4.5	6.4	0.2	7.2	11.0	2.2	2.0	5.2
1966	1.7	16.8	5.1	7.1	0.2	8.1	11.4	2.3	2.3	5.6
1967	1.9	17.4	5.2	7.4	0.2	8.3	11.6	2.3	2.5	5.7
1968	2.1	16.9	5.4	7.6	0.3	8.4	11.9	2.4	2.6	5.8
1969	2.3	18.3	5.6	8.2	0.3	9.4	12.3	2.5	2.8	6.0
1970	2.6	21.5	6.7	9.1	0.3	11.1	12.9	2.6	3.3	6.4
1971	2.9	23.8	8.0	9.9	0.4	13.3	13.6	2.8	3.8	6.8
1972	3.2	25.9	8.7	10.5	0.4	15.4	14.3	3.5	4.2	7.3
1973	3.5	27.8	9.2	11.4	0.4	16.6	15.1	3.7	4.7	7.8
1974	3.9	29.1	9.4	12.1	0.5	17.6	16.1	3.8	5.1	8.3
1975	4.4	32.1	9.4	12.9	0.6	18.6	17.4	4.0	5.7	9.0
1976	4.8	33.1	9.4	13.1	0.6	19.3	18.4	4.1	6.1	9.5
1977	5.4	35.7	9.8	13.8	0.7	20.3	19.2	4.5	6.7	10.1
1978	6.0	39.3	10.5	15.0	0.8	21.8	20.3	5.0	7.3	11.2
1979	6.6	43.2	11.2	16.3	0.9	23.5	21.2	5.7	7.8	12.3
1980	7.4	46.9	11.6	17.5	1.0	24.5	21.5	6.1	8.2	13.4
1981	8.2	49.7	11.7	18.3	1.1	25.7	21.7	6.3	8.3	14.6
1982	9.1	53.1	12.1	19.6	1.3	27.6	22.0	6.7	8.6	16.1
1983	10.1	56.8	12.5	20.7	1.4	29.4	22.7	7.1	9.1	17.6
1984	11.3	61.7	13.4	22.6	1.6	32.0	23.5	7.6	9.8	19.7
1985	12.5	67.9	14.6	24.8	1.8	37.2	25.1	8.5	11.0	22.5
1986	13.9	74.1	15.9	27.1	2.0	42.4	27.3	9.2	12.3	25.2
1987	15.5	81.7	17.2	29.1	2.3	48.0	29.3	10.2	13.7	28.1
1988	17.2	90.3	18.7	31.7	2.5	54.5	31.9	11.1	15.2	31.7
1989	16.0	96.8	20.2	34.5	2.8	62.2	34.8	11.5	16.5	35.7
1990	17.7	103.3	21.4	37.1	3.2	67.6	38.1	11.9	17.9	39.9
1991	19.5	111.2	22.7	41.2	3.6	73.3	41.2	12.5	19.3	44.5
1992	23.3	121.1	24.3	46.7	4.0	78.1	44.7	13.1	20.7	51.8
1993	27.8	135.8	26.4	54.2	4.4	87.8	48.6	13.9	22.5	61.1
1994	33.1	152.2	28.1	61.6	5.0	97.9	52.7	14.7	24.1	71.6
1995	37.4	169.9	30.9	68.8	5.9	108.4	57.4	15.7	25.5	81.7
1996	40.4	196.8	34.0	76.7	6.5	119.1	62.5	16.9	27.3	88.5
1997	43.2	217.4	37.8	86.0	7.2	128.6	68.6	18.6	29.2	96.4
1998	46.4	241.8	42.4	95.7	7.9	141.4	75.6	20.6	31.9	107.0
1999	50.1	266.2	47.9	104.7	8.7	155.2	83.5	22.7	35.0	114.5
2000	54.0	291.6	54.3	112.9	9.5	173.4	92.2	25.1	38.9	120.6

Deflator	D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
1953	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1954	100.0	100.2	101.4	99.9	100.2	104.7	98.4	101.2	101.8	102.5	100.6
1955	99.2	100.2	99.7	99.1	105.0	103.7	96.4	100.9	100.9	100.5	99.2
1956	97.5	96.4	97.5	96.6	103.3	105.2	90.9	101.2	102.1	96.4	102.0
1957	96.4	94.0	100.1	95.1	98.4	82.0	91.5	102.7	98.8	97.7	106.9
1958	97.2	92.8	103.9	94.8	97.1	86.5	85.5	99.0	94.6	101.7	125.1
1959	98.4	89.7	106.0	94.9	102.9	89.5	89.6	99.7	96.8	100.2	132.1
1960	99.9	90.0	106.2	95.5	104.1	95.5	93.4	102.7	98.5	95.7	139.0
1961	115.1	96.4	110.3	113.3	108.0	101.1	104.4	113.8	120.8	97.4	129.6
1962	114.8	99.9	110.1	112.2	112.5	106.2	113.6	115.2	118.6	110.2	133.3
1963	111.8	101.1	111.0	108.1	109.6	102.5	107.5	113.7	117.4	104.9	127.6
1964	111.4	99.9	110.0	108.3	107.9	101.5	105.5	114.7	112.7	100.1	130.0
1965	112.4	94.9	106.4	113.0	103.8	100.6	101.6	113.1	112.7	92.1	128.9
1966	110.5	95.5	109.5	111.3	109.3	99.0	98.4	113.5	112.7	90.0	127.0
1967	111.3	92.6	106.5	112.0	109.3	98.6	97.7	116.2	112.8	86.5	124.8
1968	112.8	92.9	102.1	111.9	106.9	102.3	91.0	114.5	112.7	85.0	125.9
1969	108.5	90.2	102.7	110.2	109.1	101.3	91.8	112.3	112.8	85.3	127.9
1970	105.6	78.3	104.0	106.1	111.4	97.8	88.6	109.8	106.9	83.8	128.7
1971	106.3	68.8	103.1	104.0	109.6	101.8	87.1	109.8	108.1	83.1	130.1
1972	106.3	87.1	101.1	101.2	107.5	89.3	87.2	111.0	107.3	84.1	131.2
1973	106.4	87.5	100.4	102.1	108.0	89.5	86.1	111.0	107.9	83.0	132.0
1974	106.7	87.6	100.4	101.6	107.9	91.3	85.8	111.6	107.9	78.1	131.4
1975	105.4	88.0	100.7	100.5	108.4	92.1	85.0	109.9	108.1	79.2	132.7
1976	105.2	87.6	100.1	96.7	108.5	91.8	84.5	109.4	108.1	79.6	134.1
1977	106.4	86.7	100.3	98.3	107.1	92.1	84.0	110.6	108.2	80.5	135.8
1978	107.8	86.2	101.2	99.3	106.5	95.8	85.3	110.3	109.3	82.3	134.2
1979	111.6	86.7	103.5	103.8	117.3	96.5	86.9	116.1	113.6	80.5	143.6
1980	115.9	89.8	104.8	108.5	117.6	101.1	91.3	117.9	122.0	80.8	146.7
1981	118.5	91.2	104.3	109.1	130.5	104.2	95.3	125.7	121.4	79.7	144.8
1982	118.3	95.1	105.7	110.2	129.2	105.1	98.8	127.7	123.9	77.2	147.0
1983	119.6	97.0	105.5	111.3	126.3	108.7	100.8	129.5	127.2	74.7	146.8
1984	125.4	97.6	105.7	114.2	132.2	113.4	103.8	133.7	131.6	74.4	150.5
1985	138.1	106.7	113.9	121.2	137.0	123.6	108.5	143.9	138.5	78.3	161.2
1986	144.5	108.5	119.2	126.9	138.1	129.4	116.9	152.0	151.1	78.9	166.8
1987	151.8	113.6	125.2	135.9	143.6	138.8	121.8	167.5	157.8	81.6	182.0
1988	170.2	126.4	139.7	160.9	164.0	161.2	133.6	179.1	176.4	88.0	199.4
1989	185.2	134.6	150.0	178.0	185.2	169.7	147.7	195.2	189.6	91.8	212.8
1990	195.7	140.3	156.2	183.2	201.2	172.2	154.6	205.0	203.2	96.4	217.1
1991	208.9	153.2	162.5	197.4	210.8	180.4	164.6	210.7	219.1	106.3	226.7
1992	225.4	162.5	174.5	203.7	225.4	190.6	180.2	226.2	239.9	115.4	240.7
1993	258.2	176.5	202.9	228.9	248.3	217.7	214.1	257.9	278.3	136.2	282.0
1994	309.6	195.3	240.1	257.7	275.0	253.1	235.7	294.5	344.4	155.4	327.6
1995	350.4	223.5	265.2	294.7	316.7	283.3	249.7	323.6	391.1	170.1	360.7
1996	375.0	237.1	278.0	314.7	340.9	297.2	260.0	337.0	422.1	177.4	374.4
1997	375.7	242.2	279.0	320.0	349.8	301.0	264.4	333.8	432.8	182.3	372.2
1998	365.2	245.6	275.9	310.1	321.9	300.9	265.4	330.3	417.8	181.7	361.2
1999	356.5	241.0	271.2	306.3	310.6	297.1	268.8	326.0	398.0	180.4	350.6
2000	360.3	247.5	276.8	311.6	314.4	299.3	276.2	325.8	413.0	183.7	353.4

Deflator	D11	D12	D13	D14	D15	D16	D17	D18	D19	D20
1953	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1954	101.5	99.8	99.0	103.0	101.5	101.1	100.6	102.6	103.5	100.1
1955	99.6	104.7	99.8	102.7	101.1	100.3	105.6	101.7	103.4	98.6
1956	101.8	115.1	101.2	105.5	98.8	102.4	106.6	102.1	106.8	100.5
1957	103.2	110.1	100.4	105.2	99.5	102.4	108.7	105.7	107.8	98.9
1958	102.9	129.3	101.7	107.9	99.7	108.0	111.1	109.0	112.0	97.7
1959	103.8	153.9	103.0	113.0	99.9	116.7	120.8	111.2	119.8	98.1
1960	106.2	168.3	102.5	115.4	106.6	124.6	119.7	116.1	121.9	97.2
1961	116.8	172.1	112.3	127.5	121.3	146.8	131.5	131.0	133.6	103.2
1962	122.1	145.5	108.4	130.0	126.5	135.7	138.9	139.6	141.0	102.9
1963	119.0	144.9	111.3	125.9	119.6	134.5	136.3	136.1	139.7	99.9
1964	115.9	137.2	104.8	126.1	113.8	122.5	133.1	136.6	122.1	103.9
1965	113.0	136.2	104.9	133.7	112.3	120.5	132.8	137.6	116.7	109.4
1966	115.9	145.6	104.8	141.3	109.2	121.1	149.1	135.8	124.9	109.9
1967	116.0	137.8	105.0	136.5	108.8	119.1	148.7	136.8	124.1	109.6
1968	117.4	135.9	105.2	135.7	109.8	120.3	149.5	142.9	125.1	112.3
1969	117.2	143.1	104.6	135.2	110.9	122.6	150.0	138.7	122.8	109.8
1970	117.1	143.8	106.1	141.0	111.9	125.6	136.9	135.1	126.7	106.8
1971	114.1	149.2	110.1	138.7	107.1	128.9	136.7	136.2	125.0	106.5
1972	116.2	153.0	110.2	141.9	103.6	130.3	137.8	136.2	125.7	108.2
1973	116.8	156.9	109.9	143.2	103.5	130.7	138.0	138.0	129.1	113.0
1974	117.1	155.1	109.8	144.2	104.2	131.2	140.9	139.2	129.7	114.0
1975	118.1	159.0	109.8	138.1	102.4	131.5	141.5	138.0	133.5	114.9
1976	117.7	159.6	110.9	140.5	105.2	130.2	142.5	138.9	126.6	114.2
1977	117.3	165.8	107.1	145.1	109.0	135.6	140.7	138.1	127.2	111.0
1978	119.1	174.3	115.1	149.0	118.7	137.8	142.8	135.0	138.5	112.0
1979	133.7	177.2	121.9	154.0	124.2	147.9	154.1	149.8	144.0	120.2
1980	131.1	191.5	120.9	157.7	128.6	154.5	153.3	153.4	147.3	125.3
1981	133.8	196.7	127.0	162.9	144.1	156.1	158.6	159.0	157.2	135.2
1982	137.2	197.2	129.6	164.7	147.8	157.9	155.5	161.2	164.6	136.8
1983	139.4	209.0	132.4	165.9	150.9	158.8	159.8	163.4	166.5	138.0
1984	144.0	214.5	138.0	168.7	162.5	162.8	165.2	166.7	179.3	144.1
1985	157.0	231.4	149.8	180.1	170.7	175.1	171.7	181.3	186.8	156.4
1986	163.9	240.7	157.3	185.0	175.1	186.3	181.5	190.6	193.6	166.9
1987	177.0	265.4	173.8	196.9	185.0	196.4	196.1	205.9	208.3	179.7
1988	201.8	311.4	208.6	216.9	206.0	219.8	220.1	236.7	245.1	223.0
1989	223.7	333.5	231.5	233.4	229.3	239.1	241.1	250.7	273.5	263.4
1990	229.2	346.1	245.4	255.4	254.4	251.4	264.0	280.0	275.7	288.3
1991	234.4	352.2	255.0	261.7	265.9	263.1	274.4	290.5	284.4	295.4
1992	248.5	364.0	268.4	274.2	276.0	283.2	286.6	309.4	300.2	311.4
1993	285.0	401.8	308.5	302.6	286.5	317.7	328.1	350.5	345.2	355.0
1994	331.7	463.5	376.9	349.3	343.2	373.5	375.6	418.6	381.4	425.4
1995	375.6	545.8	419.4	387.8	388.2	439.2	417.2	489.1	421.3	477.1
1996	392.0	557.1	438.5	430.5	412.3	473.0	457.8	523.7	461.0	476.6
1997	391.9	562.8	441.5	436.4	413.6	474.2	470.6	534.4	467.3	448.6
1998	385.3	546.8	439.9	435.2	402.1	463.9	458.1	525.6	460.9	426.7
1999	377.3	520.2	426.4	428.3	390.5	452.8	440.6	503.0	449.0	406.6
2000	382.3	501.9	430.1	404.7	394.0	464.5	447.0	512.2	462.5	397.9

Deflator	D21	D22	D23	D24	D25	D26	D27	D28	D29	D30
1953	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1954	100.0	102.9	104.7	99.6	100.0	101.4	101.4	100.9	100.1	104.3
1955	99.2	105.7	100.8	98.6	99.2	101.4	104.5	101.4	99.7	111.0
1956	97.5	112.3	106.9	97.5	97.5	105.6	117.3	100.1	94.8	110.0
1957	96.4	113.9	110.2	103.4	96.4	103.7	116.0	106.7	99.6	115.1
1958	97.2	112.3	114.8	99.7	97.2	97.8	112.2	108.4	90.1	102.0
1959	98.4	129.0	126.2	99.7	98.4	104.7	114.3	108.6	87.4	111.3
1960	99.9	133.4	128.0	103.5	99.9	108.3	113.3	109.7	91.2	112.3
1961	115.1	143.6	160.9	109.3	115.1	134.4	119.4	121.2	107.4	105.7
1962	114.8	155.8	166.4	118.9	114.8	127.0	121.2	118.3	116.0	111.9
1963	111.8	162.4	155.8	119.1	111.8	118.4	123.1	114.8	95.8	103.5
1964	111.4	153.0	156.0	118.7	111.4	113.4	120.5	117.3	90.0	103.3
1965	112.4	151.7	161.1	117.1	112.4	105.2	122.7	114.9	87.8	101.9
1966	110.5	150.0	167.9	115.6	110.5	107.4	122.7	112.2	87.8	100.7
1967	111.3	150.3	169.9	117.9	111.3	106.8	124.1	113.7	93.4	100.0
1968	112.8	164.1	167.8	120.5	112.8	107.6	122.8	111.8	89.8	97.4
1969	108.5	157.5	167.5	118.0	108.5	107.3	121.1	110.2	84.4	95.9
1970	105.6	152.2	166.2	115.5	105.6	99.1	125.2	106.8	78.9	95.2
1971	106.3	149.8	151.4	120.9	106.3	103.1	127.0	115.4	85.1	99.8
1972	106.3	146.7	144.8	122.2	106.3	100.5	130.5	110.9	84.8	98.1
1973	106.4	144.3	141.8	122.2	106.4	101.2	130.7	108.8	83.3	96.4
1974	106.7	147.0	136.1	120.5	106.7	101.6	130.0	111.2	87.9	105.4
1975	105.4	146.3	156.4	120.0	105.4	101.2	129.2	109.0	88.1	102.2
1976	105.2	140.8	157.7	120.3	105.2	100.6	126.8	107.1	84.7	108.3
1977	106.4	147.9	158.0	120.0	106.4	99.6	130.3	106.7	86.4	104.1
1978	107.8	149.1	157.9	121.9	107.8	103.9	126.9	109.9	85.1	104.1
1979	111.6	153.0	168.7	131.6	111.6	112.7	130.5	118.1	88.3	108.2
1980	115.9	156.3	176.1	133.0	115.9	105.5	131.0	117.5	91.0	117.8
1981	118.5	167.0	186.3	137.8	118.5	108.6	137.2	117.1	97.3	121.2
1982	118.3	174.0	188.1	139.6	118.3	109.1	136.6	119.5	93.5	121.2
1983	119.6	174.7	183.9	140.4	119.6	112.1	141.5	121.8	92.4	128.7
1984	125.4	178.6	190.2	142.5	125.4	115.2	144.1	126.2	97.0	129.0
1985	138.1	188.8	201.7	149.1	146.0	119.7	148.1	142.3	100.6	138.0
1986	143.7	191.5	215.2	157.9	153.5	126.9	152.2	153.3	106.0	142.3
1987	156.6	199.0	230.3	176.7	160.2	135.6	158.4	163.6	112.7	149.2
1988	191.1	226.2	271.4	200.3	175.8	143.9	167.5	192.5	127.5	176.7
1989	214.3	237.6	289.2	228.2	175.1	158.7	174.0	208.9	139.4	188.2
1990	217.2	271.5	305.8	261.2	179.8	173.2	184.5	233.4	147.2	212.4
1991	222.3	291.2	318.5	280.7	223.6	186.9	193.5	239.4	155.5	227.6
1992	239.1	303.7	338.5	302.7	227.3	196.3	206.1	259.8	165.9	241.0
1993	280.9	344.1	377.0	344.7	235.2	215.3	216.4	296.9	188.1	274.6
1994	310.5	410.4	435.3	386.0	250.2	245.9	237.8	346.0	224.4	329.9
1995	327.6	474.7	489.5	430.1	259.1	276.3	265.1	383.1	260.8	370.7
1996	334.4	515.6	513.5	481.6	264.8	294.7	306.8	391.7	269.2	385.2
1997	336.3	521.2	517.2	480.2	282.4	306.5	308.5	395.5	273.2	400.2
1998	326.0	511.1	508.3	490.4	303.5	294.1	314.5	392.6	270.7	396.0
1999	322.5	498.3	507.2	473.4	320.6	286.3	311.1	395.9	264.6	387.7
2000	326.2	494.3	508.6	465.6	325.9	293.2	301.9	401.7	265.1	418.2

GDP	GDP0	GDP1	GDP2	GDP3	GDP4	GDP5	GDP6	GDP7	GDP8	GDP9	GDP10
1953	82	1.9	1.8	4.2	2.0	1.6	5.3	1.9	3.2	5.2	5.3
1954	86	2.1	1.7	4.5	2.2	1.9	5.7	2.0	3.7	5.5	5.4
1955	91	2.4	1.7	4.9	2.4	1.7	5.9	2.1	3.8	5.4	5.9
1956	103	2.7	2.1	5.0	2.8	2.5	7.2	2.5	4.2	6.4	6.2
1957	107	3.3	2.4	5.2	2.9	2.1	7.9	2.5	4.4	7.0	6.5
1958	131	3.5	3.2	6.4	4.0	2.8	10.6	3.1	6.2	9.6	7.5
1959	144	4.6	4.1	7.4	4.8	3.6	13.7	3.7	7.4	12.8	8.0
1960	146	5.7	4.3	7.3	5.0	3.7	15.8	4.2	8.0	15.8	8.7
1961	122	3.7	2.8	5.5	3.4	2.5	7.6	3.2	5.4	10.2	7.2
1962	115	3.0	2.4	4.9	3.2	2.5	7.4	3.1	5.5	8.5	6.9
1963	123	3.2	2.7	4.5	3.4	2.9	7.6	3.6	6.2	9.1	7.6
1964	145	3.6	3.1	5.7	3.8	3.3	8.7	3.8	6.8	10.1	9.0
1965	172	4.0	3.6	7.3	4.4	3.5	10.3	4.3	7.9	11.4	9.5
1966	187	4.4	3.9	8.0	5.0	3.8	11.3	4.7	9.2	12.5	11.0
1967	177	3.8	3.4	7.8	4.5	3.2	9.3	4.4	9.1	11.0	9.9
1968	172	3.8	3.5	7.9	3.7	3.3	8.7	4.2	8.9	12.3	10.3
1969	194	5.1	4.3	9.2	4.5	3.3	11.4	4.5	10.1	14.2	11.2
1970	225	6.3	5.1	10.4	5.8	3.9	13.7	5.6	11.1	15.7	12.9
1971	243	6.1	5.5	10.8	6.2	4.2	14.9	6.1	11.6	16.5	14.8
1972	252	6.7	5.6	10.3	6.2	3.9	15.4	5.6	11.6	17.1	15.7
1973	272	7.3	6.0	11.3	6.6	4.4	17.2	6.3	12.3	18.5	17.1
1974	279	8.0	6.7	12.1	6.4	4.3	18.5	6.5	13.1	19.3	17.2
1975	300	9.1	7.0	13.3	7.0	4.9	19.9	7.2	14.2	20.4	18.4
1976	294	9.4	6.5	13.4	6.5	4.8	20.4	6.7	14.4	20.8	18.8
1977	320	9.9	6.8	15.8	7.5	5.2	20.4	7.3	15.6	23.0	20.2
1978	362	10.9	8.3	18.3	8.8	5.8	22.9	8.2	17.5	27.3	24.9
1979	404	12.0	9.3	20.3	10.6	6.4	24.5	9.1	18.7	28.6	29.9
1980	452	13.9	10.4	21.9	10.9	6.8	28.1	9.9	22.1	31.2	32.0
1981	486	13.9	10.8	22.3	12.2	7.8	28.9	11.1	22.8	32.5	35.0
1982	529	15.5	11.4	25.1	13.9	9.3	31.5	12.2	24.8	33.7	39.0
1983	593	18.3	12.3	28.3	15.5	10.6	36.4	15.0	27.7	35.2	43.8
1984	717	21.7	14.7	33.2	19.7	12.8	43.8	17.4	31.8	39.1	51.9
1985	896	25.7	17.6	39.7	21.9	16.4	51.9	20.0	35.5	46.7	65.2
1986	1020	28.5	19.5	43.7	23.5	18.2	60.5	22.7	40.1	49.1	74.5
1987	1196	32.7	22.0	52.2	25.7	21.2	71.9	29.7	45.5	54.5	92.2
1988	1493	41.0	26.0	70.1	31.7	27.1	88.1	36.9	55.2	64.8	120.9
1989	1691	45.6	28.3	82.3	37.6	29.3	100.4	39.2	63.1	69.7	132.2
1990	1855	50.1	31.1	89.6	42.9	31.9	106.3	42.5	71.5	75.6	141.7
1991	2162	59.9	34.3	107.2	46.9	36.0	120.0	46.3	82.4	89.4	160.1
1992	2664	70.9	41.1	127.9	57.0	42.2	147.3	55.8	96.4	111.4	213.6
1993	3463	86.4	53.6	169.1	70.5	53.3	201.1	71.8	120.3	151.2	299.8
1994	4676	108.4	72.5	218.7	85.4	68.2	246.2	93.7	161.9	197.2	405.7
1995	5848	139.5	92.0	285.0	109.2	83.3	279.3	112.9	201.5	246.3	515.5
1996	6859	161.6	110.2	345.3	130.6	98.5	315.8	133.7	240.3	290.2	600.4
1997	7477	180.8	124.0	395.1	148.0	108.8	350.1	145.0	271.0	336.0	668.6
1998	7835	201.0	134.1	423.8	148.6	119.2	380.6	156.4	283.0	368.8	720.1
1999	8191	217.4	145.0	456.9	150.7	126.8	417.2	167.0	289.7	403.5	769.8
2000	8940	247.9	163.9	508.9	164.4	140.1	466.9	182.1	325.3	455.1	858.3

GDP	GDP11	GDP12	GDP13	GDP14	GDP15	GDP16	GDP17	GDP18	GDP19	GDP20
1953	2.7	2.7	1.4	2.0	4.6	4.1	3.0	3.0	4.1	1.4
1954	2.9	2.8	1.5	2.1	5.3	4.4	2.6	3.1	4.7	1.6
1955	3.1	3.7	1.6	2.2	5.8	4.7	3.4	3.6	4.8	1.7
1956	3.4	3.5	2.1	2.2	6.3	4.8	4.5	3.8	5.3	2.0
1957	3.7	4.1	2.2	2.8	6.1	5.3	4.9	4.5	5.9	2.2
1958	4.4	5.1	2.4	3.1	7.3	6.1	6.2	5.6	6.7	2.5
1959	4.7	5.8	2.9	3.5	7.6	6.4	6.4	6.2	7.4	2.7
1960	4.7	6.0	3.0	3.7	7.1	6.6	6.4	6.4	7.3	2.6
1961	4.1	4.4	2.3	3.6	6.3	4.6	4.9	4.7	6.2	2.4
1962	4.3	3.9	2.2	3.3	6.4	4.3	5.2	5.1	7.2	2.4
1963	4.7	4.1	2.4	3.3	6.8	4.2	5.6	4.8	8.2	2.4
1964	5.2	4.5	2.6	3.5	7.2	5.1	6.1	5.7	8.2	2.7
1965	5.6	5.3	2.9	4.3	8.6	6.3	7.2	6.5	8.7	3.1
1966	5.8	6.0	3.2	4.8	9.8	7.6	8.4	7.3	9.6	3.2
1967	5.6	5.7	2.9	4.4	9.9	7.9	7.9	7.4	9.6	3.1
1968	5.5	5.6	2.6	4.6	9.9	7.2	7.3	7.6	8.7	2.8
1969	6.3	5.8	3.1	5.2	10.8	8.1	7.6	8.1	9.9	3.5
1970	6.9	7.2	3.5	5.8	12.6	9.7	8.8	9.3	11.2	3.9
1971	7.0	8.0	4.1	6.2	14.0	10.5	10.0	9.9	11.3	4.6
1972	8.4	8.6	4.5	6.7	14.7	11.1	10.3	10.7	11.8	5.3
1973	8.7	9.2	4.4	6.7	15.4	11.7	11.3	11.6	12.9	5.9
1974	8.7	9.1	4.5	6.5	13.1	12.0	10.7	10.8	13.8	6.2
1975	8.4	9.7	4.6	6.8	16.6	12.8	12.0	11.8	15.8	6.7
1976	8.7	10.6	4.7	6.4	18.0	12.6	11.5	11.9	15.6	6.7
1977	10.0	10.8	5.2	7.5	20.7	14.4	13.1	12.9	16.9	6.9
1978	12.4	11.4	6.6	8.7	22.5	16.3	15.1	14.7	18.5	7.6
1979	15.8	12.7	7.4	10.4	25.2	19.0	18.8	17.8	20.7	8.5
1980	18.0	14.1	8.7	11.1	29.2	22.9	19.9	19.2	24.6	9.7
1981	20.4	17.1	10.6	12.1	34.7	25.0	22.0	21.0	28.4	11.3
1982	23.3	18.7	11.8	13.4	39.5	26.3	24.2	23.3	33.1	12.9
1983	25.6	21.6	12.8	14.4	46.0	32.8	26.3	25.7	35.7	13.5
1984	32.2	26.6	15.7	16.9	58.2	37.0	32.8	28.7	44.2	15.0
1985	42.8	33.1	20.0	20.7	68.0	45.2	39.6	35.0	55.3	18.1
1986	50.0	38.3	22.3	22.7	74.2	50.3	44.2	39.8	63.8	20.5
1987	60.4	44.2	27.9	26.2	89.2	61.0	51.8	46.9	80.8	24.2
1988	76.6	54.7	38.3	32.1	111.8	74.9	62.7	58.4	109.9	31.3
1989	84.4	61.6	45.8	36.7	129.4	85.1	71.7	64.1	131.2	38.3
1990	89.8	65.8	52.3	42.0	151.1	93.5	82.4	74.4	147.2	44.9
1991	108.2	66.4	62.2	46.5	181.1	104.6	91.3	83.3	178.1	51.9
1992	136.5	80.1	78.8	56.0	219.7	128.0	108.8	99.8	229.4	64.7
1993	190.9	107.0	113.3	70.2	277.9	166.3	142.4	127.8	322.5	89.4
1994	266.7	148.8	168.5	94.8	387.2	222.4	187.9	169.4	424.1	124.2
1995	352.5	200.4	216.1	120.5	500.2	300.3	239.1	219.6	538.2	160.6
1996	414.6	233.9	260.7	151.7	596.0	368.3	297.0	264.7	651.9	177.0
1997	460.0	267.1	300.0	171.5	665.0	408.1	345.0	299.3	730.8	181.7
1998	498.0	282.8	333.0	185.0	716.2	433.9	370.4	321.1	793.7	190.3
1999	536.5	290.9	355.0	196.3	766.2	457.6	385.8	332.7	846.4	195.3
2000	603.6	303.8	392.0	200.3	854.2	513.8	427.6	369.2	966.2	205.0

GDP	GDP21	GDP22	GDP23	GDP24	GDP25	GDP26	GDP27	GDP28	GDP29	GDP30
1953		4.8	1.0	1.5		1.7	1.4	0.2	0.2	0.9
1954		5.6	1.1	1.7		2.0	1.6	0.2	0.2	1.1
1955		6.1	1.2	1.8		2.1	1.8	0.3	0.2	1.2
1956		7.2	1.5	2.1		2.7	2.1	0.4	0.3	1.4
1957		8.2	1.6	2.3		2.6	2.0	0.4	0.3	1.5
1958		9.0	2.0	2.3		3.1	2.3	0.5	0.3	1.7
1959		9.4	2.4	2.5		3.6	2.4	0.7	0.4	2.1
1960		8.4	2.3	2.5		3.8	1.8	0.8	0.5	2.5
1961		7.0	1.8	2.3		3.2	1.2	0.5	0.4	2.1
1962		7.7	1.7	2.5		2.7	1.3	0.5	0.4	1.8
1963		8.9	1.7	2.6		2.7	1.6	0.5	0.4	1.9
1964		9.6	2.0	2.9		2.9	2.0	0.6	0.4	2.2
1965		11.1	2.4	3.4		3.6	2.5	0.6	0.5	2.4
1966		12.5	2.5	3.6		4.0	2.5	0.6	0.5	2.7
1967		11.3	2.4	3.4		3.7	2.1	0.7	0.5	2.2
1968		9.1	2.1	2.7		2.8	2.3	0.6	0.5	2.0
1969		10.8	2.1	3.4		4.1	2.7	0.7	0.6	2.0
1970		13.2	2.8	3.9		4.7	3.5	0.8	0.7	2.3
1971		13.8	3.2	4.3		5.8	3.8	0.9	0.8	2.6
1972		13.9	3.0	5.0		5.8	4.1	1.0	0.9	2.4
1973		14.8	2.8	5.5		6.0	4.4	1.1	0.9	2.5
1974		14.2	2.4	5.2		6.2	5.0	1.2	1.1	2.5
1975		16.3	3.1	5.4		6.5	5.7	1.2	1.2	2.8
1976		13.9	2.9	4.9		6.3	5.6	1.2	1.1	3.2
1977		18.7	3.8	5.6		7.0	5.9	1.3	1.2	3.6
1978		24.5	4.7	6.9		8.1	6.5	1.6	1.3	3.9
1979		29.1	5.5	7.7		9.5	6.8	1.5	1.4	4.6
1980		32.2	6.0	8.4		9.5	7.4	1.8	1.6	5.3
1981		33.3	6.8	9.4		10.2	7.1	1.7	1.7	5.9
1982		37.9	7.9	11.0		11.2	7.7	2.0	1.8	6.5
1983		42.1	8.7	12.0		12.3	9.2	2.2	2.1	7.9
1984		49.8	10.8	14.0	1.4	14.9	10.3	2.6	2.5	9.0
1985	4.2	60.6	12.4	16.5	1.8	18.1	12.3	3.3	3.0	11.2
1986	4.7	65.5	14.0	18.2	1.7	20.8	14.1	3.8	3.5	12.9
1987	5.7	74.7	16.6	22.9	1.8	24.5	16.0	4.3	4.0	14.9
1988	7.7	92.3	21.2	30.1	2.0	31.4	19.2	5.5	5.0	19.3
1989	9.1	99.6	23.6	36.3	2.2	35.8	21.7	6.0	5.9	21.7
1990	10.2	118.6	26.0	45.2	2.4	40.4	24.3	7.0	6.5	27.4
1991	12.1	138.3	29.6	51.7	3.1	46.7	27.1	7.5	7.2	33.6
1992	18.2	162.5	34.0	61.9	3.3	53.8	31.8	8.8	8.3	40.2
1993	25.8	209.6	41.6	77.9	3.7	66.1	37.2	11.0	10.4	50.6
1994	33.1	277.8	52.1	97.4	4.6	81.7	45.2	13.8	13.4	67.4
1995	36.4	353.4	63.0	120.7	5.6	100.0	55.3	16.5	17.0	82.5
1996	39.0	421.5	72.0	149.2	6.5	117.5	71.4	18.4	19.4	91.2
1997	41.8	469.5	79.0	162.6	7.7	134.5	78.1	20.2	21.1	105.0
1998	43.9	501.5	84.4	179.3	9.1	141.1	87.0	21.9	22.7	111.5
1999	47.1	519.1	91.2	185.6	10.6	148.8	93.2	23.8	24.1	116.9
2000	51.8	560.0	99.4	195.5	11.7	166.1	98.3	26.4	26.6	136.4

Notes

1 Growing with Chinese characteristics: an introduction

1 For detailed studies on TVPs, see Byrd and Lin (1990) and Findlay *et al*. (1994).
2 See Wu (1999), Wei and Liu (2001), Zhang and Felmingham (2001) for more information on economic growth and foreign direct investment in China.
3 There is an abundant literature on productivity and efficiency in China. Examples include Wu (1993, 1996b), Kalirajan and Wu (1999), Jefferson and Singh (1999).
4 For detailed studies on this topic, see Lardy (1992) and Zhang (2000).

2 Capital formation and growth

1 For example, see the World Bank (1997a), Maddison (1998), Woo (1998) and Young (2000).
2 It is noted that researchers have attempted to derive their own deflators which are much smaller than the one used in this chapter and which involve either sectoral or nation-wide statistics only (e.g., Chen *et al.* 1988 and Woo *et al.* 1994).
3 Published works include, for example, Rosenstein-Rodan (1964) and Jorgenson and Landau (1989).

3 Sources of growth

1 Such as Barro (1991), Levine and Renelt (1992) and Sala-i-Martin (1997).
2 See Temple (1999) for a review.
3 According to Sala-i-Martin (1997), the existing literature has employed over sixty variables as the correlates of growth.
4 Guangdong and Fujian are two exceptions. FDI received by these two provinces before 1982 is incorporated into the final estimation.
5 In the past fifty years, China conducted only four population censuses (in 1957, 1964, 1982 and 1990).
6 Sala-i-Martin (1997) surveyed around 60 variables and found that the initial income has been included in most empirical studies.
7 Canning (1998) presented a detailed study of estimating indicators for world stocks of infrastructure.
8 The coefficient of correlation is 0.96 according to the statistics in 1993. Regional trade figures are available from 1993 onwards.
9 It should be pointed out that, at the early stage of economic reform, export licences were granted to companies in the coastal regions only. Though this policy has been abandoned gradually, it certainly brings about biases in the measurement of regional openness.

10 In addition, Yang (1998) and Cheung and Kwan (1999) investigated the impact of human capital on foreign investment.
11 For a review of the literature, see De Mello (1997) and Wu (1999).

4 The role of productivity

1 Comprehensive surveys of efficiency measurement techniques are documented in Fried, Lovell and Schmidt (1993) and Lovell (1996), for instance.
2 The name Malmquist (1953) productivity index was introduced by Caves *et al.* (1982). This approach has become popular largely due to Färe *et al.* (1989, 1992).
3 The three large cities are Beijing, Shanghai and Tianjin. The coastal region includes eight provinces, namely, Hebei, Liaoning, Shandong, Zhejiang, Jiangsu, Fujian, Guangdong and Guangxi. The central region contains nine inland provinces, namely, Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hunan and Hubei. Finally, the western region is composed of seven border areas, namely, Sichuan, Yunnan, Guizhou, Shaanxi, Gansu, Ningxia and Xinjiang.
4 Readers may refer to Coelli (1992) for further details about the FRONTIER programme.
5 China is divided into thirty administrative units or provinces. Data for Tibet are incomplete in the original source. Hainan Island became a province in 1988 and has been listed independently only since 1989. An initial plot of all variables against time indicates that there are serious problems with statistics from Qinghai Province. As a result, all three regions are dropped from the final data sample.
6 It is argued that China's official GDP figures might be misreported. Due to the complications of recalculating GDP figures for all Chinese regions, this chapter uses official statistics as many others do. For detailed discussions, readers may refer to Ren (1997) and Maddison (1998).

5 Regional growth, disparity and convergence

1 See Benabou (1996) for a comprehensive review on the relationship between inequality and growth.
2 Such as Lardy (1978, 1980), Selden (1988), Riskin (1987) and Lippit (1987).
3 For discussions about earlier studies, see Lyons (1991), Rozelle (1996) and Gustafsson and Li (1998). There are also studies on China's regional development broadly, e.g., Yang (1990), Denny (1991), and Zhao (1996).
4 Some studies listed in the table have also appeared in a recent volume (in Chinese) edited by Zhao *et al*. (1999).
5 Hu *et al*. (1995), and Rozelle (1996) also analysed regional shares over national totals of various economic indicators.
6 Fei *et al*. (1979, p. 328) have shown several different methods of calculating Gini coefficients.
7 In 1997, for the first time, the State Statistical Bureau of China released regional GDP figures for the pre-reform period 1952–77 (Xu and Tian 1997).
8 In 1997, Chongqin gained the same status as the three large cities, i.e., Beijing, Shanghai and Tianjin. Therefore, China now has thirty-one regions.
9 The author notices that Jian *et al*. (1996) used 1952–77 GDP figures for fifteen provinces and applied regional price indexes but, as pointed out, part of their data set was generated by the authors.
10 A discussant of a paper by Dowrick (1995) also raised the similar point.
11 The data series starts in 1984 for Tibet and in 1985 for Hainan. As a result, these two regions are excluded whenever data are missing.
12 It is argued that China's official GDP growth rates might have been overestimated (Wu 1997, Ren 1997).

13 These growth rates are in real terms and derived from the data employed in this study.

6 Growth and integration in South China

1 According to Lee (1995), Chen (1987) was the first to use the term 'Greater China'.
2 See, for example, Chen (1994), Lee (1995) and Sung (1995).
3 The government of Taiwan under the leadership of President Lee has for a long time discouraged its citizens from investing in mainland China. As a result, some figures in Table 6.2, e.g., the flow of trade and investment between Taiwan and Fujian, are considerably under-estimated due to the fact that many Taiwanese are reluctant to reveal their identities because of political concern. Thus, it can be argued that the scope of the actual linkage between Taiwan and the two mainland provinces is far greater than what the figures show in Table 6.2.
4 The sources of data are the International Financial Statistics Yearbook (International Monetary Fund 1998) for Hong Kong, Taiwan Statistical Databook (Council for Economic Planning and Development 1996) and Statistical Yearbook (1998) for Taiwan and China's GDP Data 1952–1995 (State Statistical Bureau 1997) and China Statistical Yearbook (State Statistical Bureau 1998a).
5 The exchange rate (yuan/US$1) was 1.68 in 1978 and 8.29 in 1997.
6 For detailed discussions, see Summer and Heston (1991) and Maddison (1995).
7 A single exchange rate is used for the economies of Fujian and Guangdong.
8 For reviews, see Jorgenson (1989) and Nishimizu and Jorgenson (1995).
9 For example, Nishimizu and Jorgenson (1995) found that capital share in the United States and Japan fluctuated around 0.40 during 1952–74.
10 For literature surveys, see Dogramaci (1983), Dogramaci and Färe (1988) and Lovell (1996).
11 This was first proposed by Aigner *et al*. (1977), Battese and Corra (1977), and Meeusen and van den Broeck (1977).
12 Optional models incorporating the second-order terms of logL and logK were attempted and rejected due to insignificant estimates of the coefficients.
13 This issue was first raised by Nishimizu and Page (1982). Further discussions can be found in Lovell (1993) and Färe *et al.* (1994).
14 For more recent surveys, see Bauer (1990), Greene (1993) and Lovell (1996).
15 One-step methods have been developed and applied to empirical studies by Kumbhakar *et al.* (1991), Battese and Coelli (1993) and Huang and Liu (1994).
16 Fixed effects models with constant returns to scale are formulated and estimated.
17 It is worthy of note that although the sum of the residuals with respect to all i and t equals zero, the regression of the residual variable on t and t_2 only involves the subsamples of the residuals.

7 Deregulation and growth in the telecommunications industry

1 According to State Statistical Bureau (2000a).
2 In 1996, among the major telecommunications companies in the world, the old China Telecom was ranked first and twelfth in terms of the number of subscribers and total revenue (Industry Forum, No. 4, 1998).
3 According to the *People's Daily*, Overseas Edition, 18 May 2000.
4 According to the *People's Daily*, Overseas Edition, 17 May 2000.
5 According to the *People's Daily*, overseas edition, 14 February 2001.
6 According to the *People's Daily*, overseas edition, 14 February 2001, and news release on the web site of the Ministry of Information Industry, 20 June 2000.

8 Deregulation and growth in the energy sector

1 The exchange rate was 3.7 yuan/US$ in 1987 and 5.3 yuan/US$ in 1991.
2 In 1995, the exchange rate was 8.4 yuan/US$.
3 Based on personal interviews.

References

Abramovitz, Moses (1979), 'Rapid growth potential and its realisation: the experience of capitalist economies', in Edmond Malinvaud (ed.) *Economic Growth and Resources*, Macmillan Press, London.

Abramovitz, Moses (1986), 'Catching up, forging ahead, and falling behind', *Journal of Economic History* 46(2), 385–406.

Aigner, D.J., C.A.K. Lovell and P.J. Schmidt (1977), 'Formulation and estimation of stochastic frontier models', *Journal of Econometrics* 6(1), 21–37.

Aldrich, M. and A. Rooth (1999), 'Market opportunity: an investment threat', *Telecommunications*, October, 168–170.

Alesina, A. and D. Rodrik (1994), 'Distributive politics and economic growth', *Quarterly Journal of Economics* 109, 465–90.

APERC (2000), 'APEC Energy pricing practices', mimeo, Asia Pacific Energy Research Centre, Tokyo.

Asian Development Bank (2002), *Asian Development Outlook 2002*, Oxford University Press, New York.

Barro, R.J. (1991), 'Economic growth in a cross section of countries', *Quarterly Journal of Economics* 106, 407–43.

Barro, R.J. (1997), *Determinants of Economic Growth: A Cross-country Empirical Study*, MIT Press, Cambridge, MA.

Barro, R.J. and X. Sala-i-Martin (1995), *Economic Growth*, McGraw Hill, Boston, MA.

Battese, G.E. and T. Coelli (1993), 'A stochastic frontier production function incorporating a model for technical inefficiency effects', *Working Papers in Econometrics and Statistics No.69*, University of New England, Australia.

Battese, G.E. and T. Coelli (1995), 'A model for technical inefficiency effects in a stochastic frontier production function', *Empirical Economics* 20, 325–32.

Battese, G.E. and G.S. Corra (1977), 'Estimation of a production frontier model: with application to the pastoral zone of eastern Australia', *Australian Journal of Agricultural Economics* 21(3), 169–79.

Bauer, P.W. (1990), 'Recent developments in the econometric estimation of frontiers', *Journal of Econometrics* 46, 39–56.

Benabou, Roland (1996), 'Inequality and growth', *NBER Macroeconomics Annual*, 11–74.

Benhabib, J. and M. Spiegel (1994), 'The role of human capital in economic development: evidence from aggregate cross-country data', *Journal of Monetary Economics* 34, 143–174.

Blackman, Allen and Xun Wu (1999), 'Foreign direct investment in China's power sector: trends, benefits and barriers', *Energy Policy* 27, 695–711.

Borensztein, Eduardo and Jonathan D. Ostry (1996), 'Accounting for China's growth performance', *American Economic Review (Papers and Proceedings)* 86, 225–8.

Byrd, W.A. and Q.S. Lin (eds) (1990), *China's Rural Industry: Structure, Development and Reform*, a World Bank publication, Oxford University Press, Oxford and New York.

Canning, David (1998), 'A database for the world stocks of infrastructure, 1950–95', *World Bank Economic Review* 12, 529–47.

Caves, Douglas W., Laurits R. Christensen and W. Erwin Diewert (1982), 'Multilateral comparisons of output, input and productivity using superlative index numbers', *Economic Journal* 92, 73–86.

Chen, Edward K.Y. (1979), *Hyper-growth in Asian Economies*, Macmillan Press, London.

Chen, Edward K.Y. (1987), *Hong Kong Standard*, 29 September.

Chen, Jian and B.M. Fleisher (1996), 'Regional income inequality and economic growth in China', *Journal of Comparative Economics*, 22, 141–64.

Chen, K., H.C. Wang, Y.X. Zheng, G.H. Jefferson and T.G. Rawski (1988), 'Productivity change in Chinese industry, 1953–85', *Journal of Comparative Economics* 12, 570–91.

Chen, Pochih (1994), 'Foreign investment in the Southern China growth triangle', in Thant, M., M. Tang and H. Kakazu (eds) *Growth Triangles in Asia: A New Approach to Regional Economic Cooperation*, published for the Asian Development Bank, Oxford University Press, Hong Kong.

Chen, S. and M. Ravallion (1996), 'Data in transition: assessing rural living standards in southern China', *China Economic Review*, 7, 23–56.

Chen, Zongshen (1995), *Economic Development and Income Distribution*, Shanghai Sanliang Shudian, Shanghai.

Cheung, L.K. and Y.K. Kwan (1999), 'Foreign capital stock and its determinants', in Yanrui Wu (ed.), *Foreign Direct Investment and Economic Growth in China*, Edward Elgar Publishing, Cheltenham.

China National Network Information Centre (CNNIC) (2000), Internet survey results at the end of December 2000, http://www.cnnic.com.cn.

China National Network Information Centre (CNNIC) (2002), Internet survey results at the end of July 2002, http://www.cnnic.com.cn.

Chiu, W. Henry (1998), 'Income inequality, human capital accumulation and economic performance', *Economic Journal*, 108, 44–59.

Chow, Gregory C. (1987), *The Chinese Economy*, World Scientific, Singapore, 2nd edition.

Chow, Gregory C. (1993), 'Capital formation and economic growth in China', *Quarterly Journal of Economics* 108, 809–42.

Clarke, G.R.G. (1995), 'More evidence on income distribution and growth', *Journal of Development Economics*, 47, 403–27.

Coelli, Tim J. (1992), 'A computer programme for frontier production function estimation: FRONTIER, version 2.0', *Economics Letters* 39, 29–32.

Cornwell, C., P. Schmidt and R.C. Sickles (1990), 'Production frontiers with cross-sectional and time-series variation in efficiency levels', *Journal of Econometrics* 46, 185–200.

Council for Economic Planning and Development (1996), *Taiwan Statistical Databook*, Taipei.

De Mello, Luiz R., Jr. (1997), 'Foreign direct investment in developing countries and growth: a selected survey', *Journal of Development Studies* 34, 1–34.

Demurger, Sylvie (2000), *Economic Opening and Growth in China*, Development Centre Studies, OECD, Paris.

Denny, D.L. (1991), 'Provincial economic differences diminished in the decade of reform', in US Congress Joint Economic Committee (ed.), *China's Economic Dilemmas in the 1990s: The Problems of Reforms, Modernisation and Interdependence*, Vol. 1, US Government Printing Office, Washington DC.

Dernberger, Robert F. (ed.) (1980), *China's Development Experience in Comparative Perspective*, Harvard University Press, Cambridge, MA.

Dodgson, Charles (2000), 'China looking for the great leap forward', *Communications Internationa*l, 27(5), 37.

Dogramaci, A. (ed.) (1983), *Developments in Econometric Analysis of Productivity: Measurement and Modelling Issues*, Kluwer Nijhoff Publishing, Boston, MA.

Dogramaci, A. and R. Färe (eds) (1988), *Applications of Modern Production Theory: Efficiency and Productivity*, Kluwer Academic Publishers, Boston, MA.

Dougherty, C. and D.W. Jorgenson (1996), 'International comparisons of the sources of economic growth', *American Economic Review (Papers and Proceedings)* 86(2), 25–9.

Dowrick, S. (1995), 'The determinants of long-run growth', in P. Andersen, J. Dwyer and D. Gruen (eds) *Productivity and Growth*, proceedings of a conference, Reserve Bank of Australia.

Duan, Ni (2000), 'Trend of national telecommunications network development', Telecommunications Research Institute, MII, mimeo.

Duncan, R. and X. Tian (1998), 'China's inter-provincial disparities, 1952–95', mimeo, NCDS, Australian National University.

Easterly, W. (1995), 'Explaining miracles: growth regressions meet the gang of four', in T. Ito and A.O. Krueger (eds) *Growth Theories in Light of the East Asian Experience*, University of Chicago Press, Chicago.

Economic Analytical Unit (2002), *China Embraces the World Market*, Australian Government Publications, Department of Foreign Affairs and Trade, Canberra.

Editorial Board (2001), *China's Energy Development Report*, Beijing: China Quantitative Publishing House.

EIU (Economist Intelligence Unit) (1997), 'How has China financed its telecoms build-out', *Business China*, November 24, 7–9.

ERI (2000), 'China's energy problems and development strategy', mimeo, Energy Research Institute, State Development Planning Commission, Beijing.

Färe, Rolf, Shawna Grosskopf, Lindgren and Pontus Roos (1989), 'Productivity developments in Swedish hospitals: a Malmquist output index approach', *Discussion Paper No. 89–3*, Southern Illinois University.

Färe, Rolf, Shawna Grosskopf, Lindgren and Pontus Roos (1992), 'Productivity changes in Swedish pharmacies 1980–1989: a nonparametric Malmquist approach', *Journal of Productivity Analysis* 3, 85–101.

Färe, Rolf, Shawna Grosskopf, M. Norris and Z. Zhang (1994), 'Productivity growth, technical progress and efficiency change in industrialised countries', *American Economic Review* 84(1), 66–83.

Farrell, Michael J. (1957), 'The measurement of productive efficiency', *Journal of the Royal Statistical Society, Series A, General* 120, 253–82.

Fecher, F. and P. Pestieau (1993), 'Efficiency and competition in OECD financial services', in H.O. Fried, C.A.K. Lovell and S.S. Schmidt (eds) *The Measurement of*

Productive Efficiency: Techniques and Applications, Oxford University Press, New York.

Fei, John C.H., Gustav Ranis and Shirley W.Y. Kuo (1979), *Growth with Equity: The Taiwan Case*, published for the World Bank, Oxford University Press, New York.

Findlay, C.C., A. Watson and Harry X.Y. Wu (eds) (1994), *Rural Enterprises in China*, Macmillan, London.

Fleisher, Belton M. and Jian Chen (1997), 'The coast-noncoast income gap, productivity and regional economic policy in China', *Journal of Comparative Economics* 25, 220–36.

Fong, Raymond W.L. and Christopher S.P. Tong (1998), 'Technological change of China's township and village enterprises (TVPs) and its corresponding spatial disparity: a combined DEA-Poolong approach', mimeo, Hong Kong Baptist University.

Fried, H., C.A.K. Lovell and S. Schmidt (eds) (1993), *The Measurement of Productive Efficiency*, Oxford University Press, New York.

Friedman, Edward (1987), 'Maoism and the liberation of the poor', *World Politics*, 39, 408–28.

Fujian Statistical Bureau (1998), *Statistical Yearbook of Fujian 1998*, China Statistical Publishing House, Beijing.

Greene, W. (1993), 'The econometric approach to efficiency analysis', in H.O. Fried, C.A.K. Lovell and S.S. Schmidt (eds) *The Measurement of Productive Efficiency: Techniques and Applications*, Oxford University Press, New York.

Guangdong Statistical Bureau (1998), *Statistical Yearbook of Guangdong 1998*, China Statistical Publishing House, Beijing.

Guangdong Statistical Bureau (2000), *Statistical Yearbook of Guangdong 2000*, China Statistical Publishing House, Beijing.

Gundlach, Erich (1997), 'Regional convergence of output per worker in China: a neoclassical interpretation', *Asian Economic Journal*, 11, 423–42.

Gustafsson, B. and Shi Li (1998), 'Inequality in China at the end of the 1980s: locational aspects and household characteristics', *Asian Economic Journal* 12, 35–64.

Han, Wenke, Xiaoli Liu and Xinshai Zhu (2000), 'Analysis on China's supply of and demand for oil and gas', paper presented at Natural Gas Policy Seminar, June 2000, Beijing.

Hardy, A.P. (1980), 'The role of the telephone in economic development', *Telecommunications Policy*, 4(4), 668–80.

Harwitt, Eric (1998), 'China's telecommunications industry: development patterns and policies', *Pacific Affairs*, 71(2), 175–93.

He, Zhou (1997), 'A history of telecommunications in China: development and policy implications', in Paul S.N. Lee (ed.), *Telecommunications and Development in China*, Hampton Press, Cresskill.

Hu, Angang, Chaoguang Wang and Xiaoguang Kang (1995), *Regional Disparities in China*, Liaoning People's Press, Shengyang.

Hu, Dayuan (1997), 'Economic transition and regional disparity', mimeo, CCER, Peking University.

Hu, Zuliu. F. and Mohsin S. Khan (1997), 'Why is China growing so fast?', *IMF Staff Papers* 44, 103–31.

Huang, C.J. and J.T. Liu (1994), 'Estimation of a non-neutral stochastic frontier production function', *Journal of Productivity Analysis* 5, 171–80.

Huo, Yaqin (1999), 'Current situation and sustainable development strategy of China's energy sector', *Energy of China* 2, 42–44.

Hussain, A., P. Lanjouw and N. Stern (1994), 'Income inequalities in China: evidence from household survey data', *World Development*, 22, 1947–57.

IEA (1999), 'Coal in the energy supply of China', Report of the CIAB Asia Committee, International Energy Agency, Paris.

IEA (2000), 'China's worldwide quest for energy security', International Energy Agency, Paris.

International Monetary Fund (IMF) (1998), *International Financial Statistics Yearbook 1998*, Washington DC.

ITU (2000), *International Telecommunications Indicators*, International Telecommunications Union, Geneva.

Jefferson, Gary H. and I. Singh (eds) (1999), *Enterprise Reform in China: Ownership, Transition and Performance*, Oxford University Press, Oxford and New York.

Jefferson, Gary H., Thomas G. Rawski and Yuxin Zheng (1992), 'Growth, efficiency and convergence in China's state and collective industry', *Economic Development and Cultural Change* 40(1), 239–66.

Jian, T., J.D. Sachs and A.M. Warner (1996), 'Trends in regional inequality in China', *China Economic Review* 7, 1–21.

Jondrow, J., C.A.K. Lovell, I.S. Materov and P. Schmidt (1982), 'On the estimation of technical inefficiency in the stochastic production function model', *Journal of Econometrics* 19, 233–8.

Jorgenson, Dale W. (1989), 'Capital as a factor of production', in Dale W. Jorgenson and Ralph Landau (eds) *Technology and Capital Formation*, The MIT Press, Cambridge, MA.

Jorgenson, D.W. (1997), 'International productivity comparisons', paper presented at the Taipei International Conference on Efficiency and Productivity Growth, Academia Sinica, Taiwan.

Jorgenson, Dale W. and Ralph Landau (eds) (1989), *Technology and Capital Formation*, MIT Press, Cambridge, MA.

Kalirajan, K.P. and Yanrui Wu (eds) (1999), *Productivity and Growth in Chinese Agriculture*, Macmillan Press, Basingstoke and St Martin's Press, New York.

Kalirajan, K.P., M.B. Obwona and S. Zhao (1996), 'A decomposition of total factor productivity growth: the case of Chinese agricultural growth before and after reforms', *American Journal of Agricultural Economics* 78, 331–8.

Keii, Cho (2000), 'China's energy supply and demand situations and coal industry's trends today', *Research Reports 162*, Institute of Energy Economics, Japan.

Khan, Azizur Rahman and Carl Riskin (1998), 'Income and inequality in China: composition, distribution and growth of household income, 1988 and 1995', *China Quarterly*, 154, 221–53.

Khan, Azizur Rahman, Keith Griffin and Carl Riskin (1999), 'Income distribution in urban China during the period of economic reform and globalisation', *American Economic Review*, 89(2), 296–300.

Khan, Azizur Rahman, Keith Griffin, Carl Riskin and Renwei Zhao (1993), 'Household income and its distribution in China', in Keith Griffin and Renwei Zhao (eds), *The Distribution of Income in China*, Macmillan Press, Basingstoke.

Kim, Jong-Il and Lawrence Lau (1994), 'The sources of economic growth in the East Asian newly industrialised countries', *Journal of the Japanese and International Economies* 8, 235–71.

Knight, J. and L. Song (1993), 'The spatial contribution to income inequality in rural China', *Cambridge Journal of Economics*, 17, 195–213.

Krugman, Paul (1994), 'The myth of Asia's miracle', *Foreign Affairs* 73(6), 62–78, November/December.

Kumbhakar, S., S. Ghosh and J. McGuckin (1991), 'A generalised production frontier approach for estimating determinants of inefficiency in US dairy farms', *Journal of Business and Economic Statistics* 9(3), 279–86.

Kuznets, Simon (1973), *Population, Capital and Growth: Selected Essays*, Norton, New York.

Lardy, N. (1978), *Economic Growth and Distribution in China*, Cambridge University Press, Cambridge.

Lardy, N. (1980), 'Regional growth and income distribution in China', in F.R. Denberger (ed.) *China's Development Experiences in Comparative Perspective*, Harvard University Press, Cambridge, MA.

Lardy, N.R. (1992), *Foreign Trade and Economic Reform in China, 1978–1990*, Cambridge University Press, Cambridge and New York.

Lau, Kam-tim and Josef C. Brada (1990), 'Technological progress and technical efficiency in Chinese industrial growth: a frontier production function approach', *China Economic Review* 1, 113–24.

Lawrence, S.V. (1999a), 'Telecommunications brawl', *Far East Economic Review*, September 30, 69–71.

Lawrence, S.V. (1999b), 'China Netcom Corp. breaks the mould', *Far East Economic Review*, September 30, 70–71.

Lee, J. (1994), 'Regional differences in the impact of the open door policy on income growth in China', *Journal of Economic Development*, 19, 215–34.

Lee, Joseph S.L. (1995), 'The South China economic zone', in Edward K.Y. Chen and C.H. Kwan (eds) *Asia's Borderless Economy: The Emergence of Subregional Economic Zones*, Allen & Unwin, Sydney.

Levine, Ross and David Renelt (1992), 'A sensitivity analysis of cross-country growth regression', *American Economic Review* 82, 942–63.

Ley, Eduardo and Mark F.J. Steel (1999), 'We just averaged over two trillion cross-country growth regressions', *IMF Working Paper* WP/99/101.

Li, Jingwen, Gong Feihong and Zheng Yisheng (1995), 'Productivity and China's economic growth, 1953–1990', in *Productivity, Efficiency and Reform in China's Economy* edited by K.Y. Tsui, T.T. Hsueh and Thomas G. Rawski, Chinese University of Hong Kong.

Li, Peng (2000), 'Wireless internet connection in China', *Sanliangshenghui Weekly*, No.11, 46–7.

Li, Shi and Renwei Zhao (1999), 'On China's income distribution again', *Economic Research Journal*, April, 3–17.

Li, Shi, Renwei Zhao and Ping Zhang (1998), 'China's economic transition and the change in income distribution', *Economic Research Journal*, April, 42–52.

Li, Xiaolin (1999), 'FDI in China', *Independent Energy*, July/August, pp. 23–6.

Li, Yongwu (1999), 'Welcome speech' at the Sino-IEA Conference on Natural Gas Industry, 9–10 November, Beijing.

Li, Zhidong, Zhang Kunmin, Zhou Fengqi, Kokichi Ito, Lu Minzhong, Dai Yande and Zhu Da (2000), *Collected Essays on China's Energy and Environment*, Beijing: China's Environmental Science Publishing House.

Lin, Justin Y.F. (1992), 'Rural reforms and agricultural growth in China', *American Economic Review* 82, 34–51.

Lin, Justin Y.F., F. Cai and Z. Li (1996), *The China Miracle: Development Strategy and Economic Reform*, the Chinese University Press, Hong Kong.

Lin, Justin Y.F., F. Cai and Z. Li (1998), 'An analysis of regional gaps in China's economic transition', *Economic Research Journal*, June, 3–10.

Lippit, V.D. (1987), *The Economic Development of China*, Sharpe, Armonk, N.Y.

Lovell, C.A. Knox (1993), 'Production frontiers and productive efficiency', in H.O. Fried, C.A. Knox Lovell and S.S. Schmidt (eds) *The Measurement of Productive Efficiency: Techniques and Applications*, Oxford University Press, New York.

Lovell, C.A. Knox (1996), 'Applying efficiency measurement techniques to the measurement of productivity change', *Journal of Productivity Analysis* 7, 329–40.

Lucas, Robert E. (1988), 'On the mechanics of economic development', *Journal of Monetary Economics* 22, 3–42.

Lyons, T.P. (1991), 'Interprovincial disparities in China: output and consumption, 1952–87', *Economic Development and Cultural Change*, 39, 471–506.

Lyons, T.P. (1997), 'Intraprovincial disparities in post-Mao China: a multidimensional analysis of Fujian province', *Journal of Developing Areas*, 32, 1–27.

McMillan, J., J. Whalley and L. Zhu (1989), 'The impact of China's economic reforms on agricultural productivity growth', *Journal of Political Economy* 97(4), 781–807.

Maddison, Angus (1995), *Monitoring the World Economy, 1820–1992*, Development Centre of the Organisation for Economic Cooperation and Development, Paris.

Maddison, Angus (1998), *Chinese Economic Performance in the Long Run*, OECD Development Centre of the Organisation for Economic Cooperation and Development, Paris.

Malmquist, Sten, 1953, 'Index numbers and indifference curves', *Trabajos de Estatistica* 4, 209–42.

Mao, Weining and Won W. Koo (1996), 'Productivity growth, technological progress and efficiency change in Chinese agricultural production from 1984 to1993', mimeo, North Dakota State University, Fargo.

Masud, Sam (2000), 'In China: opportunities abound, but perils remain for equipment vendors', *Telecommunications*, January, 9–10.

Meeusen, W. and J. van den Broeck (1977), 'Efficiency estimation from Cobb-Douglas production functions with composed error', *International Economic Review* 18(2), 435–44.

Meng, Xin and Harry X. Wu (1998), 'Household income determination and regional income differential in rural China', *Asian Economic Journal*, 12, 65–88.

Moody, A. and F.Y. Wang (1997), 'Explaining industrial growth in coastal China: economic reform and what else?', *World Bank Economic Review* 11, 293–325.

Nadiri, M. Ishaq and Wanpyo Son (1999), 'Sources of growth in East Asian economies', in *Economic Efficiency and Productivity Growth in the Asia-Pacific Region* edited by Tsu-Tan Fu, Cliff J. Huang and C.A. Knox Lovell, Edward Elgar, Cheltenham.

Nehru, V. and A.M. Dhareshwar (1993), 'A new database on physical capital stock: sources, methodology and results', *Revista de Analisis Economico* 8(1), 37–59.

Nishimizu, M. and J.M. Page (1982), 'Total factor productivity growth, technological progress and technical efficiency change: dimensions of productivity change in Yugoslavia, 1965–78', *Economic Journal* 92, 920–36.

Nishimizu, Mieko and Dale W. Jorgenson (1995), 'US and Japanese economic growth, 1952–1974: an international comparison', in Dale W. Jorgenson *Productivity: International Comparisons of Economic Growth*, volume 2, The MIT Press, Cambridge, MA.

Oppers, S. Erik (1997), 'Macroeconomic cycles in China', *IMF Working Papers* 135.

Persson, T. and G. Tabellini (1994), 'Is inequality harmful for growth', *American Economic Review*, 84, 600–21.
Pritchett, L. (1997), 'Where has all the education gone?', *Policy Research Working Paper* No.1551, the World Bank, Washington DC.
Raiser, M. (1998), 'Subsidising inequality: economic reforms, fiscal transfers and convergence across Chinese provinces', *Journal of Development Studies*, 34, 1–26.
Rawski, Thomas G. (1979), *Economic Growth and Employment in China*, published for the World Bank by Oxford University Press, New York.
Ren, Ruoen (1997), *China's Economic Performance in an International Perspective*, OECD Development Centre, Paris.
Research Team (1997), 'Analyses and suggestions of urban income disparities', *Economic Research Journal*, August, 3–10.
Riskin, C. (1987), *China's Political Economy*, Oxford University Press, Oxford.
Rosenstein-Rodan, P. N. (1964), *Capital Formation and Economic Development*, Allen & Unwin, London.
Rozelle, S. (1996), 'Stagnation without equity: patterns of growth and inequality in China's rural economy', *China Journal*, 35, 63–92.
Sachs J.D. and A.M. Warner (1997), 'Fundamental sources of long-run growth', *American Economic Review (Papers and Proceedings)* 87, 184–8.
Sala-i-Martin, Xavier (1997), 'I just ran two million regressions', *American Economic Review (Papers and Proceedings)* 87, 178–83.
Selden, M. (1988), *The Political Economy of Contemporary China*, Sharpe, Armonk, N.Y.
Shi, Qingqi and Jingche Zhao (eds) (1999), *Development Report of Chinese Industries 1999*, Beijing: China ZhiGong Publishing House.
Solow, R.M., 1957, 'Technical change and the aggregate production function', *Review of Economics and Statistics* 39(3*)*, 312–20.
State Development Planning Commission (2002), 'The State Council's approval of electricity reform proposal,' 11 April. http://www.sdpc.gov.cn/a/news/200204112.htm.
State Statistical Bureau (1997), *China's GDP data 1952–95*, Dongbei University of Economics and Finance Press, Daliang.
State Statistical Bureau (1998a), *China Statistical Yearbook 1998*, Statistical Publishing House, Beijing.
State Statistical Bureau (1998b), *China Energy Statistical Yearbook 1991–1996*, China Statistical Publishing House, Beijing.
State Statistical Bureau (1999a), *Comprehensive Statistical Data and Materials on 50 Years of New China*, Statistical Publishing House, Beijing.
State Statistical Bureau (1999b), *China Statistical Abstract*, Statistical Publishing House, Beijing.
State Statistical Bureau (2000a), *China Statistical Abstract 2000*, China Statistical Publishing House, Beijing.
State Statistical Bureau (2000b), *Statistics of China's Industry, Transport and Energy 1949–1999*, China Statistical Publishing House, Beijing.
State Statistical Bureau (2001), *China Statistical Abstract 2001*, China Statistical Publishing House, Beijing.
State Statistical Bureau (2002), *China Statistical Abstract 2002*, China Statistical Publishing House, Beijing.
State Statistical Bureau (various issues), *Statistical Yearbook of China*, Statistical Publishing House of China, Beijing.

Statistical Yearbook (1998), Directorate-General of Budget, Accounting and Statistics, Executive Yuan, Taipei.

Summers, R. and A. Heston (1991), 'The Penn World Table (Mark 5): an expanded set of international comparison, 1950–1988', *Quarterly Journal of Economics*, May, 327–68.

Sung, Yun-Wing (1995), 'Subregional economic integration: Hong Kong, Taiwan, South China and beyond', in Edward K.Y. Chen and Peter Drysdale (eds) *Corporate Links and Foreign Direct Investment in Asia and the Pacific*, HarperEducational Publishers, Pymble, NSW.

Tang, M. and M. Thant (1994), 'Growth triangles: conceptual and operational considerations', in M. Thant, M. Tang and H. Kakazu (eds) *Growth Triangles in Asia: A New Approach to Regional Economic Cooperation*, published for the Asian Development Bank, Oxford University Press, Hong Kong.

Temple, J. (1998), 'Robustness tests of the augmented Solow model', *Journal of Applied Econometrics* 13, 361–75.

Temple, J. (1999), 'The new growth evidence', *Journal of Economic Literature* 37, 112–56.

Tian, X. (1998), 'Uneven regional growth in post-1978 China', mimeo, NCDS, Australian National University.

Tsui, Kai-yuen (1996), 'Economic reform and interprovincial inequalities in China', *Journal of Development Economics*, 50, 353–68.

Tsui, Kai-yuen (1998), 'Factor decomposition of Chinese rural inequality: new methodology, empirical findings and policy implications', *Journal of Comparative Economics*, 26, 502–28.

Wan, Guanghua (1998), 'An empirical analysis of inhabitants' income differential among China's rural areas and its changes', *Economic Research Journal*, May, 36–41.

Wan, Xiangdong (1998), *Information Age: China's Choices in the 21st Century*, Social Sciences Documentation Publishing House, Beijing

Wei, Shang-Jin (1995), 'The open door policy and China's rapid growth: evidence from city-level data', in *Growth Theories in Light of the East Asian Experience* edited by Takatoshi Ito and Anne O. Krueger, University of Chicago Press, Chicago and London.

Wei, Wei (1995), *Regional Disparities and Coordination in China*, Anhui People's Press, Hefei.

Wei, Yingqi and Xiaming Liu (2001), *Foreign Direct Investment in China: Determinants and Impact*, Edward Elgar Publishing, Cheltenham.

Weiss, Ed (2000), 'Internet growth hastens network upgrades', *Telecommunications* 34(5), 22 and 28, May.

Wolff, Edward (1991), 'Capital formation and productivity convergence over the long term', *American Economic Review* 81, 565–79.

Woo, Wing Thye (1998), 'Chinese economic growth: sources and prospects', in *The Chinese Economy* edited by M. Fouquin and F. Lemoine, Economica Ltd, Paris.

Woo, Wing Thye, Wen Hai, Yibiao Jin and Gang Fan, (1994), 'How successful has Chinese enterprise reform been? Pitfalls in opposite biases and focus', *Journal of Comparative Economics* 18, 410–37.

World Bank (1997a), *China 2020: Development Challenges in the New Century*, The World Bank, Washington DC.

World Bank (1997b), *Sharing Rising Incomes: Regional Disparities in China*, The World Bank, Washington DC.

World Bank, 2000, 'The private sector and power generation in China', *World Bank Discussion Paper* No. 406, Washington, DC.

Wu, H. (1997), 'Reconstructing Chinese GDP according to the National Accounts concept of value added: the industrial sector, 1949–94', *Research Report* 97C24, Research Institute of Systems, Organisations and Management, University of Groningen.

Wu, Yanrui (1993), 'Productive efficiency in Chinese industry: a review', *Asian-Pacific Economic Literature* 7(2), 58–66.

Wu, Yanrui (1995), 'Productivity growth, technological progress and technical efficiency change in China: a three-sector analysis', *Journal of Comparative Economics* 21, 207–29.

Wu, Yanrui (1996a), 'Productive Performance in Chinese Enterprises', Macmillan Press, London.

Wu, Yanrui (1996b), 'Technical efficiency and firm attributes in Chinese iron and steel industry', *International Review of Applied Economics* 10(2), 235–48.

Wu, Yanrui (1998), 'Redundancy and firm characteristics in Chinese state-owned enterprises', *Asia Pacific Journal of the Economics and Business* 2(1), 33–44.

Wu, Yanrui (1999), 'FDI and economic growth', in Yanrui Wu (ed.), *Foreign Direct Investment and Economic Growth in China*, chapter 1, Edward Elgar Publishing, Cheltenham.

Wu, Yanrui (2000a), 'Is China's economic growth sustainable: a productivity analysis', *China Economic Review* 11(3), 278–96.

Wu, Yanrui (2000b), 'Income disparity and convergence in China's regional economies', in P. Lloyd and X. Zhang (eds), *China in the World Economy*, Edward Elgar, Cheltenham.

Xu, Xianchun and Xiaoqin Tian (1997), 'The collection of China's GDP data (1952–77) and the method of measurement', *Economic Research Journal*, September, 65–71.

Yang, Dali (1990), 'Patterns of China's regional development strategy', *China Quarterly*, 122, 230–57.

Yang, Dennis Tao (1999), 'Urban-biased policies and rising income inequality in China', *American Economic Review*, 89(2), 306–10.

Yang, Qiumei (1998), 'The impact of human capital on foreign investment: the case of China', manuscript, OECD Development Centre, Paris.

Yang, Tianjun (2000), 'Unicom listed in New York and Hong Kong Stock Exchanges', *China Business Times*, 23 June, 1.

Yao, Xinhuan (1999), 'Market demand for Guangzhou natural gas and LNG experimental project', paper presented at the Sino-IEA Conference on Natural Gas Industry, 9–10 November, Beijing.

Young, A., (1994a), 'Lessons from the East Asian NICs: a contrarian view', *European Economic Review* 110, 641–80.

Young, A. (1994b), 'The tyranny of numbers: confronting the statistical realities of the East Asian growth experience', NBER Working Paper No. 4680, National Bureau of Economic Research.

Young, A. (2000), 'The Razor's Edge: Distortions and Incremental Reform in the People's Republic of China', *Quarterly Journal of Economics* 115(4), 1091–1136.

Yu, Yongding, Bingwen Zheng and Hong Song (eds) (1999), *The Research Report on China's Entry into WTO: The Chinese Industries*, Social Sciences Documentation Publishing House, Beijing.

Zhang, Allan (2002), *China's Energy Industries*, unpublished, PriceWaterhouseCoopers.

Zhang, Ping (1998), 'Regional income inequality and nonagricultural employment in rural China', *Economic Research Journal*, August, 59–66.

Zhang, Qing and Bruce Felmingham (2001), 'The relationship between inward direct foreign investment and China's provincial export trade', *China Economic Review* 12(1), 82–99.

Zhang X.G. (2000), *China's Trade Patterns and International Comparative Advantage*, Macmillan, Basingstoke.

Zhao, Renwei and S. Li (1997), 'Increasing income inequality and its causes in China', *Economic Research Journal*, September, 19–28.

Zhao, Renwei, Shi Li and Carl Riskin (eds) (1999), *On China's Income Distribution Again*, China Fiscal and Economic Publishing House, Beijing.

Zhao, S. Xiaobin (1996), 'Spatial disparities and economic development in China: 1953–92: a comparative study', *Development and Change*, 27, 131–63.

Zhou, Fengqi (1999), 'Role of gas in China's energy economy and long-term forecast for natural gas demand', paper presented at the Sino-IEA Conference on Natural Gas Industry, 9–10 November, Beijing.

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