Sources of Regional Growth Difference and Income Disparity during the Reform Period in China: An Empirical Analysis

von der Carl von Ossietzky Universität Oldenburg

- Fakultät II Informatik, Wirtschafts- und Rechtswissenschaften -

genehmigte

Dissertation

zur Erlangung des Grades eines

Doktors der Wirtschaftswissenschaften (Dr. rer. pol.)

vorgelegt von

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geboren am 29. Juni 1976 in Jilin (V. R. China)

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Abstract

The purpose of this dissertation is to make an empirical analysis on the sources of regional growth difference and income disparity during the reform period in China. The general background of this study lies in two folds. On the one side, there is growing concern, both within and outside of China, that the fruits of rapid economic growth since the initiation of economic reform in China have been unequally distributed, as shown by the increased growth difference and income disparity between the coastal and inland regions. This unequal regional development raises the question on the sustainability of the development process in China, since it tends to create economic, political and social tensions that might hold back the growth of the Chinese economy in the long term. Thus, an analysis on the sources of regional growth difference and income disparity during the reform period is of high practical importance for the Chinese economy.

On the other side, a review of previous empirical studies in growth literature, most of which are based on neoclassical growth theories, suggests to us that two crucial questions concerning the regional growth pattern in China have not been correctly answered. The first question is related to the sources of growth difference. Namely, what explains the difference in growth rates across provinces? What are the major factors that drive high economic growth in the coastal region, and what causes the inland region to lag behind? The second question is related to the driving forces of income convergence. Namely, why do the poorer inland provinces fail to catch up to the richer coastal provinces while, within the coastal region, provinces with lower income levels at the outset of economic reform have caught up with the three rich municipalities successfully?

This dissertation is different from previous studies in the respect that it applies an original but more reasonable analytical framework to answer the above-mentioned questions. Our framework is constructed mainly based on the growth theory of cumulative causation

proposed by Myrdal (1957). However, we add to the literature of cumulative causation in two main ways. Firstly, we have drawn from Myrdal's theory a number of conceptualized variables and structural relationships, which enable the hypotheses and their consequences to be confronted more easily with empirical evidence. Secondly, we have formalized determinants of technological progress and their cumulative relationships with economic growth and capital accumulation more precisely in our framework.

Compared with previous empirical studies, the adoption of more appropriate econometric techniques for hypotheses tests is another unique characteristic of this dissertation. We have applied the Granger-causality test to ascertain the mutual causal relationships between productivity increase and its underlying economic factors proposed by our framework. In order to avoid any estimation bias, instead of estimating any single regression equation, we have used a panel data approach to estimate a system of equations simultaneously.

Based on our empirical analyses, we are able to conclude that the main factors accounting for the regional growth difference in China include not only different rates of factor accumulation but also different rates of technological progress. The higher rate of capital accumulation and technological progress in the coastal region should be ascribed partly to the cumulative relationships between productivity increase and its underlying economic factors, and partly to the state preferential policies favouring the coastal provinces. With respect to the driving forces of income convergence and divergence, the gradual strategy of economic reform is a fundamental factor for understanding the coexistence of income divergence between the coastal and inland regions, and income convergence within the coastal region. In addition, the effect of "direct growth contagion" among provinces complements our explanation of income convergence in the coastal region.

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Index of Abbreviations

ADF: Augmented Dickey-Fuller

AIC: Akaike Info Criterion

CCP: Chinese Communist Party

CEL: Caselli, Esquivel and Lefort

CYS: China's Yearbook of Statistics

DGC: Direct Growth Contagion

EP: Export Promotion

FDI: Foreign Direct Investment

FIEs: Foreign-invested Enterprises

FPE: Final Prediction Error

FTCs: Foreign Trade Corporations

GE: General Entropy

GDP: Gross Domestic Product

GNP: Gross National Product

HSCV: Half the Squared Coefficient of Variation

LDCs: Less-developing Countries

LP: Labour Productivity

LPS: Lee, Pesaran and Smith

MNCs: Multinational Corporations

MPS: System of Material Products Balance

MRW: Mankiw, Romer and Weil

NIS: National Innovation System

OECD: Organization for Economic Cooperation and Development

OT: Ordinary Trade

R&D: Research and Development

RSS: Residual Sum of Squares

SC: Schwarz Criterion

SEZs: Special Economic Zones

SNA: System of National Accounts

SOEs: State-owned Enterprises

SSB: State Statistical Bureau

TFP: Total Factor Productivity

TOVS: Total Output Value of Society

TVEs: Township and Village Enterprises

Index of Symbols[1]

a	Intercept Term in Regression
c	Vector of Coefficients of X
dummy	Dummy Variable (coded to take the value of one if the province is in the coastal region and the value of zero otherwise)
fdi	Ratio of FDI Inflow to GDP
g	Rate of Technological Progress
g_x	Growth rate of any variable x during a time period
i	Index of Income Units, $i = 1, 2, \ldots, N$
j	Index of Subgroup, $j = 1, 2, \ldots, J$
k	Capital per Labour (or, per capita capital)
$\tilde{k}$	Capital per Effective Unit of Labour
m	Vector of Coefficients of M
n	Growth Rate of Labor Productivity
p_d	Domestic Price
p_f	Foreign Price
r	Wage Ratio, $r = wL / Y$
rd	Ratio of R&D Expenditure to GDP
s	Saving Rate (or, investment rate)

[1] Unless explicitly mentioned otherwise, for any variable x included in this index, x_t denotes the value of x at time t, t=0, 1, …; x_i denotes the value of x for income unit i, i=1, 2, …, N; x^* denotes the steady-state value of x; $\dot{x}$ denotes the change of x during a unit period of time, i.e. $\dot{x} = dx / dt$.

s_h	Fraction of Income invested in Human Capital
s_k	Fraction of Income invested in Physical Capital
$trade$	Growth Rate of Trade Volume
u	White Noise Residual
w	Wage Rate
y	Output per Labour (or, per capita output)
$\tilde{y}$	Output per Effective Unit of Labour

A	Level of Technology
DGC	Explanatory Variable (effect of direct growth contagion)
E	Export
GE_w	GE Measure with Parameter w
GE_0	GE Measure with Parameter $w=0$, i.e. Theil's L Index
GE_1	GE Measure with Parameter $w=1$, i.e. Theil's T Index
GE_2	GE Measure with Parameter $w=2$, i.e. HSCV
GE_w^W	Within-group Component of GE Measure
GE_w^B	Between-group Component of GE Measure
$GE_w(j)$	Value of GE Measure within the Subgroup j
H	Stock of Human Capital
	Explanatory Variable in Chapter 5 (number of people having completed secondary education as a proportion of total population)
I	Investment
J	Number of Subgroups
K	Capital Stock
L	Labour
L_R	Labour working in the Research Sector

L_Y	Labour working in the Final-good Sector
LP	Labour Productivity
M	Vector of Policy Variables
N	Number of Income Units
N_j	Number of Income Units of Subgroup j
P	Total Population
S_k	Factor Shares of Capital in Income
S_l	Factor Shares of Labour in Income
S_R	Fraction of Labour working in the Research Sector, $S_R = L_R / L$
T	World Technology Frontier
U	Fraction of an Individual’s Time spent learning Skills
X	Vector of Variables (taken as proxies for differences in steady-state positions)
Y	Output
Z	World Income
a	Output Elasticity of Capital Stock
a'	Output Elasticity of Human Capital
b	Coefficient of Initial Income Level
g	Constant, $0 < g < 1$
d	Productivity Parameter, $d > 0$
e	Productivity Parameter, $0 < e < 1$
z	Elasticity of World Income
h_d	Elasticity of Domestic Price
h_f	Elasticity of Foreign Price
q	Vector of Elements (accounting for different steady-state income levels)
	Exponential Time Trend of Investment in Chapter 5

i	Investment Rate
k	Capital-output Ratio
l	Constant, $l = (1-a)(n+g+s)$
Λ	Coefficient of Verdoorn Relationship
m	Positive Constant
x	Elasticity of Export
p	Profit Rate
r	One plus the Percentage Mark-up over Unit Labour Costs
s	Depreciative Rate of Physical Capital
t	Time Period between t_1 and t_2, i.e. $t = t_2 - t_1$
f	Productivity Parameters, $0 < f < 1$
c	Level of Social Capabilities
y	Positive Constant
w	Parameter of GE Measure

Chapter 1 Introduction

Having one fifth of the world population and being the largest developing country, the People's Republic of China[1] naturally forms a crucial part of both world development and human welfare. The remarkably high and sustained level of economic growth, with an average real GDP (Gross Domestic Product) growth of 9 percent per annum since the initiation of economic reform in 1978, puts furthermore the Chinese economy at the centre of world economic interests. Actually, this remarkable economic growth in China has been compared favourably as another miracle to the Golden Age in Europe and Japan as well as the Asian Miracle in some new industrialised countries.

While many economists, both within and outside of China, make great efforts to examine sources of this phenomenal growth (e.g. Hu and Khan, 1997) with a focus on providing valuable experiences to other developing countries, there is growing concern that the fruits of this growth have been unequally distributed, as shown by the increased growth difference and income disparity between provinces and regions (e.g. Jian *et al.*, 1996; Tsui, 1996; Kanbur and Zhang, 1999, 2001; etc.). Specifically, the provinces in the coastal region have experienced continuously higher growth rates than the central and western regions during the reform period, which has enlarged income disparity between the coastal and inland regions.

The unequal regional development raises the question concerning the sustainability of the development process in China, since it tends to create economic, political and social tensions that might hold back the growth of the Chinese economy in the long term.

The issue of inter-regional variation in economic development is recently of serious concern to the Chinese government. It is vividly demonstrated by the program "Development Strategy of Western China" promoted by the State Council and the Central Committee of the Chinese Communist Party (CCP) in the late 1990s. This program requests all organizations and local governments to make their best efforts to help economic development in the west. For the effective implementation of this

[1] Hereafter we refer to the People's Republic of China as China.

program throughout the country, the State Council set up a special committee to facilitate economic development in the western region. The committee is headed by some of the most senior members of the State Council. This unprecedented campaign focusing on regional development by the country and party leadership reflects an acute situation of regional inequality in China.

In this context, an analysis on the sources of regional variation in economic development is of high practical importance for the Chinese economy. In the past decades, there has been a growing literature devoted to this issue. We argue that previous empirical studies, mainly based on the framework of neoclassical growth theory, failed to provide reasonable explanations for the regional growth difference and income disparity in China. Policy recommendations based on the results of these empirical studies would be misleading. Based on a new analytical framework, this dissertation is to identify the factors accounting for the regional growth difference and the driving forces of regional income convergence (and/or divergence) during the reform period in China, with a view to prescribe appropriate policy measures for a balanced regional development.

Although this dissertation incorporates some additional dimensionalities relative to previous theoretical literature on the issue of growth difference and income disparity, its principal contribution is not theoretical. Rather, this dissertation is different from the previous studies in the respect that it applies an original but more reasonable analytical framework to examine the sources of regional growth difference and income disparity in China empirically. We argue that, among the existent growth theories on the issue of regional growth difference[2], the theory of cumulative causation by Myrdal (1957) provided us more reasonable hypotheses for the sources of growth difference and income disparity across economies. However, since the theory of cumulative causation was presented verbally and lacks conceptualized variables and formalized analytical structures, it is difficult to make direct statistical measures and empirical tests for its hypotheses. In this dissertation we will formalize the ideas embodied in the theory of cumulative causation and construct a new testable analytical framework for the issue of

[2] The existent growth theories on the issue of growth difference and income disparity can be classified roughly into three groups, i.e. neoclassical growth theory, new growth theory (or, endogenous growth theory), and the theory of cumulative causation. We will describe and evaluate these theories detailedly in Chapter 2.

growth difference and income disparity across economies. The insightful hypotheses proposed by the endogenous growth theory will also be considered within this framework.

Compared with the analytical framework of the neoclassical growth theory adopted by previous empirical studies, we argue that our framework proposes more reasonable hypotheses about important features of regional development. Within this framework, we could identify the most important economic factors accounting for the growth difference and income disparity among provinces and regions in China. The extent to which such a framework is able to explain the regional growth pattern in China is verified empirically to Chinese statistical data using econometric techniques, such as the Granger-causality and multiple-regression tests. In addition, we analyse impacts of economic reform on different evolutions of these economic factors among provinces and regions in China, which underlie our prescriptions of policies for a balanced regional development in China.

This chapter is an introductory chapter. The rest of this chapter is organised in sections. In the first section, the administrative structure and regional division of China will first be introduced. Then two economic policy regimes since the foundation of China will be described briefly. The description of China's economic policy regimes is based on the premise that understanding the sources of regional growth difference and income disparity requires attention to the features of China's economic transformation and to the institutional details in these two regimes. The unique characteristic of Chinese economic reform, namely, the adoption of a gradual strategy instead of a "big bang" strategy, will be highlighted as well in this section. As we will see in Chapter 6, this gradual strategy of economic reform has had great impacts on the regional development and income distribution in China.

In the second section of this chapter, stylised facts of regional growth performance and income distribution of the Chinese economy will be presented with the help of some economic indicators. A temporal and regional breakdown of these economic indicators reveals a complex regional growth pattern in China. In the subsequent section, two crucial questions arising from these stylised facts will be brought forward and previous studies on these two questions will be summarised. The motivation and outline of this dissertation will be presented in the last two sections.

1.1 Background

1.1.1 Administrative Structure and Regional Division in China

At the provincial level, the administrative map of China is divided into 31 entities excluding Hong Kong, which became a Special Administrative Region on 1 July 1997, Macao, which became a Special Administrative Region on 20 December 1999, and Chinese Taipei. These 31 entities are composed of 22 provinces *(sheng)*, 5 autonomous regions *(zizhiqu)*[3], and 4 municipalities under the direct control of the central government *(zhixiashi)*[4]. Unless otherwise stated, we hereafter refer to these 31 provincial-level entities as provinces.

Following the three-fold division adopted in China's national accounts published by the State Statistical Bureau (SSB), the 31 entities at the provincial level are classified according to their geographical locations into three regions: coast, centre and west. The coastal region is composed of three municipalities that are under the direct control of the central government (Beijing, Tianjin and Shanghai), eight provinces (Hebei, Liaoning, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan). The central region is composed of eight provinces (Shanxi, Jilin, Heilongjiang, Henan, Anhui, Hubei, Hunan and Jiangxi). The western region is composed of a municipality under the direct control of the central government (Chongqing)[5], six provinces (Gansu, Shaanxi,

[3] An "autonomous region" or "autonomous district" is a subnational region with special powers of self-rule. Nations with autonomous regions include China, Spain, Portugal, Russia, Ukraine and Italy. Typically an autonomous region gains its autonomy either because of its great distance from the capital of the country (like in Portugal), or because it contains a national minority which is different from the national majority (like in Spain and China). Traditionally, the definition of a minority nationality in China is a group of people who speak a common language, occupy a common area, and share a common sense of social values. They see themselves as not belonging to the majority of the Han Chinese population. The five autonomous regions in China are based on the location of five of the larger and more important minority nationalities. They share the same administrative powers as other provinces in China.
[4] "Municipalities under the direct control of the central government" are the cities with status equal to that of the provinces. Geographically and culturally, the Chinese municipalities under the direct control of the central government are enclave in the middle of provinces and occur in strategic positions between provinces.
[5] Chongqing was a municipality under the authority of Sichuan province and has held the status of a municipality under the direct control of the central government since 1997.

Sichuan, Guizhou, Yunnan and Qinghai) and five autonomous regions (Guangxi, Inner Mongolia, Ningxia, Xinjiang and Tibet).

The division of regions used for statistical and econometric analysis in this dissertation accords mainly with the above-mentioned three-fold division, with the following modifications being that[6]:

- Chongqing and Sichuan in the western region are not treated separately. This treatment is due to the lack of separate statistics for Chongqing before 1997;
- The province of Hainan in the coastal region and the autonomous region of Tibet in the western region are excluded because many data are missing for relevant variables used in subsequent empirical analyses.

In addition, we also use the terms "inland region" and "inland provinces", which refer to all non-coastal provinces, i.e. the provinces of the centre and west. Table 1.1 and the attached "Map of China" in Appendix 1 provide the list and geographic location of China's provinces and regions.

Table 1.1: **Regional Division in China**

"Provinces" in the Coastal Region	"Provinces" in the Central Region	"Provinces" in the Western Region
Beijing (BJ)	Shanxi (SX)	Inner Mongolia (NM)
Tianjin (TJ)	Jilin (JL)	Guangxi (GX)
Hebei (HEB)	Heilongjiang (HL)	Sichuan (SC)
Liaoning (LN)	Anhui (AH)	Guizhou (GZ)
Shanghai (SH)	Jiangxi (JX)	Yunnan (YN)
Jiangsu (JS)	Henan (HEN)	Shaanxi (SN)
Zhejiang (ZJ)	Hubei (HB)	Gansu (GS)
Fujian (FJ)	Hunan (HN)	Qinghai (QH)
Shandong (SD)		Ningxia (NX)
Guangdong (GD)		Xinjiang (XJ)

Note: in the parentheses is the code for the corresponding province, which is displayed in the map of Appendix 1.

[6] Actually, in the empirical literature on the Chinese economy, the classification of economic regions is often not based on the official definition. The authors may make their own revisions depending on their research emphasis. For example, some authors may divide China only into two regions, coastal and non-coastal (e.g. Chen and Fleisher, 1996).

1.1.2 Two Distinct Economic Regimes

China was founded in 1949. During the last five decades, the Chinese economy has been subject to two major distinct economic regimes, i.e. the pre-reform period from 1952 to 1977[7] and the reform period after 1978.

1.1.2.1 Pre-reform Period (1952-1977)

The pre-reform period can also be referred to as the central planning period or Maoist Period[8]. The major economic policy was a push for a Soviet-style central planning system within all provinces of China. The characteristics of the Chinese economy can be summarised as follows:

- centrally planned economic system within all provinces of China
- autarkic and closed local economies
- restrictive relations with the outside world

Centrally Planned Economic System

The Chinese economy adopted a centralized production and resource allocation system within all the provinces during the pre-reform period. A centralized fiscal system, commune system in the agricultural sector, nationalization of enterprises in the industrial sector and other related measures were adopted to assure that the central government had absolute control over all aspects of its economic management.

The fiscal system of China during the pre-reform period was characterized by centralized revenue collection and centralized fiscal transfers, i.e. all taxes and profits were remitted to the central government and then transferred back to the provinces according to expenditure needs approved by the central government. No local government had a separate budget.

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[7] China was involved in the Korean War during 1950-1951. There were therefore no officially-recorded economic planning and statistics before 1952.

8 The pre-reform period can be further divided into four episodes: Land Reform and the First 5-Year Economic Plan (1952-1957), Great Leap Forward and Great Famine (1958-1961), Post-Famine Recovery (1962-1965), Cultural Revolution and Transition to Reform (1966-1977).

The Chinese government tried to acquire absolute control over both agricultural and industrial activities during the pre-reform period. With respect to the agricultural activity, agricultural operations were practiced collectively under the “commune system”. About 20-30 of neighbouring households were organised into each commune. In each commune, an economic and administrative unit controlled the labour force and all means of production. Wages were controlled by the state, and all agricultural products were marketed through state agencies. Because of management problems of large collectives, rewards to individual farmers were not tied directly to their efforts, and incentives to work as well as productive efficiency were thus very low (Lin, 1988, 1992).

In the industrial sector, the central or local governments had taken over most of the enterprises, which belonged to privates or other organizations before 1949. This nationalisation had established the dominant role of state-owned enterprises (SOEs) in the industrial sector. These SOEs did not have managerial autonomy in terms of production and investment. They were required to remit all profits or financial surplus to the state, and the state covered all their expenditures by fiscal appropriation.

We can divide China’s industrial sector into two broad categories, i.e. the state-owned sector, in which SOEs are under the direct control of the central or local governments, and the so-called non-state sector. The backbones of the non-state sector are township and village enterprises (TVEs)[9], foreign-invested enterprises (FIEs) and private enterprises. The examination of Table 1.2 reveals that the ownership structure of the Chinese industry has undergone great changes during the last five decades. During the pre-reform period, the share of state-owned sector in the total industrial activities has increased in all provinces. In 1978, the dominance of SOEs in the industrial sector existed in all provinces.

[9] The TVEs are non-state enterprises in the sense that they operate entirely outside of the state plan, and with rather hard budget constraints (receiving almost no subsidies from the state budget, or state banks, and only rarely from the local government). At least formally, they are not private enterprises, however, since they lack clear private owners.

Table 1.2: **Share of Gross Industrial Output by SOEs in Total Provincial Industrial Output in 1952, 1978 and 2001**

Provinces	1952	1978	2001
Coastal Region:			
Beijing	0.58	0.90	0.43
Tianjin	0.55	0.81	0.22
Shanghai	0.27	0.92	0.25
Hebei	0.31	0.76	0.23
Liaoning	0.61	0.82	0.20
Jiangsu	0.36	0.61	0.12
Zhejiang	0.23	0.61	0.07
Fujian	0.12	0.74	0.08
Shandong	0.45	0.68	0.21
Guangdong	0.13	0.64	0.11
Central Region:			
Shanxi	0.48	0.78	0.17
Jilin	0.78	0.79	0.48
Heilongjiang	0.75	0.83	0.42
Anhui	0.34	0.80	0.20
Jiangxi	0.39	0.78	0.35
Henan	0.24	0.74	0.29
Hubei	0.66	0.77	0.22
Hunan	0.44	0.75	0.24
Western Region:			
Inner Mongolia	#	0.79	0.33
Guangxi	0.30	0.79	0.29
Sichuan	0.37	0.84	0.32
Guizhou	0.13	0.81	0.53
Yunnan	0.37	0.85	0.47
Shaanxi	0.23	0.84	0.42
Gansu	0.36	0.94	0.48
Qinghai	0.15	0.83	0.70
Ningxia	0.35	0.83	0.53
Xinjiang	0.32	0.89	0.66
National	0.41	0.87	0.28

Note: # means that data is not available.
Sources: SSB (1999); China Statistical Yearbook (SSB, 2002); and author's calculations.

Autarkic Local Economies

One of distinguishable characteristics of China's economy during the pre-reform period was its autarkic local economies. While China has been a unitary political state since 1949, the political power at the centre has not been used to pursue the goal of establishing an integrated national economy to complement its political unity. This is a marked contrast to the former Soviet Union where central planning led to gigantic monopoly producers for many products, with production for the whole country often concentrated in one huge plant.

The Chinese government has both strategic military and ideological reasons for promoting the development of local autarkic economies and developing duplicate sets of industries in each province[10]. This situation of regional self-sufficiency is reflected in Table 1.3, which shows that the secondary industry accounted for one third or more of the national income in all provinces during the pre-reform period.

Low factor mobility across the provinces was another important feature of China's local economy. During the pre-reform period, the central government controlled the interregional migration of labour. The toll of this control lies in the "Regulation on the Registration of Households" enacted in 1958, which required every household to register its place of residence, and to gain permission for any change in residence. Until the early 1980s, migration without permission was extremely difficult.

Similarly, there was also no significant evidence for capital mobility across China's provinces in the pre-reform period, because the state-sector investment, which accounted for almost all investment, was allocated across provinces on the basis of planning and bureaucratic considerations. It is worth noticing that we define here "provincial or regional capital mobility" as the change of capital allocation among provinces or regions driven by market forces (or, by profitability) instead of by administrative appropriations. The latter can be called "capital transfer", but by no means "capital mobility"[11].

[10] From the strategic viewpoint, the risk of military conflict, first with the United States and subsequently with the former Soviet Union, was an incentive to diversify economic activity outside the coastal region, which was particularly vulnerable to attack, in order to make the individual provinces self-sufficient in terms of plant and consumer goods. The development of a "Third Front" – covering the provinces of Sichuan, Guizhou, Shaanxi, Gansu, Qinghai, Ningxia, Henan, Hubei, Hunan and Shanxi – between 1964 and the early 1970s was part of this strategy (Hsueh, 1994). The ideological reasons included both egalitarian ideas and the fact that the authorities considered the inland provinces as more politically stable and more "trustworthy" than the coastal provinces, which had been subject to western influence for many years before the Communists came to power.

[11] We will describe detailedly the investment system in China during the pre-reform and reform periods in Chapter 6, as we analyze the sources of uneven capital allocations among regions since the economic reform.

Table 1.3: **Industrial Structure of the Chinese Economy by Provinces in 1952, 1978 and 2001**

Provinces	Share in National Income in 1952(%)			Share in National Income in 1978(%)			Share in National Income in 2001(%)		
	Primary	Second	Tertiary	Primary	Second	Tertiary	Primary	Second	Tertiary
Coastal Region:									
Beijing	22.2	38.7	39.1	5.2	71.1	23.7	3.3	36.2	60.5
Tianjin	14.5	49.3	36.3	6.1	69.6	24.3	4.3	49.2	46.6
Shanghai	5.9	52.4	41.7	4.0	76.0	19.9	1.7	47.6	50.7
Hebei	62.3	18.8	18.9	28.5	50.5	21.0	16.4	49.6	34.0
Liaoning	29.0	48.3	22.7	14.1	71.1	14.8	10.8	48.5	40.7
Jiangsu	52.7	17.6	29.7	27.6	52.6	19.8	11.4	51.6	37.0
Zhejiang	66.4	11.3	22.3	38.1	43.3	18.7	10.3	51.3	38.4
Fujian	65.9	19.0	15.1	36.1	42.5	21.5	15.3	44.8	39.9
Shandong	65.8	18.1	16.1	33.3	52.9	13.8	14.4	49.3	36.3
Guangdong	48.7	22.7	28.6	29.8	46.6	23.6	9.4	50.2	40.4
Central Region									
Shanxi	58.8	16.9	24.4	20.7	58.5	20.8	9.6	51.6	38.8
Jilin	55.5	27.4	17.0	29.3	52.4	18.3	20.1	43.3	36.5
Heilongjiang	45.8	30.0	24.2	23.5	61.0	15.6	11.5	56.1	32.4
Anhui	75.1	9.9	15.0	47.2	35.5	17.3	22.8	43.0	34.2
Jiangxi	65.6	13.1	21.3	41.6	38.0	20.4	23.3	36.2	40.5
Henan	62.4	22.9	14.8	39.8	42.6	17.6	21.9	47.1	31.0
Hubei	56.7	15.6	27.7	40.5	42.2	17.3	14.8	49.6	35.5
Hunan	67.3	12.3	20.4	40.7	40.7	18.6	20.7	39.5	39.8
Western Region:									
Inner Mon.	71.1	11.3	17.7	32.7	45.4	21.9	23.2	40.5	36.3
Guangxi	65.1	23.0	11.9	40.7	34.0	25.3	25.2	35.5	39.3
Sichuan	66.8	14.4	18.8	36.7	38.6	24.8	20.7	40.3	39.1
Guizhou	68.4	18.6	13.0	41.7	40.2	18.2	25.3	38.7	36.0
Yunnan	61.7	15.4	22.8	42.7	39.9	17.4	21.7	42.5	35.8
Shaanxi	65.4	14.9	19.7	30.5	52.0	17.6	15.6	44.3	40.2
Gansu	65.0	13.0	22.0	20.4	60.3	19.3	19.3	44.9	35.8
Qinghai	73.6	7.4	19.0	23.6	49.6	26.8	14.2	43.9	41.9
Ningxia	82.7	4.6	12.7	23.5	50.8	25.7	16.6	45.0	38.4
Xinjiang	64.7	22.0	13.3	35.8	47.0	17.3	19.4	42.4	38.2
National	50.5	20.9	28.6	28.1	48.2	23.7	18.4	48.7	32.9

Source: see Table 1.2

Restrictive Relations with the Outside World

Besides the autarkic local economies, another feature of the Chinese economy during the pre-reform period was the restrictive relations with the outside. China, like other planned economies, had a highly centralized, monopolistic foreign trade regime before the reform. There were only twelve national monopoly foreign trade corporations (FTCs), each with the responsibility for a different set of commodities. The import and export of any good was planned administratively and conducted monopolistically by national FTCs. The ratio of trade volume (i.e. exports plus imports) to GDP was 9 percent in 1952 and decreased to 8 percent in 1978, whereas it amounted to 43 percent in 2001. This comparison reflects clearly the relatively closed economy in the pre-reform period. Control over international transactions was not only of the flow of goods but also of the flow of money. Supportive evidence for the restrictive capital inflows is the lack of official statistics on foreign investment before 1983.

From the above mentioned evidence we can make subsequent conclusions about the Chinese economy during the pre-reform period. At the national level, China was a closed economy under centralized planning; at the regional level, the Chinese economy was characterised with autarkic and fragmented local economies.

1.1.2.2 Reform Period (1978-present)

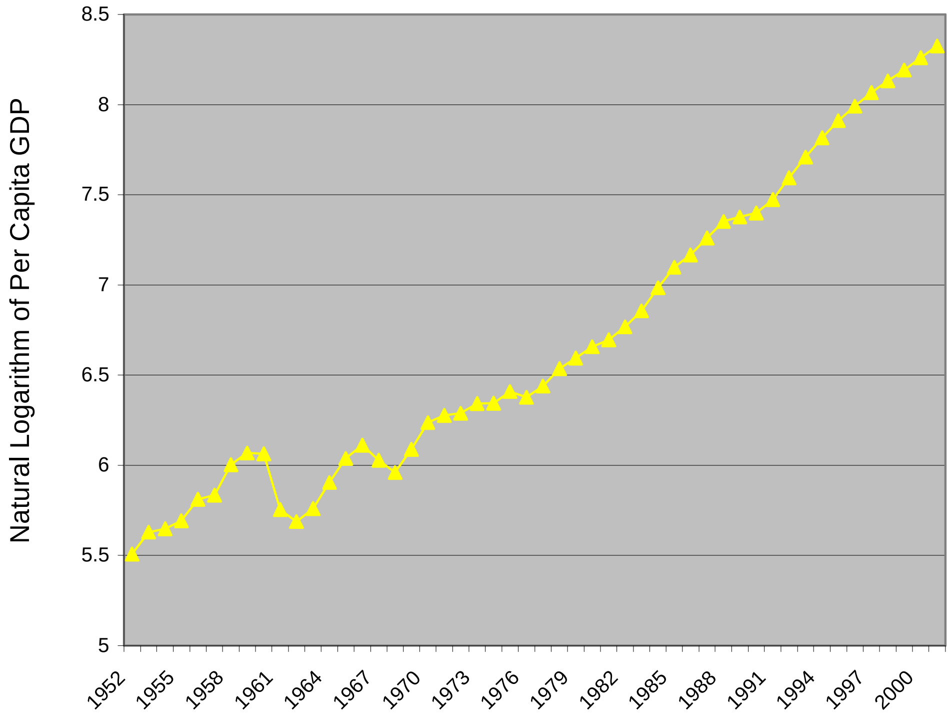
In 1978, China initiated economic reform with the intention of both improving the functioning of domestic economy and developing economic relations with the rest of the world.[12] According to these intentions, the reform policies are comprised of two main parts: (1) decentralisation; and (2) opening-up. In terms of decentralisation, China has progressively reduced the scope of mandatory planning, decentralised economic decision making to productive entities (individuals and firms) and allowed market forces to operate. With respect to the opening-up policy, China has focused on two aspects: attraction of foreign direct investment (FDI) and international trade liberalization.[13]

Since the initiation of economic reform in the late 1970s, the Chinese economy has sustained a continuously high rate of annual growth. The well being of the world's largest populace in particular have improved significantly. Figure 1.1 shows the change of per capita GDP of the Chinese economy over the period 1952-2001.

[12] The reform period can be divided into two main phases: Rural Reform (1978-1984) and Decentralization and Opening-Up (1985-present). The year of 1984 was defined as a division line because it saw not only a substantial geographical extension of the open door policy but also the implementation of further domestic reform measures.

[13] Here, we summarise the characteristics of the economic regime during the reform period. The basic economic characteristics and institutional details will be described in Chapter 6, as we analyse the impacts of state policies on the regional growth difference and income disparity during the reform period in China.

Figure 1.1: **Natural Logarithm of Per Capita GDP of Chinese National Economy from 1952 to 2001 (at 1990 constant price)**



Sources: China's Statistical Yearbook (SSB, 2002) and author's calculations

The pre-reform period 1952-1977 is characterized by unsteady and slow growth. The average annual growth rate of per capita GDP was only 4.5 percent across all provinces in the pre-reform period[14]. Since the late 1970s the economy has experienced faster growth than the economy during the pre-reform period. The average annual growth rate of real per capita GDP of all provinces during the reform period is 9.09 percent. The real per capita GDP (at 1990 constant price) increased by a factor of 6 from 689 yuan/person in 1978 to 4122 yuan/person in 2001, which is in contrast to the increase by a factor of 2.8 from 246 yuan/person in 1952 to 689 yuan/person in 1978. For the

[14] In particular, there were two major negative shocks to the Chinese economy: (1) a sharp up and down in the years between 1958 and 1960 due to the "Great Leap Forward" movement and its subsequent breakdown along with agricultural failures and a nation-wide famine; (2) a large decline in the second half of the 1960s caused by the political and social chaos that followed the initiation of the Cultural Revolution (1965-1968). The early 1970s was the recovery period of the Chinese economy from the erratic performance resulting from the Cultural Revolution.

period from 1952 to 2001 as a whole, the real per capita GDP has grown by a factor of 16.7.

However, as shown by stylised facts presented in the next section, the fruits of economic growth during the reform period have not been enjoyed equally by different provinces and regions. The provinces in the coastal region generally have experienced continuously higher growth rates than the central and western regions during the reform period, which has enlarged income disparity between the coastal and inland regions.

1.1.3 Gradual Strategy of Economic Reform

An important distinctive feature of the economic reform in China is the adoption of a gradual or incremental strategy. This is different from the “big bang” strategy adopted by East Europe and the former Soviet Union. As stated in Sachs and Woo (1997), the “big bang” strategy is characterised with: “a commitment to mass privatisation of SOEs, ending legal discrimination against all types of non-state enterprises, rapid and comprehensive price and trade liberalization, alignment of the official exchange rate to the market rate, etc.”. Rather than attempting to “cross the chasm in one leap”, China has negotiated a series of small steps, moving from a planned and closed economy towards a market and open economy.

According to this gradual strategy, a new policy would be experimentally introduced only in a specific sector or geographically in some provinces. Once the experiment is proved to be successful, the new policy will then be extended to other sectors or provinces. For example, the decentralisation of production factors first started in the agricultural sector in 1978.[15] Specifically, this rural reform was first experimented in the Anhui and Sichuan provinces and had then extended to all provinces from 1978 to 1984. Reforms in the industrial sector began systematically until 1984, when the rural reform had achieved substantial success.

[15] The reason why this began was that the agricultural reform had the spontaneous backing and enormous enthusiasm from the peasantry, but reforms in the industrial sector encountered strong resistance from the party leaders. Specially, the privatisation of SOEs and the emergence of non-state enterprises were thought of against the communistic ideology by some party leaders.

The process of openness exemplifies the gradual strategy of the economic reform in China as well. Measures aimed at attracting FDI and trade liberalization were limited geographically in only two provinces, Fujian and Guangdong, and were small scopes before 1984.[16] Once the contributions of FDI were well demonstrated by the vital development of host economies in Guangdong and Fujian, the openness was extended to the whole coastal region during the 80s. In the 1990s, all provincial capitals and other main cities were authorised to adopt an open door policy.

As we will see in Chapter 6, this gradual strategy of economic reform, especially the gradual geographical extension of the openness, has had great impacts on the regional growth difference and income disparity.

1.2 Regional Growth Difference and Income Disparity: Stylised Facts

1.2.1 A New Data Set of China's National and Provincial Income Account

During the pre-reform period of 1952-77, the Chinese statistical system adopted the System of Material Products Balance (MPS). The making of MPS is tailored to meet the needs of the central planning economy. The main aggregate indicators are Total Output Value of Society (TOVS)[17] and National Income[18]. National income is calculated as value-added and comparable with the main aggregate indicator GDP in the System of National Accounts (SNA), adopted by the market-economy countries[19]. The main difference between GDP and National Income is that the latter do not account for the value-added of the service sector and depreciation of fixed assets.

[16] There are several reasons for the decision to adopt this "discriminatory" policy focusing on two "experimental" provinces. The first reason is related to the relatively small size of the economies of Guangdong and Fujian provinces in 1978. By limiting the trial efforts at liberalisation to these provinces instead of liberalising areas, which were much more developed, such as Shanghai, the Chinese government avoided the possibility of disastrous consequences for the country if the experiment failed. Another reason for this choice was the geographical proximity of these two provinces to the buoyant economies of Hong Kong, Macao and Chinese Taipei, which not only generated positive externalities but also made it possible to prepare China for reunification with Hong Kong, Macao and Chinese Taipei.

[17] TOVS is obtained by summing up the gross output values in five types of material production activities during a certain period of time and suffers from the double-accounting problem. The material production activities refer to: agriculture, industry, construction, transport, communication and commerce.

[18] National Income refers to the newly created value by labour engaging in five types of material production activities during a certain period of time, i.e. the net value calculated by substracting the value of input materials consumed in the process of production from TOVS.

Since the adoption of the comprehensive reform policy in 1978, China's statistical system has also followed the reform wave. Starting from 1985, the SSB of China has received financial aid from both the World Bank and the Asian Development Bank for further developing the national income accounts system, particularly for the estimation of GDP and its components in the SNA and to make up the deficiency of MPS. SNA was completely implemented for the entire economy in 1992.

Because China has adopted these two statistical systems successively during the last decades and data for the aggregate indicators from both two systems were included in the statistical yearbooks from 1985 to 1992, it is no wonder that, in the previous studies on regional growth patterns, different aggregate indicators have been used. Studies that covers both the pre-reform and post reform have used mostly the national income and gross industrial output (e.g. Chan and Fleisher, 1996), since there was no provincial GDP data available for the period before 1992. We benefit from the "Comprehensive Statistical Data and Materials on 50 Years of New China" released in 1999. In this statistical book, nominal provincial GDP and its index are available for most provinces from 1952 to 1998. In the present study, we are able to use consistent real provincial GDP series from 1952 to 2001.

1.2.2 Overview of Provincial and Regional Growth Difference

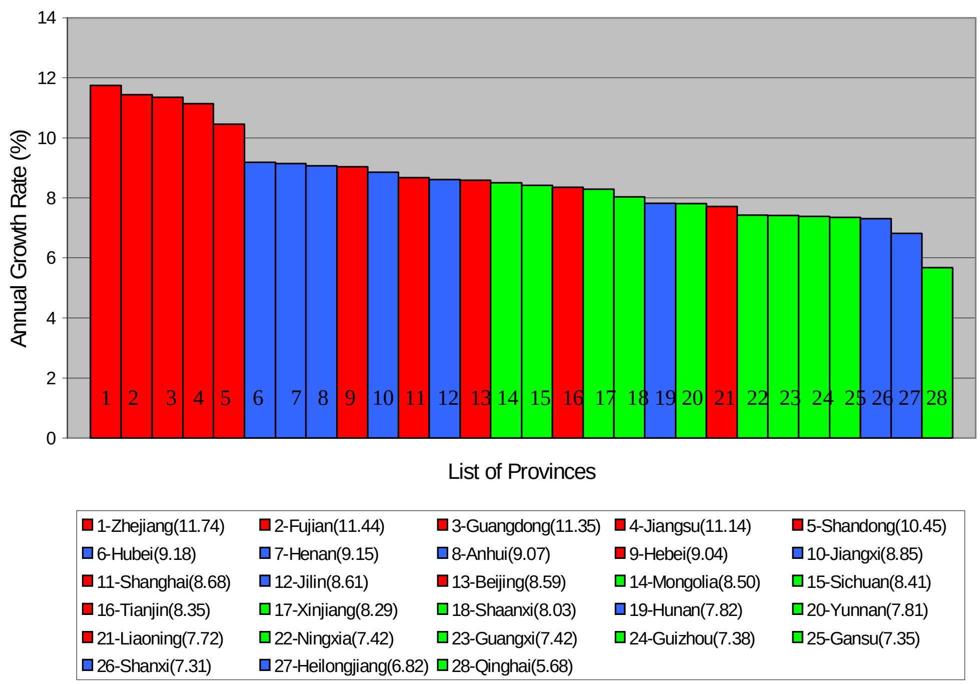
To reveal the geographical distribution of growth performance during the reform period, we compare the rate of economic growth by different provinces and regions in Figure 1.2. To be noticed, throughout this dissertation, we use the real per capita GDP (or, real per capita income) as the main indicator of economic performance. If not mentioned otherwise, the term "growth difference" means the different growth rates of real per capita GDP. And the term "income disparity" means the disparity in levels of real per capita GDP.

In Figure 1.2, provinces are ranked in terms of their annual growth rate of real per capita GDP during the reform period 1978-2001. The provinces in the coastal region are

[19] Another main aggregate indicator in the SNA, Gross National Product (GNP), equals to GDP plus overseas income as labour's compensation and poverty income less payment abroad as labour's compensation and poverty income.

represented by red columns, the provinces in the central region by blue columns and the provinces in the western region by green columns. As displayed in Figure 1.2, the average annual growth rates over the last two decades of the reform period have varied significantly across the provinces and regions.

Figure 1.2: **Provincial Annual Growth Rate of Real Per Capita GDP (1978-2001)**

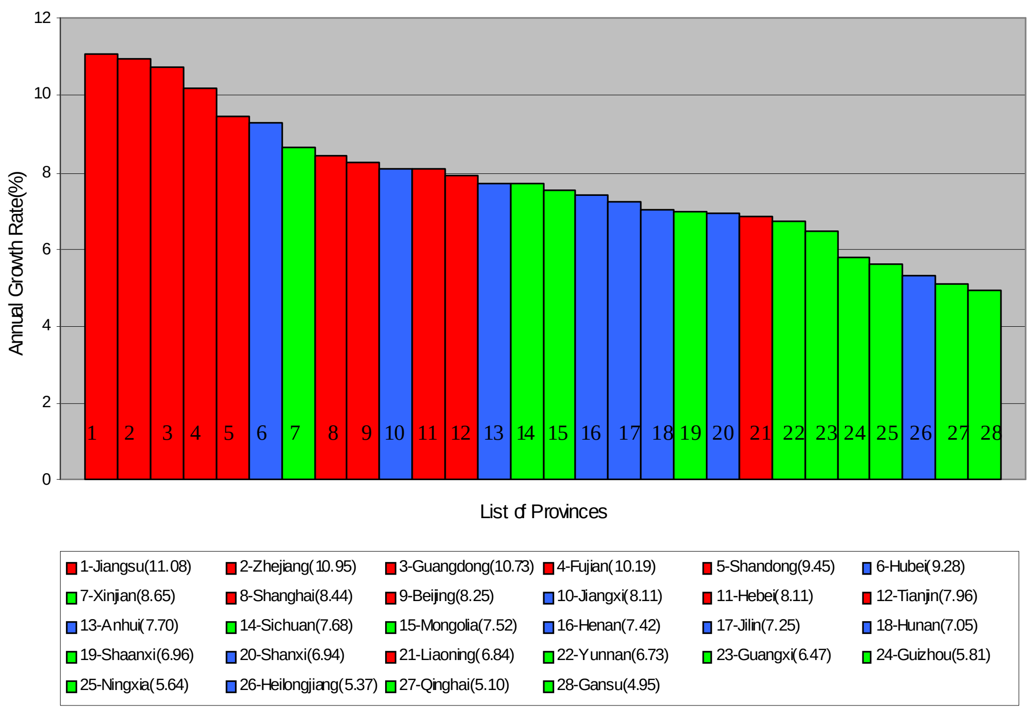


Note: the number in the parenthesis is the annual growth rate (%)
Sources: Comprehensive Statistical Data and Materials on 50 Years of New China, SSB (1999); China Statistical Yearbook (SSB, 2002, 2001, 2000) and author's calculations

Apparently, there is a systematic tendency for coastal provinces to grow faster than the inland provinces. In the coastal region, there are five provinces with double-digit average annual growth rates[20]. However, the slowest growing province, Qinghai located in the west, only grows at an annual average of 5.68 percent. The second slowest-growing province is Heilongjiang, a heavy-industry base in the central region of China, which grows annually at 6.82 percent. Qinghai and Heilongjiang's growth performances sharply contrast to the five coastal provinces.

From simple derivation we know that the growth difference of per capita GDP may result from the growth difference of either the labour productivity or labour participation rate. Therefore it is interesting to compare the provincial growth paths of labour productivity as well. In Figure 1.3, we rank the provinces in terms of their annual growth rate of labour productivity in the same way as in Figure 1.2. It is apparent that, despite some changes of the rankings, the labour productivity of provinces in the coastal region grows faster than that of provinces in the inland region. The difference in growth rate of per capita GDP is consistent with that of labour productivity across provinces.

Figure 1.3: **Provincial Annual Growth Rate of Labor Productivity for the Period 1978-2001**



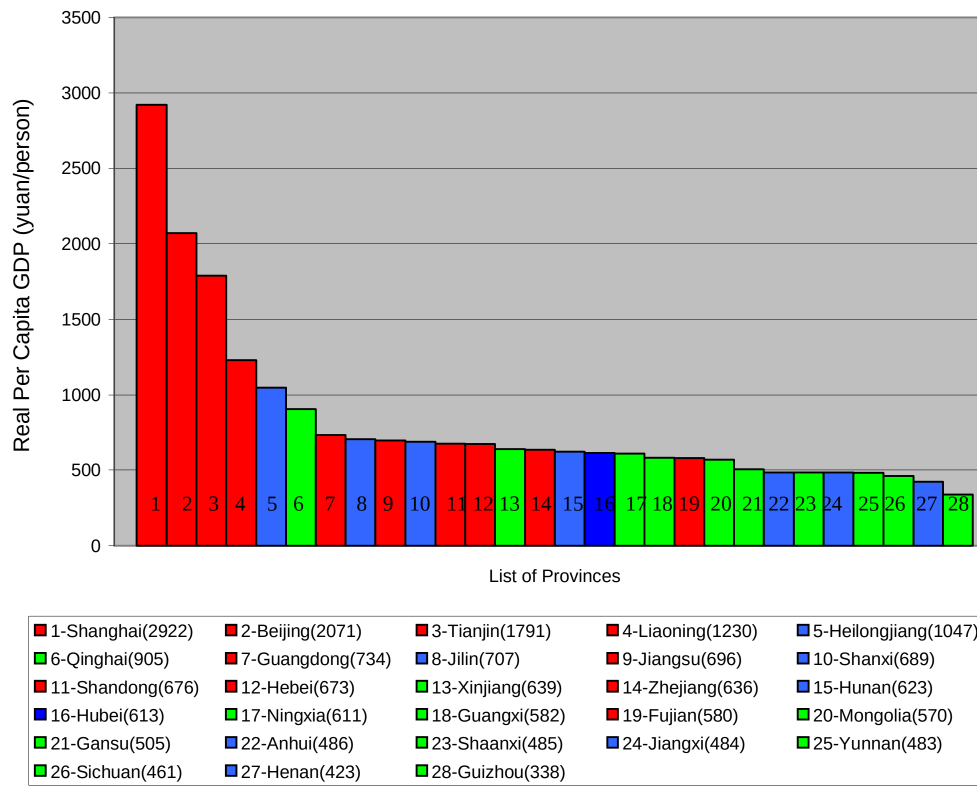
Note: the number in the parenthesis is the annual growth rate (%)
Sources: see Figure 1.2

1.2.3 Overview of Provincial and Regional Income Disparity

The differing provincial growth paths were naturally accompanied by changes of income disparities. In Figure 1.4 and 1.5, the provinces of China are ranked in terms of their real per capita GDP for the year 1978 and 2001, respectively.

[20] They are Zhejiang, Fujian, Guangdong, Jiangsu, and Shandong.

Figure 1.4: **Provincial Per Capita GDP in 1978 (at 1990 constant price)**



Note: the number in the parenthesis is the real per capita GDP in 1978 (yuan/person)
Sources: see Figure 1.2

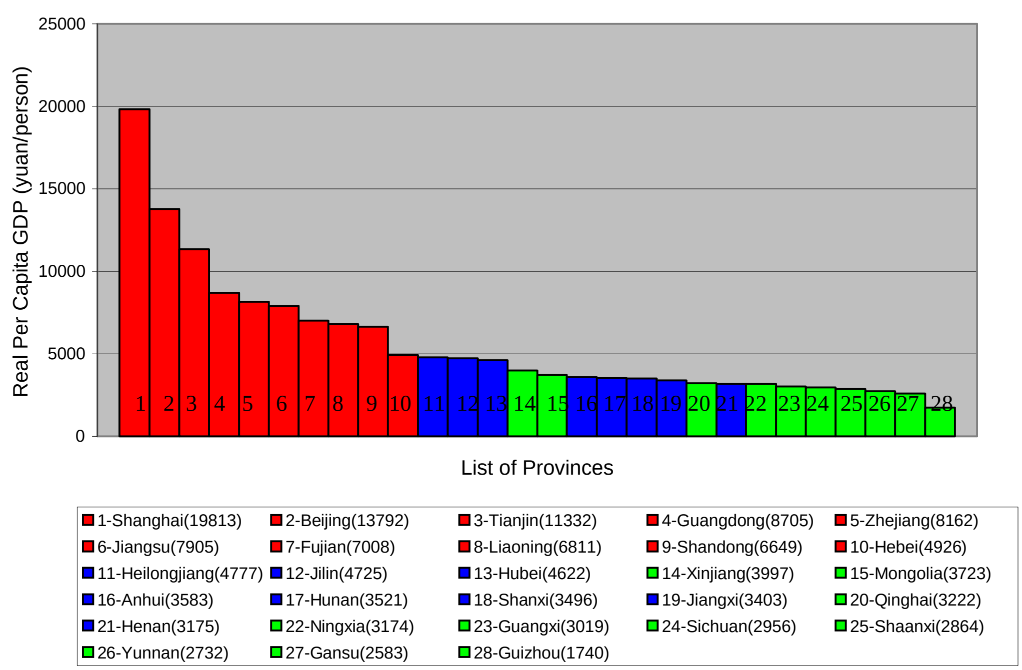
As displayed in Figure 1.4, in 1978, income levels in the three municipalities under the direct control of central government, i.e. Shanghai, Beijing and Tianjin[21], were substantially higher than those in any of the other provinces. While the absolute income gap between the poorest province (Guizhou) and the wealthiest province (Shanghai) involved a ratio of 1 to 9, provincial per capita GDP of other provinces were of comparable size. Excluding the three richest municipalities, the per capita GDP of other provinces were all around the national average, which amounted to 689 yuan/person, regardless of their geographical location. Some provinces in the coastal region had income levels under the national average, such as Shandong, Hebei, Zhejiang, and Fujian, and some provinces in the inland region had income levels above the national average, such as Heilongjiang, Qinghai, Jilin, and Shanxi. Therefore, it can be

[21] Hereafter we refer to these three municipalities under the direct control of the central government simply as three municipalities.

concluded that the income disparity on the onset of economic reform in China was primarily reflected between the three municipalities and other provinces.

The differing growth paths over the reform period had changed this distribution. As presented in Figure 1.5, except for the increased gap of income between Shanghai and Guizhou with a ratio of 1 to 11, the disparities within the set of all the provinces have presented a complex pattern. Firstly, the higher growth rates of other provinces in the coastal region lead their per capita income levels to move closer to the income levels of the three municipalities. The income gap between the richest coastal province (Shanghai in 1978 and 2001) and the poorest coastal province (Fujian in 1978 and Hebei in 2001) has decreased from a factor of 5 in 1978 to a factor 4 in 2001. Secondly, the moderate growth rates of inland provinces lead their income levels to remain still very low. It is worth noting that, in 2001, income levels of all provinces in the coastal region were above the national average, which amounted to 4122 yuan/person, whereas the income levels of all provinces in the west were under the national average. It is reasonable to suppose that the income disparity between coastal region and inland region has widened since the economic reform.

Figure 1.5: **Provincial Real Per Capita GDP in 2001 (at 1990 constant price)**



Note: the number in the parenthesis is the real per capita GDP in 2001 (yuan/person)
Sources: see Figure 1.2

The comparison of levels of provincial labour productivity in 1978 and 2001 reveals the same evolution of regional disparity in labour productivity as that in per capita income. As displayed by figures in Appendix 2 and 3, the disparity in levels of labour productivity between coastal region and inland region has widened during the reform period, whereas the disparity within the coastal region has decreased.

The comparison of levels of income disparity in China and other countries, as represented by the ratio of per capita GDP between the most prosperous region and the least prosperous region in a country in Table 1.4, reveals further the serious situation of regional income inequality in China.

Table 1.4: **Income Disparities between the Richest and the Poorest Regions in China, Some European Countries, the USA and Japan**

Country (1)	Most Prosperous Region (2)	Least Prosperous Region (3)	Ratio (2)/(3) of Per Capita GDP in 2000 (4)
China	Shanghai	Guizhou	11.25
Germany	Hamburg	Dessau	2.83
Poland	Mazowiechie	Lubelskie	2.21
Hungary	Kozep-Magyarorszag	Eszak-Alfold	2.40
Czech Republic	Prague	Stredni Morava	2.69
Slovakia	Bratislava	Vychodne Slovensko	2.76
Italy	Trentino-Alto Adige	Calabria	2.19
Belgium	Brussels	Hainaut	3.07
USA	Connecticut	Mississippi	1.84
Japan	Tokyo	Okinawa	2.05

Note: Only the data of European countries are treated by the Standards of Parity Price.
Sources: China's Statistic Yearbook (2001); Data of European countries are from Lackenbauer (2004); Regional Economic Accounts, Bureau of Economic Analysis, US Department of Commerce; Japan Statistic Yearbook (2001).

1.2.4 Temporal and Regional Decomposition of Income Disparity

For a more thorough understanding of the regional growth pattern during the reform period in China, it is important to examine how the income disparity at national and regional levels has evolved during the last two decades. In addition, it is also important to know the extent to which the overall income disparity in China is attributed to income disparity between the regions and the extent to which it is attributed to the income disparity within the regions. To explore the above questions, we have made a decomposition analysis of income disparity by regions with the help of the family of generalized entropy inequality measures (GE measures) developed by Shorrocks (1980, 1984).

Compared with other inequality indices that are popularly used to examine the income inequality, such as the Gini coefficient and the coefficient of variation, the key advantage of GE measures is that they are additively decomposable. Consider a population of N income units divided in J subgroups with populations N_1, N_2, …, N_J and average incomes $\bar{y}_1$, $\bar{y}_2$, …, $\bar{y}_J$ respectively, the GE measures enable us to decompose the overall income disparity of the total population into a within-group and a between-group component. The between-group component is the income disparity that would remain if all income units of each group had income equal to the group's average. The within-group component is the income disparity that would emerge if average incomes of all groups were equalized, but disparity within each group remained the same.

The decomposition analysis of inequality by population subgroups has been broadly used by various studies that investigate inequality within a country. The population subgroups used in these studies are usually those formed according to certain social and demographic characteristics of the unit of analysis such as the household size or type, the age, occupational status and educational level of the individuals. In the present analysis, China is considered as the total population and the three regions as the population subgroups. The income units consist of 28 provinces. The GE measures can be expressed as:

$$GE_w = \begin{cases} \dfrac{1}{w(w-1)}\left[\dfrac{1}{N}\sum_{i=1}^{N}\left\langle\left(\dfrac{y_i}{\bar{y}}\right)^w - 1\right\rangle\right] if\, w \neq 0,1 \\ \dfrac{1}{N}\sum_{i=1}^{N}\left\langle\dfrac{y_i}{\bar{y}} * \ln\left(\dfrac{y_i}{\bar{y}}\right)\right\rangle if\, w = 1 \\ \dfrac{1}{N}\sum_{i=1}^{N}\ln\left(\dfrac{\bar{y}}{y_i}\right) if\, w = 0 \end{cases} \qquad 1.1$$

Here, y_i is the income level of unit i and $\overline{y}$ is the average income of the total population. Obviously, the GE measures are measures of relative dispersion. When the value of GE measures becomes smaller during a period, that means the income gaps among income units within a population or group become smaller. Or, we can say that the income convergence appears.

For each value of w the GE measures can be additively decomposed as:

$$GE_w = GE_w^W + GE_w^B \qquad 1.2$$

where GE_w^W is the within-group component and GE_w^B is the between-group component. The within-group component can be written as:

$$GE_w^W = \begin{cases} \sum_{j=1}^{J} \left\langle \frac{N_j}{N} * \left(\frac{\overline{y}_j}{\overline{y}} \right)^a * GE_w(j) \right\rangle if\, w \neq 0,1 \\ \sum_{j=1}^{J} \left(\frac{N_j}{N} * \frac{\overline{y}_j}{\overline{y}} * GE_w(j) \right) if\, w = 1 \\ \sum_{j=1}^{J} \left(\frac{N_j}{N} * GE_w(j) \right) if\, w = 0 \end{cases} \qquad 1.3$$

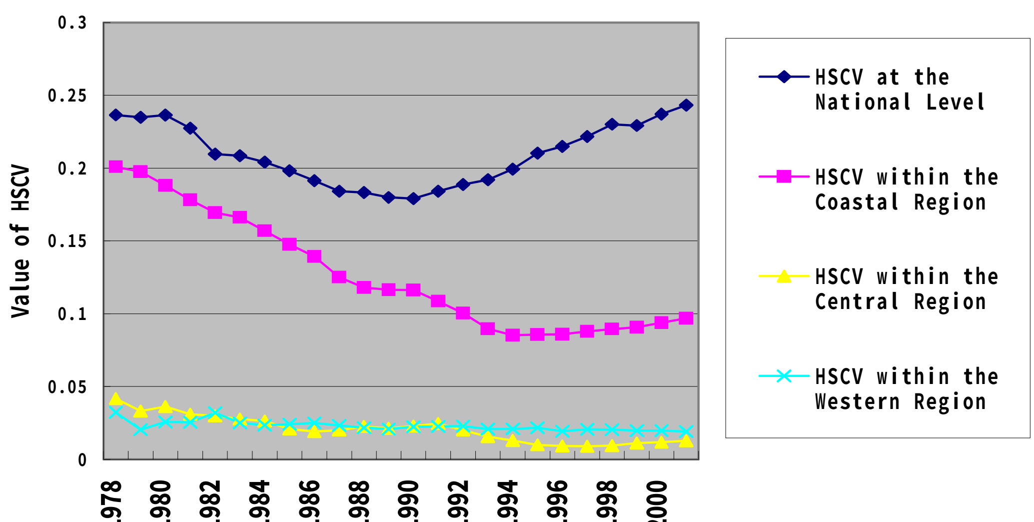
where $GE_w(j)$ is the value of GE inequality measure within the subgroup j. The between-group component can be written as:

$$GE_w^B = \begin{cases} \frac{1}{w(w-1)} \left[\sum_{j=1}^{J} \frac{N_j}{N} * \left\langle \left(\frac{y_j}{\overline{y}} \right)^w - 1 \right\rangle \right] if\, w \neq 0,1 \\ \sum_{j=1}^{J} \frac{N_j}{N} * \frac{y_j}{\overline{y}} * \ln\left(\frac{y_j}{\overline{y}} \right) if\, w = 1 \\ \sum_{j=1}^{J} \frac{N_j}{N} * \ln\left(\frac{\overline{y}}{\overline{y}_j} \right) if\, w = 0 \end{cases} \qquad 1.4$$

For the decomposition analysis of inequality, the following three indices, part of the family of GE measures, are often used in the literature, i.e. GE_2 (Half the Squared Coefficient of Variation, HSCV), GE_1 (Theil's T Index) and GE_0 (Theil's L Index). In the present analysis, we have calculated the values of all these three indices at the national and regional levels and have decomposed the indices at the national level into a within-region component and between-region component. The results of GE_2 will be analysed in details in the rest of this section, while the results of GE_1 and GE_0 can be found in Appendix 4 and 5.

As presented in Figure 1.6, we have calculated the values of HSCV in per capita GDP at the national and regional levels from 1978 to 2001. The change of these values gives us more information about the evolution of income disparity in China during the reform period. In the central and western regions, income disparity has been reduced across provinces but it is not very significant. In the coastal region, the income convergence has appeared evidently and the income disparity across provinces has reduced dramatically. At the national level, income convergence has appeared during the period from 1978 to the end of the 1980s. Since then, however, the income disparity across provinces has increased steadily.

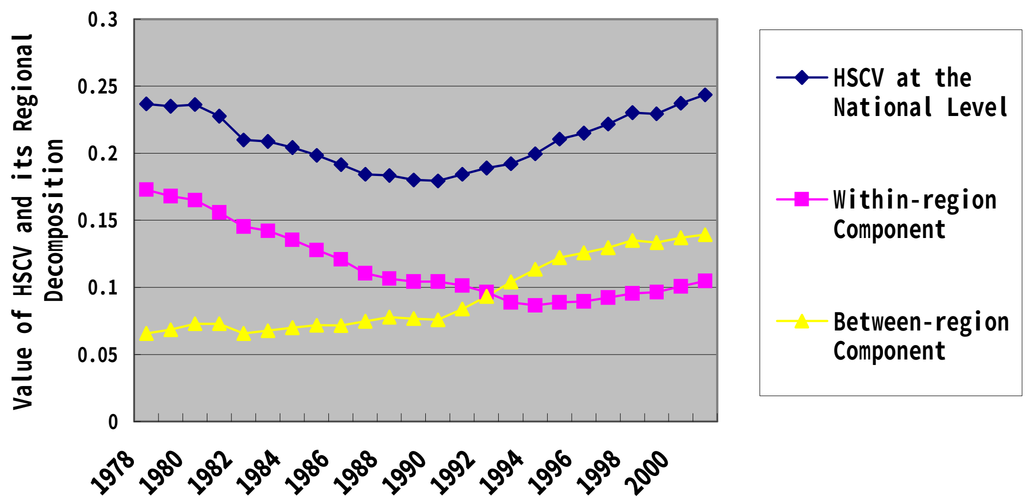
Figure 1.6: HSCV in per capita GDP at the National and Regional Levels during the Reform Period



Note: HSCV is the abbreviation of "Half the Square of Coefficient of Variation"
Sources: see Figure 1.2

To see whether the change of income disparity across provinces in China as a whole during the reform period is driven mainly by the change of income disparity within regions or between regions, we have decomposed the HSCV in per capita GDP at the national level into a within-region component and a between-region component and put them in Figure 1.7.

Figure 1.7: Within-region and Between-region Components of HSCV in per capita GDP at the National Level

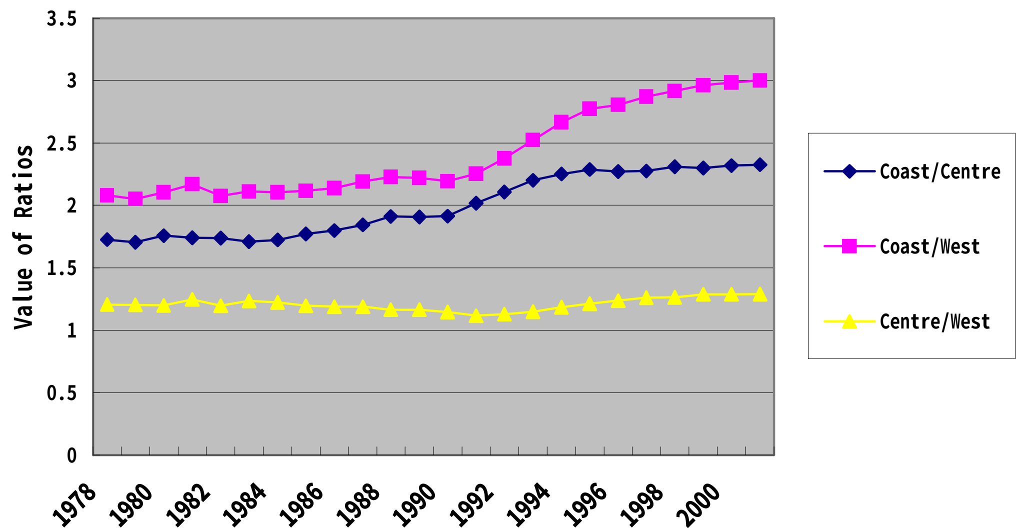


Note and Sources: see Figure 1.6

Obviously, during the reform period, the contribution of income disparity between regions to the overall income disparity in China has increased steadily, while the contribution of the within-region component has decreased. Before the end of the 1980s, the overall income disparity was mainly driven by the within-region component. Since the income disparity within each region, especially within the coastal region, has reduced steadily during this period, the overall income disparity has decreased consequently. In the 1990s, the steady increase of income disparity between regions led to its dominant contribution to the overall income disparity in China. This implies that the increase of overall income disparity in the 1990s was mainly driven by the widening income disparity between regions.

To see whether the increasing contribution of the between-region component to the overall income disparity is driven mainly by the widening income gap between coastal and inland regions, we plot ratios of the population-weighted average of per capita GDP between regions in Figure 1.8.

Figure 1.8: Ratios of per Capita GDP between Regions

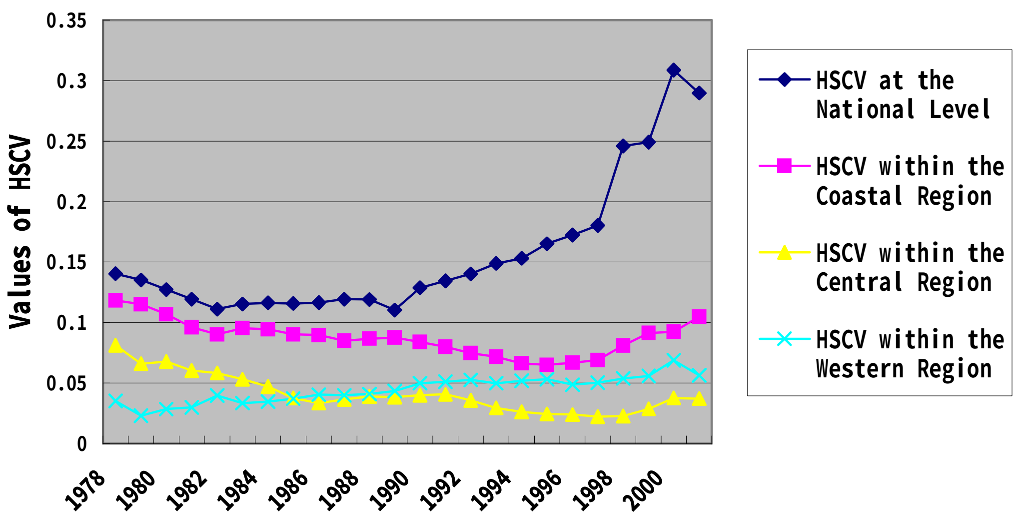


Sources: see Figure 1.2

The ratio of the average per capita income between the central and western regions was relatively stable and close to 1.2, suggesting that the interregional income difference between the central and western regions was small and stayed relatively steady over the reform period. On the other hand, the ratios of the average per capita income between the coastal and other two regions rose steadily during the whole period, showing that interregional inequality between the coastal and inland regions has widened considerably. This implies that the increase of income disparity at the national level in the 1990s was mainly driven by the widening income gap between coastal and inland regions.

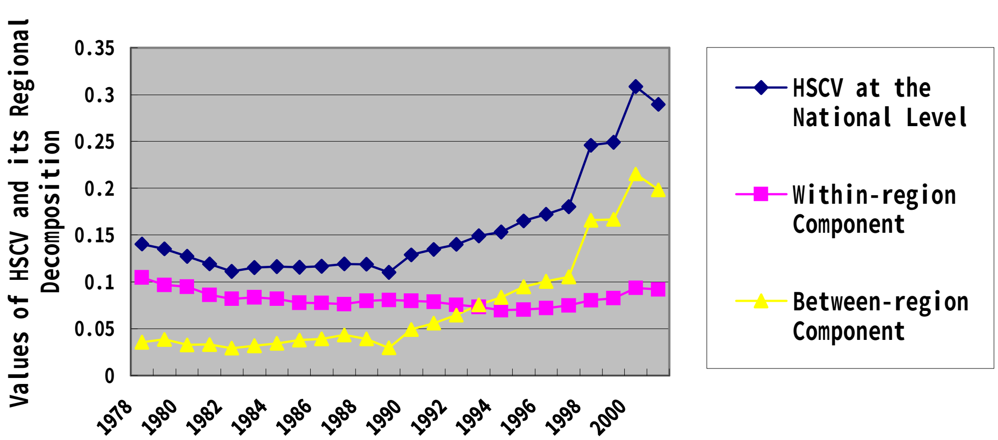
To see whether the disparity in labour productivity between regions has the same temporal evolutions as the disparity in per capita GDP, we calculate the HSCV and its two components as well as the ratios of labour productivity between regions in the same way as we do for the per capita GDP for the period from 1978-2001. As displayed in Figure 1.9, 1.10, and 1.11, regional disparity in labour productivity has the same temporal evolutions as the regional disparity in per capita income. At the national level, the provincial disparity in labour productivity decreased at the beginning of the reform period but has experienced a steady increase since the end of the 80s. The decrease of provincial disparity in labour productivity at the national level was driven mainly by the productivity convergence across provinces within the coastal region. The gap of labour productivity between coastal and inland regions has widened during the entire reform period.

Figure 1.9: HSCV in Labour Productivity at the National and Regional Levels during the Reform Period



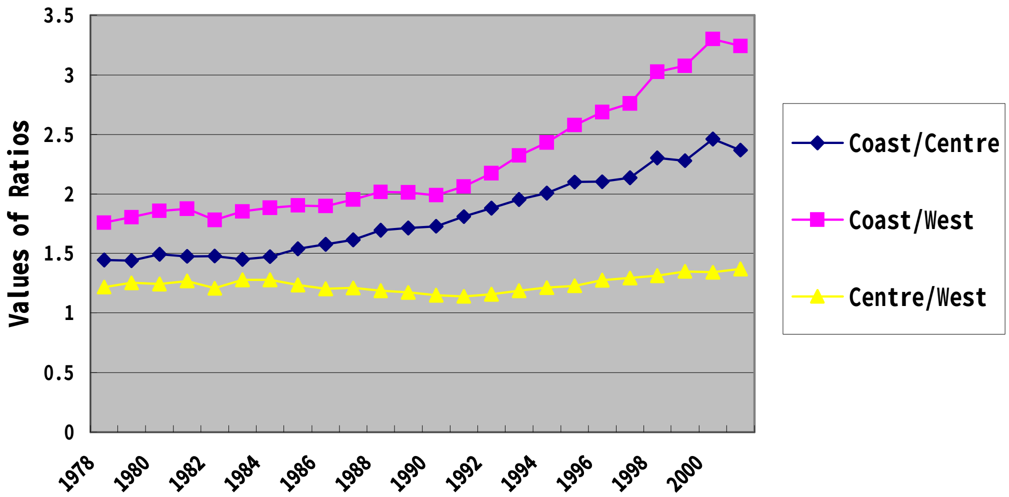
Note and Sources: see Figure 1.6

Figure 1.10: Within-region and Between-region Components of HSCV in Labour Productivity at the National Level



Note and Sources: see Figure 1.6

Figure 1.11: Ratios of Labour Productivity between Regions



Note and Sources: see Figure 1.2

1.2.5 Summary

Based on the stylised facts presented above, we can summarize the regional growth pattern in China during the reform period as follows:

- At the outset of the economic reform, the provincial disparity in per capita income was mainly reflected by the income gap between the three municipalities under direct control of the central government (Beijing, Tianjin, and Shanghai) and other provinces. Aside from the three municipalities, provinces in the coastal region had no superior level of per capita income than the provinces in the inland region.

- The differing provincial growth paths have changed the income distribution. During the reform period, the provinces in the coastal region have experienced continuously higher growth rates of per capita income than the central and western regions, which has enlarged income disparity between the coastal and inland regions. The growth rate of per capita income in five coastal provinces is higher than the three municipalities, which has led to a significant convergence of income within the coastal region.

- The parallel evolution of disparity in per capita income and labour productivity leads us to conclude that the main driving force of the income disparity between regions in China is the disparity in levels of labour productivity instead of different demographical characteristics. Therefore, factors accounting for the different levels of labour productivity between regions are exactly those accounting for the regional income disparity in China.

In order to avoid confusions of expressions in the rest of this dissertation, there are two points to be noticed. Firstly, as we will see in Chapter 2, most theoretical models in growth literature assume a constant participation rate of labour force. Some of them assume even the participation rate of labour force to be unity for modelling convenience. Our stylised facts have justified the empirical sense of such assumptions in the Chinese economic context. Therefore, in the rest of the theoretical and analytical discussions in this dissertation, we treat the terms of "regional income disparity" and "regional disparity in labour productivity" as being interchangeable. If needed, this assumption will be relaxed when doing empirical analysis. Secondly, since the income disparity between regions in China is mainly reflected by the income disparity between the coastal and inland regions, we treat the central and western regions the same as the inland region in the rest of the theoretical and empirical analyses.

1.3 Two Crucial Questions and Previous Studies

The stylised facts presented above show clearly that the coastal region has experienced higher growth rates of labour productivity than the inland region during the reform period, which has enlarged income disparity between these two regions. However, a relationship of income convergence exists within the coastal region significantly.

Two crucial questions arise from the above-mentioned stylised facts:

- The first question is related to the sources of growth difference. Namely, what explains the difference in growth rates across provinces? What are the major factors that drive high economic growth in the coastal region, and what causes the inland region to lag behind?

- The second question is related to the driving forces of income convergence. Namely, why do the poorer inland provinces fail to catch up to the richer coastal provinces while, within the coastal region, provinces with low income levels at the beginning of economic reform have caught up with the three rich municipalities successfully?

These two questions are not equivalent but highly related with each other. Therefore, most studies in growth literature focus on both of these questions. Since we will review the relevant theoretical and empirical literature detailedly in the next two chapters, we sum up only main methodologies and results of previous studies on these two questions in this section.

To ease subsequent discussion, it helps to express per capita GDP by using an aggregate production function with constant returns to scale. Suppose the aggregate production function of economies is given by

$$Y_{(i,t)} = K_{(i,t)}^{a}(A_{(i,t)}L_{(i,t)})^{(1-a)} \text{ or } y_{(i,t)} = k_{(i,t)}^{a}A_{(i,t)}^{(1-a)} \qquad 1.5$$

where $Y_{(i,t)}$ is an economy i's output at time t, $K_{(i,t)}$ is its capital stock at time t, $A_{(i,t)}$ is the level of labour-augmenting technology or Harrod-neutral technology, $L_{(i,t)}$ is labour force; $y_{(i,t)}$ is per capita income, $k_{(i,t)}$ is per capita capital stock and a is the factor weight of capital stock.

Here, terms of "technology" and "technological progress" deserve a further description. "Technology" in equation 1.5 includes not only productive methods but also know-hows and experiences in management and industrial organization. That is, technology includes the innumerable insights on packaging, marketing, distribution, inventory control, payment systems, information systems, transaction processing, quality control, and worker motivation that are all used in the creation of economic value in a modern economy. "Technological progress", as explained in Solow (1956), is used as a short-hand expression for any kind of shift in the production function. Technological progress implies that the potential output obtainable from any inputs of "physical" factors is increased, or that the inputs required to produce any quantity of output are reduced.

1.3.1 Sources of Growth Difference

Theoretical Studies

According to equation 1.5, technological progress and capital deepening are two well-accepted sources of economic growth. Therefore, the difference in growth rates can be attributed to either of these two elements or both intuitively. Based on formal models or literal descriptions, growth theories have focused on formulations of mechanisms of capital accumulation and technological progress with a view to put forward hypotheses about the factors accounting for the different rates of capital accumulation and/or technological progress, hence, different rates of economic growth.

According to their assumptions about properties of technological progress and their theorizing methodologies, growth theories can be roughly divided into three groups:

- neoclassical growth theory, which is represented by the Solow growth model and the augmented Solow growth model;
- new growth theory or endogenous growth theory, including the AK-version growth model, innovation-based growth model, and theory of technological catch-up;
- growth theory of cumulative causation.

The neoclassical growth theory and new growth theory are both characterised with a very specific dynamic model, which can be explicitly solved for equilibrium. Hypotheses embodied in these theories are mostly derived from a formal theoretical model. Another common feature of these theories is their assumption that capital accumulation is driven by the savings behaviour of households. However, the neoclassical growth theory and new growth theory do not share the same hypotheses about the mechanism of technological progress.

In the neoclassic growth models, technological progress is conceived as a “free good” or “manna from heaven”. Each economy has free access to the existing technology. Hence, the difference of growth rates is attributed to different rates of (physical or human) capital accumulation. The new growth theory has attributed growth difference not only to different rates of capital accumulation but also to different rates of technological progress. In the AK-version growth model, technological progress is treated as "learning by doing" or as the externality of investment in physical or human capital, which leads to the constant returns to capital and increasing returns of scale. Therefore, the different rates of growth are attributed to different investment activities in the AK-version model as in the neoclassical models. But these two theories have different hypotheses about the income convergence, as mentioned in the next subsection. The innovation-based growth theory treats the technological progress as a result of intentional activities, i.e. innovation or invention. Hence, the growth differences are attributed not only to different investment activities, but also to different innovative abilities. The theory of technological catch-up argues that the different rates of technological progress across economies should be attributed not only to the different innovative abilities but also to the adoptive abilities of technologies existing in the advanced economies.

The growth theory of cumulative causation differentiates itself from the above-mentioned theories in respect not only to their different hypotheses for growth mechanisms but also to their different theorizing approaches. Based on a diverse body of evidence, the growth theory of cumulative causation, expressed verbally instead of using formal models, generates neither a set of equations to be solved for equilibrium nor sharp quantitative predictions. It is no more than a conceptual framework for thinking about growth.

The main hypothesis of this theory is the assumption of circular and cumulative causation between all factors in the economic system resulting in self-sustaining (or, self-reinforcing) "virtuous cycle" or "vicious cycle" of economic growth. Hence, an initial increase in some variable X induces supporting changes in the vector of variables Z, which promotes further increase in X, and so on. Interpreted in terms of equation 1.5, it can be proposed that the increase in per capita income induces supporting changes in the capital accumulation and technological progress, which promotes a further increase in per capita income. According to this hypothesis, one could say that the foremost reason for the regional great disparity in growth rates is that, long ago, perhaps caused by accident or by initial comparative advantages such as location, minerals or labour, small disparity had arisen in growth rates among regions.

Empirical Studies

Empirical studies on the question of growth difference are aimed to test the above-mentioned hypotheses to data and evidence with a view to identify the relative important factors accounting for growth difference across specific economies during a sample period. The main methodologies of existing empirical studies on this question are:

- growth accounting exercises;
- Barro-style regressions based on neoclassical growth theory;
- regressions based on new growth theory;
- and mixed growth regressions.

The growth accounting exercises tell us that both the different rates of capital accumulation and technological progress are sources of growth difference. The Barro-style regressions argue that the evidence on the international or inter-regional disparity in economic growth is quite consistent with the neoclassic growth models. That means, under the assumption of common technological progress, they find, that different investment rates provide a satisfactory explanation of cross-economic variation in rates of economic growth. Regressions based on the innovation-based growth theory have found that different rates of growth can be attributed to different levels of Research&Development (R&D) expenditure across economies as well. Regressions based on the theory of technological catch-up propose that the initial level of economic development, treated as a proxy for the scope of technological catch-up, has great explanatory power for growth difference. Mixed growth regressions have found empirical linkages between growth rates and a variety of economic policy, political and institutional indicators.

In Chapter 3, we will evaluate these four types of empirical studies in detail. The review of the previous empirical studies suggests to us that important forces underlying economic growth remain unaddressed by the empirical growth literature.

1.3.2 Driving Forces of Income Convergence

Theoretical Studies

The different growth rates across economies can lead to two situations concerning their relative income levels: income convergence or income divergence. Another implication of equation 1.5 is that there are two driving forces of income convergence across economies, namely, capital transfer and technological diffusion from a rich to poor economy.

Theoretical studies on the second crucial question have focused on mechanisms of capital transfer and/or technological diffusion with a view to propose hypotheses about conditions, under which the capital transfer and/or technological diffusion will take place or fail to take place. The neoclassic growth theory hypothesizes that the income convergence comes from capital transfers from the rich to the poor economy because of diminishing returns to capital. That is, because the poor economy always has a low level of capital intensity and hence higher returns to capital, the capital transfers from the rich to poor economy will take place and cause the income convergence. The AK-version growth theory abandons the assumption of decreasing returns of capital and hence predicts income divergence. The innovation-based growth theory predicts systematic divergence of income due to different innovative abilities across economies. The theory of technological catch-up suggests that income convergence may come from technology diffusion from the rich to poor economy.

According to the theory of cumulative causation, there is a tendency inherent in the free play of market forces to create widening regional inequalities. By circular causation and cumulative effects, an economy superior in productivity and income will become more superior, while an economy on an inferior level will tend to be held down at that level or even to deteriorate further as long as matters are left to the free unfolding of market forces. Such a cumulative mechanism resulting in income divergence is explained in terms of tension between the “backwash effects” of capital flow, trade and migration that promote inequality across economies, and the “spread effects” that mitigate it. Most proponents of the theory of cumulative causation argue that the backwash effects tend to dominate the spread effects internationally or interregionally.

Empirical Studies

Empirical studies on the second question are aimed at both identifying the existence of income convergence or divergence across economies and testing hypotheses proposed by different theories concerning the driving forces of income convergence to data and evidence.

Until recently, these tests tended to make regress of the following equation[22]:

$$g_{y_i} = a + b\, y_{i,t_1} + cX_i + u_i \qquad 1.6$$

where $g_{y_i} = \ln y_{i,t_2} - \ln y_{i,t_1}$, denotes the growth rate of real per capita GDP over a time period of length $t_2 - t_1$, and y_{i,t_1} is the initial level of real per capita GDP at t_1, and $i = 1.....N$ denotes the index of income units (regions or countries); X_i is a vector of variables, on which the income convergence is conditional. b and c are coefficients. If the result of the regression without X_i[23] shows that b is significantly negative, then an absolute (unconditional) income convergence is said to appear. If the result of regression including X_i reveals that b is significantly negative, it is said that a conditional income convergence occurs.

Although the questions of which variables should be included in X_i remain controversial, there is a broad consensus in the empirical literature that absolute or unconditional income convergence occurs in a number of regions including US states, Japanese prefectures and European countries. For a broad sample of countries, the absolute convergence fails to occur. But most studies have found the existence of conditional income convergence. However, different studies have given the same result different interpretations. The studies based on the neoclassical growth models hold that income convergence, either unconditional or conditional, comes from diminishing

[22] Equation 1.6 is the econometric specification when cross-sectional data are used. When panel data are used, the equation takes the form: $g_{y_{i,t}} = a_i + b\, y_{i,t_1} + cX_{i,t} + u_{i,t}$

[23] That is, only one variable y_{i,t_1} is on the right hand side of equation 1.6.

returns to capital; while the studies based on the theory of technological catch-up treat the convergence as a result of technological diffusion.

1.4 Motivation of This Dissertation

Increasing income disparity across regions in China during the reform period has posed a serious challenge for China's government. Historical experience elsewhere in the world suggests that few countries have succeeded in maintaining social and political stability under conditions of severe income disparity. China's own history is full of uprisings, rebellions and revolutions sparked by economic injustice.

Policy makers are seriously concerned with the widening inter-regional inequality not only for political and social reasons but also because income inequality may have long-run negative effects of economic growth.

The question of how income inequality affects macro-economic performance, as reflected in rates of economic growth, has been a major concern of social scientists and development economists for more than a century. The theoretical analyses on the macroeconomic consequences of income inequality tend to have offsetting effects and the net effects of inequality on growth in the theoretical literature are ambiguous. The models emphasizing positive effects of inequality argue that inequality could be good for growth because it puts resources into the hands of those with the capacity to accumulate capital, as workers were assumed to have a low propensity to save (Aghion, Caroli, and Garcia-Penalosa, 1999). The migration of labour force from under-developed regions with low levels of wage rate to developed regions makes profits possible to flourish, which provides for the large savings necessary for rapid development. On the other hand, Schueler (2000) argues that, when all regions are equally developed, they can be mutually helpful to each other. If there are regional inequalities, the low levels of income in the backward regions will retard the development of the developed regions due to a lack of adequate demand for their products. Moreover, balanced regional development also avoids transport and supply bottlenecks and minimises inflationary pressures within the economy. Furthermore, it is suggested by some economists that possible social and political upheaval caused by inequality may lead to high levels of uncertainty to investors and therefore restrict growth (Rodriquez, 2000). Most of the empirical studies show a negative effect of income inequality on future economic growth. For example, Persson and Tabellini (1994) and Partridge (1997) showed that income inequality is harmful for economic growth based on a panel data of US states. In the empirical study of Barro (2000), the evidence from a broad panel of countries showed that inequality tends to retard economic growth, especially in developing countries.

Inter-provincial income inequality and its related regional policy are particularly crucial in China because they also bear directly on the sustainability of economic reform and openness policy. The widening income inequality across regions during the reform period tends to bring suspicion of economic reform and open-up policy and hence hamper further implementation of reform measures.

In this context, an analysis on the regional variation in economic development is of high practical importance for the Chinese economy. For this reason, many economists, both within and outside China, have tried to investigate the sources of growth difference and income disparity in China empirically with a view to give policy recommendations to restrain the divergence and speed up convergence within the country.

This research is mainly motivated by the dissatisfaction with previous empirical studies. Chapter 3 will demonstrate that important forces underlying economic growth remain unaddressed by the empirical growth literature. Specifically, most empirical studies, especially those in the Chinese economic context, ignore a long tradition among economic historians and technologists who emphasize the importance of technological progress. They also lag behind much of the new growth theory, which makes a great effort in exploring sources of technological progress. Albeit some empirical studies based on the new growth theory trying to investigate the sources of technological progress, it will also be indicated in Chapter 3 that their regressive functions are to some extent specified incorrectly.

Most importantly, almost all the empirical studies ignore the proposal by the growth theory of cumulative causation that lines of causation do not run only one way. In our view, mutual causation and interdependence through multiple feedback loops are the rule of the economic system and any serious attempts at modelling the economic process must take note of this fact.

It is obvious that there is a discontinuity between theoretical analysis and empirical research on the issue of growth difference and income disparity. This dissertation seeks to close up this gap. A new analytical framework based on the growth theory of cumulative causation will be proposed for the understanding on sources of growth difference and income disparity. The extent to which such a framework is able to explain the regional growth pattern in China will be verified empirically to Chinese statistical data using econometric techniques.

1.5 Outline of This Dissertation

As mentioned above, the purpose of this dissertation is to make an empirical analysis on the sources of regional growth difference and income disparity during the reform period in China within a new analytical framework. For this purpose, we will carry out the following three tasks in the rest of this dissertation:

- to demonstrate that existing empirical studies have not provided satisfying explanations for the regional growth difference and income disparity in China;
- to put forward hypotheses about the factors accounting for growth difference and income disparity based on the growth theory of cumulative causation;
- to test these hypotheses to data and evidence of the Chinese economy;

The outline of this dissertation generally corresponds to these three tasks.

Chapter 2 reviews the existing theoretical analysis on growth difference and income disparity with a focus on laying down the theoretical foundation for subsequent empirical studies.

Chapter 3 makes a critical review about the empirical studies with a view on identifying opportunities for further improvements.

Chapter 4 puts forward hypotheses about the factors accounting for growth difference and income disparity based on the growth theory of cumulative causation. We propose that the different rates of economic growth across economies should be attributed not only to their different rates of factor accumulation, but also to their different rates of technological progress. The investment in physical capital, consisting of domestic investment and FDI, is mainly driven by the profit rate. Technological progress may come from the experience (or, learning-by-doing) represented by the cumulative production of capital goods, intentional innovative activities, and technological adoption from outside economies. Moreover, there are mutual causal relationships between the economic growth and these proposed factors, which have led to the cumulative process in the economic system.

Hypotheses tests are carried out in Chapter 5 and 6. In Chapter 5, with the help of statistical and econometric techniques, the extent to which our new analytical framework is able to explain uneven growth between the coastal and the inland regions is tested empirically. Chapter 6 analyses specially the impacts of economic reform on the uneven geographical distributions of domestic investment, FDI and international trade. The analysis indicates that, as proposed by our analytical framework, state policies have had great impacts on the formation of current regional growth patterns.

Chapter 7 is the concluding chapter of this dissertation. We summarize the main findings of this study and then, provide some policy recommendations based on the empirical analysis for reduction of regional income gaps in China.

Chapter 2 Critical Review of Theoretical Analysis on Growth Difference and Income Disparity

2.1 Introduction

Some countries grow quickly, whereas some countries grow slowly. Even within a country, it is very usual that some regions grow faster than others. In some cases, the different growth rates lead to a reduction of income gaps, that means, the country or region with an initial lower income level grows faster. However, the disparity in growth rates may also lead to the widening of income gaps. As in the case of China, the different regional growth rates lead to the widening of income inequality between coastal and inland regions, whereas the different provincial growth rates within the coastal region lead to income convergence.

Since the unequal development across economies (either among countries or among regions within a country) tends to create economic, political and social tensions that might hold back the long run growth, the issue on growth difference and income inequality across economies has been of serious concern to economists and policy makers for a long time. During the last decades, the issue has been subject to extensive research.

Research on this issue can be roughly divided into two groups, namely theoretical analysis and empirical study. Based on either formal models or literal descriptions, the theoretical analysis on this issue provides us with a conceptual framework for thinking about economic growth. Specifically, the main objective of the theoretical analysis is to propose hypotheses for factors accounting for growth difference and driving forces for income convergence under some assumptions. The main objective of empirical studies on this issue is to examine the validity of assumptions made in growth theory and to test the proposed hypotheses to specific data and evidence with a view to give policy recommendations for a reduction of income gaps across economies.

This chapter is a brief review of current theoretical models to lay down the theoretical foundation for the subsequent discussions on empirical studies[24]. According to their assumptions about mechanism of technological progress and their theorizing methodologies, growth theory can be divided into three groups:

- neoclassical growth theory, which is represented by the Solow growth model and augmented Solow growth model;
- new growth theory or endogenous growth theory, including the AK-version growth model, innovation-based growth model, and theory of technological catch-up[25];
- growth theory of cumulative causation.

Neoclassical and new growth theories are both characterised with a very specific dynamic model, which can be explicitly solved for equilibrium. Hypotheses embodied in these theories are mostly derived from a formal theoretical model. Another common feature of these theories is their assumption that capital accumulation is driven by the savings behaviour of households. However, neoclassical growth and new growth theories do not share the same hypotheses about the mechanism of technological progress.

Growth theory of cumulative causation differentiates itself from the above-mentioned theories in respect not only to their different hypotheses for growth mechanisms but also to their different theorizing approaches. Based on a diverse body of evidence, the growth theory of cumulative causation, expressed verbally instead of using formal models, generates neither a set of equations to be solved for equilibrium nor sharp quantitative predictions. It is no more than a conceptual framework for thinking about growth.

[24] For the review of theoretical models on growth issues, see also, Romer (1994), Grossman and Helpman (1994), Solow (1994), Pack (1994), Barro and Sala-i-Martin (1995), Mankiw (1995), among others.

[25] Traditionally, the AK-version growth model and innovation-based growth model are labelled together as two branches of new growth theory (or, endogenous growth theory) in growth literature. In this dissertation, we classify the theory of technological catch-up in new growth theory as well, since this theory has also tried to endogenize the determinants of technological progress.

In the following sections, we will introduce the basic framework of these theories with an emphasis on their hypotheses about growth difference and income convergence. In addition, their limitations will be highlighted.

2.2 Neoclassical Growth Theory

2.2.1 Solow Growth Model and b -absolute Convergence

Historically, the main objective of the Solow growth model (1956) was to show that once factor substitution was allowed, the economy could achieve stable dynamic equilibrium instead of suffering from inherent instability that characterized previous growth models by Harrod (1939, 1948) and Domar (1946, 1947). But Solow himself had not foreseen that, in a period of 30 years, his model became the basic theoretical framework for analysis on cross-economic growth difference and income disparity in growth literature.

We are all familiar with the Solow growth theory of economic growth; it has been taught almost unrivalled for about three decades. For this reason there is no need for me to dwell upon it in detail. Nevertheless, my discussion of the development of theoretical work on growth difference and income convergence would not be grossly complete without the introduction of assumptions and hypotheses in this model. Therefore, I will present the structure of the Solow growth model in detail, focusing on its assumptions and hypotheses. As will be seen below, the subsequent development of growth theories has, to a large extent, been concerned with the question of whether one or more of the assumptions in the Solow growth model should be relaxed, so as to improve the ability of theoretical models to explain cross-economic regularities of growth and income distribution.

Basic Settings

The Solow growth model is built around two key equations: a production function and a capital accumulation equation. We assume a Cobb-Douglas production function for an economy with output (Y) and three inputs, capital (K), labour (L) and labour-augmenting production technology (A)[26]. Assuming constant returns to scale[27] we can write for continuos time:

$$Y_t = K_t^{a} (A_t L_t)^{1-a} \qquad 2.1$$

where $0 < a < 1$. The intensive form is

$$\tilde{y}_t = f(\tilde{k}_t) = \tilde{k}_t^{a} \qquad 2.2$$

where $\tilde{y}_t = \dfrac{Y_t}{L_t A_t}$ denotes output per effective unit of labour and $\tilde{k}_t = \dfrac{K_t}{L_t A_t}$ denotes capital per effective unit of labour. Capital is subject to diminishing marginal returns such that $f^{'}(\tilde{k}_t) > 0$ and $f^{''}(\tilde{k}_t) < 0$. Labour force and technology grow at the following constant and exogenous rates respectively:

$$L_t = L_0 e^{nt} \qquad 2.3$$

and

$$A_t = A_0 e^{gt} \qquad 2.4$$

where n is the growth rate of the labour force, g is the rate of technological progress, L_0 is the initial state of labour force and A_0 is the initial state of technology. For modelling convenience, we assume the participation rate of labour force to be unity. Therefore, n is also the growth rate of population. We further assume that a constant

26 The other possibilities are $F(AK, L)$, which is known as “capital-augmenting” or “Solow-neutral” production technology, and $AF(K, L)$, which is known as “Hicks-neutral” production technology. With the Cobb-Douglas functional form assumed here, this distinction is less important. A is an index of the level of production technology.

27 The model can get along perfectly well without constant returns to scale. The occasional expression of belief to the contrary is just a misconception. The assumption of constant returns to scale is a considerable simplification, both because it saves a dimension by allowing the whole analysis to be conducted in terms of ratios and because it permits the further simplification that the basic market-form is competitive. …It is perfectly possible to have increasing returns to scale and preserve all the standard neoclassical results. (See Solow, 1994)

fraction of output, s is invested[28] and capital depreciates at rate s . The change of the capital stock over time can be therefore written as:

$$\dot{K}_t = sY_t - s\,K_t \qquad 2.5$$

Equation 2.5 can be transformed into the intensive form:

$$\dot{\tilde{k}}_t = s\tilde{y}_t - \tilde{k}_t(n + g + s\ ) \qquad 2.6$$

Equation 2.6 provides an equation of motion for the capital stock per effective unit of labour and is another key equation of the Solow model. $s\tilde{y}_t$ is the actual amount of investment. $\tilde{k}_t(n + g + s\ )$ is the investment which is necessary to keep the capital stock exactly at the previous level, and, we will refer to it as ***break even investment***.

Properties of Steady State

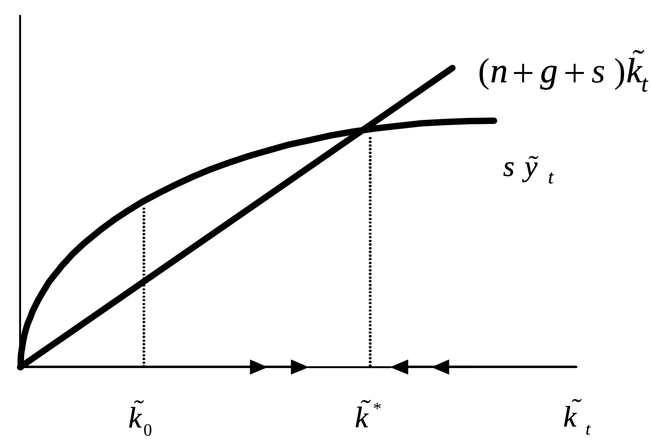
We have derived the two key equations of the Solow model in terms of output per effective unit labour and capital per effective unit labour. Now we are ready to answer fundamental questions about economic growth. For example, an economy starts out with a given capital stock per effective unit of labour, $\tilde{k}_0$, and a given population growth rate, depreciation rate, and investment rate. How then, does output per effective labour evolve over time in this economy – i.e. how does the economy grow?

These equations are most easily analysed in a Solow diagram, as shown in Figure 2.1. The Solow diagram consists of two curves, plotted as functions of $\tilde{k}_t$. The first curve is the amount of investment per effective labour, $s\tilde{y}_t = s\tilde{k}_t^{\,a}$. The second curve is the line

[28] The Solow growth model has treated the saving rate as an exogenous parameter and allows us to abstract from household behaviour in order to highlight the roles of capital accumulation, population growth and productivity increase. Other models have tried to add an explicit analysis of household behaviour to the framework of the Solow growth model, such as the overlapping-generations model by Samuelson (1958) and Diamond (1965) and the representative-consumer model of Cass (1965) and Koopman (1965). Both of these models turn the Solow model into a rigorous general-equilibrium model. But for most of the issues addressed by the Solow growth model, the two alternatives yield similar results. In this thesis, we focus on the Solow growth model.

$\tilde{k}_t(n+g+s)$, which represents the amount of new investment per effective labour required to keep the amount of capital per effective labour constant. By no coincidence is the difference between these two curves the change in the amount of capital per effective labour, $\dot{\tilde{k}}_t$. When this change is positive and the economy increases its capital per effective labour, ***capital deepening*** occurs. When this per effective labour change is zero but the actual capital stock K_t grows, ***capital widening*** occurs.

Figure 2.1: **The Solow Diagram**



Suppose an economy has capital equal to $\tilde{k}_0$, as drawn in Figure 2.1. What happens over time? At $\tilde{k}_0$, the amount of investment per effective labour exceeds the break-even investment, so that capital deepening occurs, that is $\tilde{k}_t$ increases over time. This capital deepening will continue until $\tilde{k}_t = \tilde{k}^*$, at which point $\dot{\tilde{k}}_t = 0$. At this point, the amount of capital per effective labour remains constant, and we call such a point a ***steady state***.

What would happen if instead the economy began with a capital stock per effective labour larger than $\tilde{k}^*$? At points to the right of $\tilde{k}^*$ in Figure 2.1, the amount of investment per effective labour is less than the break-even investment. The term $\dot{\tilde{k}}_t$ is negative, and therefore the amount of capital per effective labour begins to decline in this economy. This decline occurs until the amount of capital per effective labour falls to $\tilde{k}^*$.

The steady state capital stock $\tilde{k}^*$ can be determined by setting equation 2.6 equal to zero:

$$\tilde{k}^* = \left(\frac{s}{n+g+s} \right)^{\frac{1}{1-a}} \qquad 2.7$$

The steady state output per effective unit of labour can be derived by substituting equation 2.7 into production function 2.2

$$\tilde{y}^* = \left(\frac{s}{n+g+s} \right)^{\frac{a}{1-a}} \qquad 2.8$$

To see what this implies about output per labour, we can rewrite equation 2.7 and 2.8. Then, the steady state per labour capital at time t can be expressed as:

$$k_t^* = A_t \left(\frac{s}{n+g+s} \right)^{1/(1-a)} = A_0 e^{gt} \left(\frac{s}{n+g+s} \right)^{1/(1-a)} \qquad 2.9$$

Similarly, steady state per labour output at time t is

$$y_t^* = A_t \left(\frac{s}{n+g+s} \right)^{a/(1-a)} = A_0 e^{gt} \left(\frac{s}{n+g+s} \right)^{a/(1-a)} \qquad 2.10$$

Equation 2.10 means that per labour output, i.e. the income per capita, in the steady state grows at the constant rate g. In other words, the long-run growth rates in the Solow model are determined entirely by the exogenous rate of technological progress.

The steady state level of output per capita depends on vector q , which has the following six elements ($A_0, g, s\ , n, s\ , a$)[29].

The above predictions of the Solow model can be summarized as:

1. In the long run, the economy tends to approach a steady-state that is independent of initial conditions due to the diminishing marginal returns to capital;
2. The steady-state growth rate of income per capita depends only on the rate of technological progress;
3. The steady-state level of income per capita depends on the vector q , which has the following six elements ($A_0, g, s, n, s\ , a$). The higher the rate of saving (i.e. investment), the higher the steady state level of income per capita. The higher the rate of population growth, the lower the steady-state level of income per capita.

Dynamic Adjustment Mechanisms

We have known what economic growth looks like in the steady state in the Solow growth model. The answer is that the steady-state growth rate of income per capita and capital per capita depends on the exogenous rate of technological progress. Now we investigate the income dynamics around the steady state. Suppose an economy begins with a point apart from the steady state, the question is what does capital per capita and income per capita experience along the ***transitional path*** to the steady state?

Consider the key differential equation of the Solow growth model about the motion for the capital stock per effective unit of labour, given in equation 2.6. Dividing both sides of equation 2.6 by $\tilde{k}_t$ provides us with an expression for the growth rate of the capital stock per effective unit of labour, $g_{\tilde{k}}$

$$g_{\tilde{k}} = \frac{\dot{\tilde{k}}_t}{\tilde{k}_t} = \frac{s\tilde{y}_t}{\tilde{k}_t} - \left(n + g + s\ \right) = s\tilde{k}_t^{\,a-1} - \left(n + g + s\ \right) \qquad 2.11$$

[29] In the case of the Cass-Koopmans model, q also has a similar set of elements with s replaced by parameters for the rate of time preference and the inter-temporal elasticity of substitution.

Remember that $\tilde{y}_t$ is equal to $\tilde{k}_t^a$. Therefore, the average product of capital $\frac{\tilde{y}_t}{\tilde{k}_t}$ is equal to $\tilde{k}_t^{a-1}$. In particular, it declines as $\tilde{k}_t$ rises, because of the diminishing returns to capital accumulation in the Solow growth model.

We can analyse this equation in a simple diagram, shown in Figure 2.2. The two curves in the figure plot the two terms on the right-hand side of equation 2.11. Therefore, the difference between the curves is the growth rate of $\tilde{k}_t$. Notice, that the growth rate of $\tilde{y}_t$ is simply proportional to this difference according to equation 2.2. Furthermore, because the growth rate of technology is constant, any changes in the growth rate of $\tilde{k}_t$ and $\tilde{y}_t$ must be due to changes in the growth rates of capital per labour k_t and output per labour y_t.

Figure 2.2: **Transitional Dynamics in the Solow Growth Model**

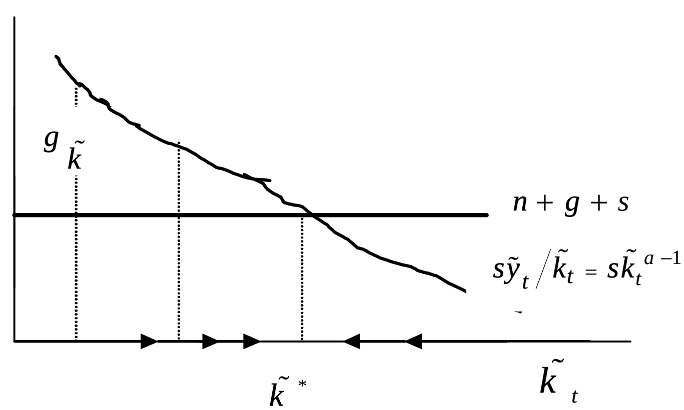


Figure 2.2 clearly demonstrates the fourth prediction of the Solow growth model:

4. The further an economy is below its steady state, the faster the economy should grow. The further an economy is above its steady state, the slower the economy should grow.

The Notion of Convergence: Within-Economy and Across-Economies

The crucial assumption in the Solow model of diminishing marginal returns to capital leads the growth process within an economy to eventually reach the steady state where per capita output, capital stock, and consumption grow at a common constant rate equalling the exogenously given rate of technological progress, no matter whether the economy starts off from a per capita income that is lower or higher than the equilibrium. Moreover, the lower the starting level of per capita income is relative to the long run or steady state position, the faster is the growth rate. Hence, this is indeed a proposition of *convergence* in terms of both growth rate and income level, albeit within an economy.

This within-economy property of the Solow growth model has been reinforced by Solow himself in his exposition (1970) of growth theory. In this exposition, Solow starts out by relating to the six stylised facts about growth that were put forward by Kaldor (1961). Coming to the fifth and sixth of these[30], he pauses and makes the following comments: "the remaining stylised facts are of a different kind, and will concern me less, because they relate more to comparisons between different economies than to the course of events within any one economy".

But the notion of *convergence within an economy* has been transformed to a cross-economic concept by subsequent researchers on growth difference and income disparity across economies. The validity of this transformation is supposed to be based on the "public good" property of "technological progress" in the Solow growth model. To allow for long-run growth in GDP per capita, Solow (1956) defined an exogenous term, labelled "technological progress". In the Solow growth model, technology, or knowledge about how to produce, was interpreted as a "free" good, i.e. something that is accessible for everybody free of charge. The rate of technological progress was assumed to be constant and exogenous. As proposed by Solow (1994), this assumption about technological progress is a short cut to concentrate on the progress of capital accumulation, since the original objective of the Solow growth model is to achieve a stable dynamic equilibrium in the growth progress.

[30] The fifth of these stylised facts was that the growth rate of per capita output varied widely across countries and the sixth, that economics with a high share of profits in income has higher investment-output ratios.

Although Solow did not discuss the implications of such an assumption of the technological progress for a multi-economy world[31], subsequent researchers based on the neoclassical perspective took it for granted that if technology is freely available in, say, the USA, it would also be so at the global level. The following remark by Denison (1967) is typical: “Because knowledge is a free commodity, I should expect the contribution of advances of knowledge…to be of about the same size in all the countries….” Here, the term “knowledge” has the same sense as “technology”. On this assumption, i.e. the common growth rate of technological progress, it is predicted that, in the long run, GDP per capita in all economies will grow at the same, exogenously determined rate of technological progress. If we further assume that all economies have similar preference and institutions, that is, all the six elements (A_0, g, s, n, s, a) in vector q are similar across economies, it can be predicted that in the long run all economies tend to approach the same steady state levels of income.

The only factor left within this framework that can explain differences in per capita growth across economies is “transitional dynamics”: because initial conditions generally differ, economies may grow at different rates in the process towards long run equilibrium. A case can be made then, for poor economies growing faster than the richer ones: economies where capital is scare compared to labour (i.e., where the capital-labour ratio is low) should be expected to have a higher rate of profit on capital, a higher rate of capital accumulation and per capita growth. To the extent that capital is internationally or interregionally mobile, and moves to the economies where the prospects for profits are highest, this tendency should be considerably strengthened. Hence, the gaps in income levels between rich and poor economies should be expected to narrow and ultimately disappear. This type of convergence across economies is known *as b -absolute convergence (or b -unconditional convergence).*

Growth economists, who base their empirical studies on this theoretical framework, hold that, for the industrialized countries or regions within one country, the assumption that their economies have similar technology levels, investment rates, and population growth rates may not be a bad one. As we will see as follows, their empirical studies

[31] Actually, he would not extend this assumption to multi-economy dimension, because in the growth accounting exercise by Solow (1957), he found great international variations in technological progress.

have testified that there exists b -unconditional convergence among the OECD (Organization for Economic Cooperation and Development) countries and regions (prefectures) in the USA, Japan and countries in Europe. But it is supposed by proponents of the theory of technological catch-up that this phenomenon of income convergence may reflect another mechanism, i.e. technology diffusion and catching-up.

Concluding Remarks

From the deviation above within the framework of the Solow growth model, the factor that can explain differences in per capita growth across economies is "transitional dynamics": because initial conditions generally differ, economies may grow at different rates in the process towards long run equilibrium. Economies where capital is scare compared to labour will have a higher rate of capital accumulation and hence higher economic growth because of capital transfer from the rich economy to poor economy. Furthermore, the Solow growth model implies the hypothesis of b -unconditional convergence, that is, the income gap across economies will disappear. The assumptions underlying this hypothesis can be summarized into three aspects:

1. The growth of per capita capital stock is subject to the diminishing returns.
2. All economies can access the existing technical knowledge instantaneously, i.e. a common rate of technological progress. The rate of technological progress is assumed to be exogenous.
3. Besides the same technological levels, the b -unconditional convergence is also based on the assumption of a common steady state income level, which implies that all elements (A_0, g, s, n, s, a) of vector q are similar across economies under consideration during the sample period.

To ease subsequent discussion, it helps to formalize the above-mentioned hypotheses as:

$$g_{y_i} = f\left(y_i, y_i^*\right) \qquad 2.12$$

where g_{y_i} is the growth rate of per labour output or per capita income in the economy i, y_i is the current level of per capita income in the economy i, and y_i^* is the steady-state level of per capita income. In the Solow growth model, the level y_i^* depends on elements ($A_{0,i}$, g_i, s_i, n_i, s_i, a_i) of vector q. Given the steady-sate level of per capita income y_i^*, an increase in current level of per capita income y_i decreases its growth rate because of diminishing returns (i.e. $\left(\partial g_{y_i}\right) / (\partial y_i) < 0$). Given the current level of per capita income y_i, an increase in the eventual equilibrium level of income y_i^*, as a consequence of favourable changes of elements in vector q, will increase the growth rate of output (i.e. $\left(\partial g_{y_i}\right) / (\partial y_i *) > 0$).

Since the elements in vector q are assumed to be the same across economies, the factor accounting for the difference of g_{y_i} across economies is the different levels of initial income y_i. The economy with a lower y_i tends to growth faster and hence the income convergence occurs.

2.2.2 Convergence Controversy since the mid-1980s

Although the issue on growth difference and income convergence has self-contained intellectual interests and the relevant hypotheses were well embodied in the neoclassical growth theory in the 1950s and 1960s, it is surprising that empirical studies on this issue associated with growth theories emerged extensively until the mid-1980s, which has been spurred by the renewed interest in the general topic of economic growth. Actually, the insufficiency of empirical studies on growth issues is exactly the reason why growth theory from the late 1960s onwards went into a state of hibernation.

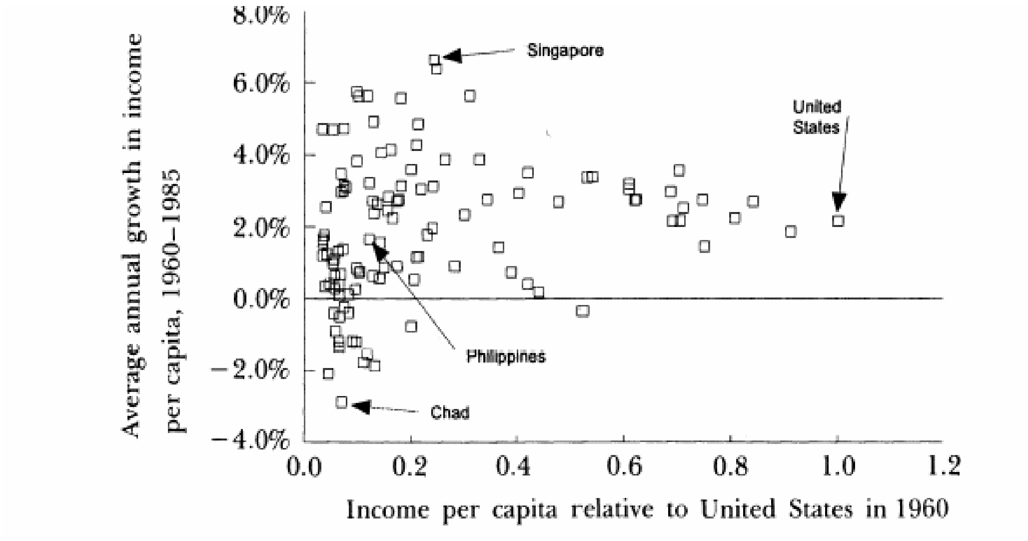
In the mid-1980s, the question whether per capita income in different countries is converging began to once again attract attention in the empirical and theoretical work of economists. A crucial stimulus to work on this question was the creation of new data sets with information on income per capita for many countries and long periods of time (e.g. Maddison, 1982; Summers und Heston, 1988, 1991).

Baumol (1986), alert to the analysis provided by economic historians, was one of the first economists to provide statistical evidence documenting convergence among some countries and the absence of convergence among others. To be noticed, the theoretical foundation of his empirical work is the theory of technological catch-up proposed by economic historians. In his analysis of the Maddison data (1982), Baumol (1986) found that there is a remarkable convergence of labour productivity levels (output per worker) and income levels (GDP per capita) among industrialized nations in the years from 1870 to 1979.

Two objections to his analysis soon became apparent. First, in the Maddison's data set, convergence takes place only in the years since World War II. Between 1870 and 1950, income per capita tended to divergence (Abramovitz, 1986). Second, the Maddison dataset included only those economies that had successfully industrialized by the end of the sample period. This induces a sample selection bias that apparently accounts for most of the evidence in favour of convergence (De Long, 1988).

As a result, attention then shifted to the broad sample of countries in the Heston-Summers data set (1988, 1991). As Figure 2.3 shows, unconditional b -convergence clearly fails in this broad sample of countries. In this figure, income per capita in 1960 is plotted on the horizontal axis. The average annual rate of growth of income per capita from 1960 to 1985 is plotted on the vertical axis. On average, poor countries in this sample grow no faster than the rich countries.

Figure 2.3**: International Growth Difference and Income Disparity (1960-1985)**



Source: Romer (1994)

The failure of cross-country income convergence has led to a dissatisfaction concerns traditional Solow growth model and has motivated new models of growth that drop one or more of the three central assumptions mentioned in the above section, which are respectively:

1 diminishing returns to capital which imply higher marginal productivity of capital in a capital-poor economy;
2 same technology level available in all economies of the world;
3 similar institutions and preferences across economies (including similar investment rates and population growth rates, etc.).

The first wave of new theoretical models has taken the most radical action to abandon both the idea of diminishing returns to capital and the assumption of exogenous technological progress as the final drive for generating economic growth (Romer, 1986; Lucas, 1988; Rebelo, 1991; Barro, 1990). In these models, “capital” is not just the tangible physical capital. Instead, it is interpreted as the whole collection of accumulable factors of production, such as human capital, the stock of knowledge or even the expenditure of government. Since the production function of the models in this class can be written simply as Y=AK, they have also been referred to as the AK-version models[32]. In these models economic growth does not depend on any kind of exogenously specified technological progress[33]. The level of per capita output in different economies does not converge, even if they have the same preference and institutions.

However, the strict theoretical assumption of constant returns to capital by the AK-version models has received criticism from other economists (e.g. Solow, 1994). But the most important reason why the AK-version models soon became old-fashioned is that the augmented Solow model with the assumption of exogenous technological progress and diminishing returns to capital proposed by economists (e.g. Barro and Sala-I-Martin, 1991, 1992; Mankiw, Romer and Weil, 1992, etc.) are theoretically and empirically consistent with the stylised facts of disparity in income levels across countries. These authors argue that the evidence on the international disparity in levels of per capita income and the rates of growth is quite consistent with a standard Solow model, once it has been augmented to include human capital as an accumulable factor and to allow for cross-country differences in investment and population growth rates that may reflect differences in taste or culture.

But until now the second assumption of the (augmented) Solow growth model, i.e. the exogenous technological progress and the same technology level available in all countries and regions of the world still remain and this seems, to some economists, inconsistent with the obvious disparities of production technology across economies and with the mechanism by which real-world growth is sustained. Hence, the intellectual interests shift apart from the first assumption of the Solow growth model and concentrate on modelling the endogenous component of technological progress as an integral part of the theory of economic growth. The models in this class are referred to as the innovation-based growth models and the theory of technological catch-up.

In the following sections, we will review the formation of the above mentioned models successively. Their hypotheses for growth difference and income convergence will be evaluated critically.

[32] Here, K denotes the sufficiently broad definition of capital and A is a constant.
[33] Hence, the models in this class have also been referred to as the first branch of the endogenous growth models.

2.2.3 Augmented Solow Growth Model and b -conditional Convergence

The augmented Solow growth model supposes that total capital stock consists of human capital and physical capital. Remember, there are two key equations in the Solow growth model, i.e. production function and accumulation function of physical capital. In the augmented Solow growth model there are three key equations, i.e. production function which takes human capital as one of production inputs, accumulation function of physical capital and accumulation function of human capital.

Basic Settings of the Model

Generally, there are two types of opinion about how the human capital should be accumulated and set in the production function. The first one is proposed firstly by Mankiw, Romer and Weil (MRW, 1992) and is thought to be less robust than the second one proposed by Lucas (1988)[34] , which has currently been implemented by most economists.

In the model of MRW (1992), the form of production function is:

$$Y_t = K_t^{a} H_t^{a'} (A_t L_t)^{1-a-a'} \qquad 2.13$$

K is the stock of physical capital. H is the stock of human capital, and all other variables are defined as before.

The accumulation function of physical capital is the same as in the Solow growth model, that is:

$$\dot{K}_t = s_k Y_t - s K_t \qquad 2.14$$

[34] Although the second type of human capital accumulation was firstly proposed by Lucas (1988), the model of Lucas (1988) is not an augmented Solow growth model but an AK-version model.

s_k is the fraction of income invested in physical capital. The accumulation function of human capital is:

$$\dot{H}_t = s_h Y_t - s\, H_t \qquad 2.15$$

where s_h is the fraction of income invested in human capital. This form assumes that an economy accumulates human capital in the same way that it accumulates physical capital, i.e. by foregoing consumption.

Instead, Jones (2002) has followed Lucas (1988) and assumed that individuals in the economy accumulate human capital by spending time learning new skills instead of working. Let U denote the fraction of an individual's time spent learning skills, and let L denote the total amount of (raw) labour used in production in the economy[35]. Assume that unskilled labour learning skills for time U generates skilled Labour H according to

$$H_t = e^{yU} L_t \qquad 2.16$$

where y is a positive constant. Notice that if $U = 0$, then $H = L$. By increasing U, a unit of unskilled labour increases the effective units of skilled labour H.

The production function in the model of Jones (2002) takes the form:

$$Y_t = K_t^{a} \left(A_t H_t\right)^{1-a} \qquad 2.17$$

In spite of the different forms of production function and human capital accumulation, the basic predictions of these two types of augmented Solow growth model is the same as in the Solow growth model. Specifically, the steady-state growth rate in both models is the exogenous growth rate of A. The only difference lies in the steady-state income level. In the model of MRW (1992), the steady-state per capita income is:

[35] Notice that if P denotes the total population of the economy, then the total amount of labour input in the economy is given by $L = \left(1 - U\right) P$.

$$y_t^* = A_0 e^{gt} \frac{s_k^{a/(1-a-a')} s_h^{a'/(1-a-a')}}{(n+g+s)^{(a+a')/(1-a-a')}} \qquad 2.18$$

The steady-state per capita income in the model of Jones (2002) is:

$$y_t^* = A_0 e^{gt} \left(\frac{s_k}{n+g+s} \right)^{a/(1-a)} e^{yU} \qquad 2.19$$

Implications for Growth Difference and Income Disparity

Both of the above-mentioned models of augmented Solow type have similar implications for growth difference and income disparity as the Solow growth model. Specifically, the factor accounting for growth difference is left to be "transitional dynamics". That is, the growth rate of an economy depends on the distance of its current income level and its steady state income level. Remember, the steady state income level in the Solow growth model depends on the elements (A_0, g, s, n, s, a) in vector q. In the augmented Solow growth model, there should be new elements in the vector q, i.e. s_h in the model of MRW (1992) and y and U in the model of Jones (2002). In the Solow growth model, a crucial assumption is that all elements in vector q are the same across economies. This assumption has led to the relationship $(\partial g_{y_i}) / (\partial y_i) < 0$. The augmented Solow growth model argues that the investment rates in the physical capital and human capital as well as the population growth rates across economies do not need to be the same. That means different economies may have different steady sate income levels. It can be understood that, in the steady state, the logarithm of income per capita of all economies follows a set up of linear time trends. The slopes of these linear trends are the same and exogenously determined by the rate of technical progress, while the different intercepts reflect the different rates of population growth and the shares of output devoted to investment in physical and human capital. Therefore, the different growth rates across economies should be attributed not only to their different initial income levels y_i but also to their different steady-sate income levels y_i^*.

With respect to the income convergence, the augmented Solow growth model has introduced a new concept of convergence, i.e. b *-conditional Convergence*. That is, each economy converges to its own steady-sate income level because of diminishing returns to capital. However, the income gaps across economies will reach a positive value rather than zero. The form of b -conditional convergence has definitely a weaker inference on income inequality than the b *-absolute convergence*. But economists are still interested in the analysis of this type of convergence since the identification of the country-specific variables (i.e. elements in vector q) accounting for different income levels can still give clues about how to reduce the income gaps across economies.

Limitations of the Augmented Solow Growth Model

Based on the above-mentioned framework, the augmented Solow growth model has provided explanations for the fact that poor economies fail to grow faster than the rich ones as depicted in Figure 2.3, since the growth rate of an economy does not just depend on its initial economic position. By regressing the growth rate to variables including the initial economic position, investment rate in capital and the population growth rate based on cross-section data, empirical studies do find a negative coefficient in front of y_i and plausible magnitude for other variables as well as a model fit much to their liking (an adjusted R square of 0.78 in MRW, 1992, for example). However, there are still reasons leading us to conclude that the augmented Solow model has not provided a satisfactory explanation for cross-economic growth difference and income disparity.

The deficiencies of empirical regressions based on this framework will not be pointed out until Chapter 3. Here we evaluate the augmented Solow growth model along the theoretical line. The dissatisfaction with these neoclassic models is based on the belief that the real value of growth theory should emerge from its attempt to model the endogenous component of technological progress as an integral part of the theory. As stated by Grossman and Helpman (1994), a story of growth that neglects technological progress is both ahistorical and implausible.

Actually, it seems to many economists (Schumpeter, 1934; Solow, 1970; Romer, 1990; etc.) that improvements in technology have been the real force behind perpetually rising standards of living. However, for some reasons, the neoclassic models assume simply that technological progress occurs like “manna from heaven”. We are left with time as the only explanatory variable for the technological progress. Hence, these models are not intellectually satisfactory. As stated by Arrow (1962), it is exactly “a confession of ignorance”.

2.3 New Growth Theory

The dissatisfaction with the neoclassic growth models has motivated the emergence of new growth theories (labelled also as endogenous growth theories), which try to model the technological progress explicitly in their framework.

In a sense, the commonly labelled “new growth theories” are not as new as they may seem. There were some attempts in the 1960s to develop models in which technological progress had been endogenous. Basically, there were three different ideas that were developed in the earlier literature. The first interpreted technological progress as an unintended but positive externality of investment (Arrow, 1962). The second considered technological progress as an output from a separate technology-sector in the economy (Uzawa, 1965; Phelps, 1966; Shell, 1967). The third emphasized the technological adoption as a main driving force for technological progress (Gerschenkron, 1952, 1962). The more recent new growth models in the 1980s follow in these footsteps.

Romer (1986) and Lucas (1988) follow the Arrow’s route and assume that new investments in physical and/or human capital lead to technological progress in the form of “learning by doing”. This is assumed to be external to the firm, so that there are constant returns to scale at the firm level, but increasing returns to scale at the aggregate level. Consequently, the assumption of perfect competition can be retained. Since the production function of the models in this class can be written simply as Y=AK, they have also been referred to as the AK-version models.

Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1992) and others follow in the footsteps of Uzawa and others by assuming that there is a separate technology sector in the economy that supplies the other sectors with new technologies: producers buy the new technology from the technology sector, and in turn they receive an exclusive right to the use of the technology. These producers must charge a price above marginal cost for what they produce, i.e., there is imperfect competition. However, in addition to the private, proprietary component, innovation also has a public component (externality) that facilitates, or raises the productivity of, all subsequent innovation projects. This counteracts the tendency toward decreasing productivity of new investments in innovative activity and allows innovation - and hence growth - to go on.

Abramovitz (1986), Nelson and Wright (1992) and others share the same belief as Geschenkron that the technological diffusion is a main driving force of technological progress, especially for the developing countries. They have further developed this idea and formalized the mechanisms of technological diffusion and its implications for growth performance.

2.3.1 AK-version Models based on Externality

As mentioned above, the emergence of new or endogenous growth models was motivated by two dissatisfactions with the Solow growth model. The first one is that the prediction of income convergence of the Solow growth model is not consistent with the sustained international disparities in income levels. The second is that the economic growth is driven by unexplained technological progress.

But the direction taken at first by the new growth-theoretic models was not toward a direct approach to the economics of technological progress. It was something much simpler: a straightforward abandonment of the idea of diminishing returns to capital. The definition of capital is enlarged to allow for investment in many reproducible factors of production except for plants and equipments, such as, reclamation of land through building dykes, accumulation of human capital through training, build-up of know-how through R&D, spending on infrastructure and other public goods, etc.

Basic Settings of the Model

Suppose the labour force is constant for modelling simplicity, the production function of these models has the form:

$$Y = AK \quad 2.20$$

Notice, A is here a constant including the contribution of labour force rather than the index of technology level in the Solow growth model. This production function has the general feature of the AK-version models, i.e. the constant returns to the broadly-defined capital. If we double the amount of capital, we double the amount of output.

The presence of externalities is essential for the assumption of constant returns to capital in the AK-version models. For example, the work of Romer (1986) relies on the mechanism of externalities proposed by Arrow (1962) but redirected its application to the accumulation of knowledge rather than the accumulation of plant and equipment. In Romer's (1986) model, the stock of knowledge is taken as a part of capital. In an individual firm, the accumulation of knowledge exhibits diminishing returns. But, investment in knowledge suggests a natural externality. The creation of new knowledge by one firm is assumed to have a positive external effect on the production possibilities of other firms because knowledge cannot be perfectly patented or kept secret. The increasing returns of scale are external to an individual firm but internal to the whole economy. Lucas (1988) treated the externality of human capital in a way that is very close technically to the model of Romer (1986) based on the work of Uzawa (1965). In Lucas's model, the capital includes both human and physical capital. The accumulation of human capital subjects to diminishing returns for a person but constant returns for a society (or an economy) because of externality effects. In the model of Barro (1990), the externality effect of the government's expenditure on infrastructure as part of capital has been investigated.

Except for the constant returns to capital, another general feature of these models is that the improvement of productivity is endogenously provided as a side effect of private investment decisions, either investment in stock of knowledge or human capital. Any explicit role for technological change is suppressed in these models.

The accumulation equation of capital in these models is as usual:

$$\dot{K} = sY - s\,K \qquad 2.21$$

This equation together with the production function 2.20 implies:

$$\dot{Y}/Y = \dot{K}/K = sA - s \qquad 2.22$$

As long as $sA > s$, income grows forever, even without the assumption of exogenous technological progress.

Implications for Growth Difference and Income Disparity

From equation 2.22, we can conclude that different growth rates across economies could be attributed to their different investment patterns. Per capita output levels across economies do not have a tendency to converge. This type of model suggests another explanation of why absolute income convergence does not take place as depicted in Figure 2.3: the beneficial external effects of capital accumulation outweigh the detrimental consequences of increasing capital per worker. Hence, the marginal productivity of capital does not decline with increasing GDP per capita. The capital transfer from the rich economy to the poor economy fails to take place naturally. Thus, rich countries stay rich, and poor countries stay poor.

Objections to AK-version Models

The objections to the AK-version models came from three directions. The first one came from the empirical sides. Based on cross-section data sets, empirical economists (MRW, 1992; Barro and Martin, 1991, 1992; etc.) find a negative coefficient for y_i allowing for differences of elements in vector q , which implies the existence of conditional income convergence. This is always interpreted as a verification of the un-robustness of the AK-version models. The last two objections are along just the theoretical lines. One was proposed by Solow (1994) and the other was proposed by the advocators of innovation-based growth theories.

According to Solow (1994), the AK-version models could be described as a return to generalized Domar, although with sophisticated bells and whistles. The assumption of constant returns to capital seems unpromising when we recognized how restrictive this assumption is. There is no tolerance for deviation. Lucas (1988) emphasized in his 1988 article that a touch of diminishing returns to capital (human capital in his case) would change the character of the model drastically, making it incapable of generating permanent growth. He did not notice that a touch of increasing returns to capital do the same, but in a quite different way.

Suppose that the production function is $F(K,L)$, with non-decreasing returns to capital. Treat L as constant for the moment, so we can think of this as just $F(K)$. Let net investment be the fraction s of output so that the time path of K is determined by $dK/dt = sF(K)$. It is obvious that there is potential for fairly explosive behaviour if $F(K)$ increases more and more rapidly with K. For instance, if $F(K)/K$ increases with K, the rate of the growth of K gets faster as K gets larger. Then the time path for this growth model has the property that the stock of capital becomes infinite in finite time. There is a knife-edge character of the constant-returns model. The conclusion has to be made that this version of the endogenous growth model is very un-robust. It cannot survive without exactly constant returns to capital.[36]

According to the opinions of advocates of innovation-based growth theories, the AK-version models suffer from the limitations that they assume that productivity improvements occur serendipitously as a by-product of capital accumulation, while deliberate efforts to develop new products and technologies have been very prominent indeed. It suffices to recall the dramatic developments in consumer electronics, computers and pharmaceuticals in order to see the important role of deliberate research and development in raising our standards of living. In their opinions, most technological progress requires, at least at some stage, an intentional investment of resources by firms or governments. As Romer (1993) has put it,

[36] This view was shared by Fine (2000) as well, as he has put it: “The problem is that, in the absence of what are often special assumptions, endogenizing the growth theory can readily lead to its becoming an explosively fast rate or to its being eroded to the exogenous rate over time. In some respects, this is simply Harrod’s existence problem raised to a higher plane.”

> Our knowledge of economic history, of what production looked like 100 years ago, and of current events convinces us beyond any doubt that discovery, invention, and innovation are of overwhelming importance in economic growth and that the economic goods that come from these activities are different in a fundamental way from ordinary objects. We could produce statistical evidence suggesting that all growth came from capital accumulation with no room for anything. But we would not believe it.

With this belief in mind, Romer, actively involved in both branches of new growth theories, admitted in his 1994 article that: " when I look back on my work on growth, my greatest satisfaction comes from that I have rejected the first round of external effects models that I tried."

2.3.2 Innovation-based Endogenous Growth Model

The above-mentioned dissatisfaction has led to the development of formal models that cast industrial innovation as the engine of growth. With the aid of these innovation-based endogenous growth models, one can examine how variations in economic structures, institutions and policies translate into different rates of technology innovation and productivity gain across economies.

Basic Settings of the Model

The pioneer of the innovation-based endogenous growth model was Romer (1990). Many others have followed his lead (e.g. Grossman and Helpman, 1991; Aghion and Howitt, 1992; Stockey, 1992; Young, 1991; and Jones, 1995; etc.). The innovation-based endogenous growth model has examined the technological progress driven by research and development (R&D) in the advanced countries of the world as a whole. It concerns how the world technological frontier is continually pushed outward. Instead of assuming advancements in technology like "Manna from Heaven" as in the neoclassic growth models, technological progress is understood as an endogenous outcome of the economy. Specifically, technological advance results from purposive R&D activity by profit-maximizing agents (firms or inventors) in the economy, and this activity is rewarded by some form of temporary monopoly rents.

To model the process how profit-maximizing agents endogenize technological progress, many economists divide an economy into three sectors: a final-goods sector, an intermediate-goods sector and a research sector. The research sector creates new technology to improve productivity, which takes the form of new varieties of intermediate goods[37]. The research sector sells the exclusive right to produce a specific intermediate good to an intermediate-goods firm. The intermediate-goods firm, as a monopolist, manufactures intermediate goods using (raw) capital goods and sells them to the final-goods sector, which produces output with labour and intermediate goods.

As was the case with the Solow growth model, there are two main elements in the endogenous growth model: an equation describing the aggregate production function and a set of equations describing how the inputs for the production function evolve over time.

The aggregate final-goods production function[38] describes how the capital stock K, and labour working in the final-good sector, L_Y, combine to produce output, Y, using the stock of technology A:

$$Y = K^a \left(A L_Y \right)^{1-a} \qquad 2.23$$

The key equation that differentiates the innovation-based growth model from other growth models is the equation describing the accumulation of technology:

$$\dot{A} = d\, L_R^e A^f \qquad 2.24$$

[37] The technology can also take the form of better qualities of capital goods, as in the quality-ladder models (e.g. Helpman, 1992). But the main results remain the same.

[38] To be noticed, we just take this production function as given at this point. The market structure and the micro-foundations of the economy that underlie this aggregate production function will not be presented here. The complete system of equations in each sector can be referred to Romer (1990), Helpman (1992) and Jones (1995, 2002).

where $\dot{A}$ is the number of innovations produced at any given point in time. d , e and f are productivity parameters and are assumed to be constant. Specifically, it is assumed that d >0, 0< e <1, and 0< f <1.[39] L_R is the amount of labour working in the research sector.

This equation captures two assumptions. The first assumption is that devoting more human capital to research leads to a higher rate of production of new technologies. The second is that the higher the total stock of designs and knowledge, the higher the productivity of labour working in the research sector.

The other main equations are similar to the equations for the Solow growth model. Capital accumulates as people in the economy forego consumption at some given rate, s_K , and depreciates at the exogenous rate s :

$$\dot{K} = s_K Y - s\,K \qquad 2.25$$

Labour, L , which is the sum of L_Y and L_R , grows exponentially at some constant rate n :

$$L = L_Y + L_R \qquad 2.26$$

and

$$\dot{L}/L = n \qquad 2.27$$

[39] In the model of Romer (1990), f is assumed to be unity. But Jones (1995, 2002) indicated that this assumption is strongly rejected by empirical observations. Under this somewhat arbitrary case, the growth rate of A , which is also the growth rate of per worker output along the balanced path, can be derived to be: $\dot{A}/A = d\,L_R{}^{e}$. That implies that the economic growth will be accelerated when the research effort has been increased. But the average growth rate of the advanced economies has been very constant for the last hundred years, though world research effort has increased enormously at the same time. Therefore, in Jones's model, it is assumed that $0 < f < 1$. Besides, f has to be less than 1 since, if f turns out to be even slightly greater than 1, the equation implies that the stock of technology will go to infinity in finite time.

We assume here that a constant faction of the labour force engages in R&D activities:

$$L_R / L = S_R \tag{2.28}$$

It is argued by Grossman and Helpman (1991) that the allocation of resources to innovation (either the labor force engaged in R&D activities or R&D expenditure) is determined by the appropriability of returns to innovation. The appropriability of returns to innovation depends positively on the size of the market, the productivity of labour in research, and the degree of market power in selling the products resulting from innovation.

Steady-state Properties of the Model

Letting g_x denote the growth rate of some variable x, it is easy to show that

$$g_{y*} = g_{k*} = g_{A*} \tag{2.29}$$

That is, per capita output, the capital-labour ratio and the stock of technology all grow at the same rate along a steady-state growth path. If there is no technological progress in the model, then there is no growth.

Therefore the important question is "what is the rate of technological progress along a steady-state growth path?" The answer to this question is found by rewriting the production function for technology, equation 2.24. Dividing both sides of this equation by A yields:

$$\frac{\dot{A}}{A} = d \, \frac{L_R^{\,e}}{A^{1-f}} \tag{2.30}$$

Along a steady-state growth path, $\dot{A}/A = g_A$ is constant, if and only if the numerator and the denominator of the right-hand side of equation 2.30 grow at the same rate. Taking logs and derivatives of both sides of this equation:

$$0 = e\frac{\dot{L}_R}{L_R} - (1-f)\frac{\dot{A}}{A} \qquad 2.31$$

Along a steady-state growth path, the growth rate of the number of researchers must be equal to the growth rate of the population - if it were higher, the number of the researchers would eventually exceed the population, which is impossible. That is, $\dot{L}_R / L_R = n$. Substituting this into equation 2.31 yields:

$$g_{y*} = g_{k*} = g_{A*} = \frac{en}{1-f} \qquad 2.32$$

Thus the long-run growth rate of this economy is determined by the productivity parameters of the production function for technology and the growth rate of researchers.

The steady state per capita output level is:

$$y^*_t = A_0 e^{g_{A^*} \bullet t} \cdot \left(\frac{s_K}{n + g_{A^*} + s}\right)^{a/(1-a)} \cdot (1 - S_R) \qquad 2.33$$

The first two terms are familiar from the Solow growth model. The last term adjusts for the difference between output per worker, L_Y and output per labour L.

Implications for Growth Difference and Income Disparity

From equation 2.32 and 2.33, we know that, in the innovation-based growth model, different economies have not only different steady state income levels but also different steady state growth rates. The augmented Solow growth model predicts that the logarithm of income per capita of all economies follows a set up of linear time trends. These linear trends have the same slopes and different intercepts. The innovation-based growth model predicts that these linear trends have both different slopes and different intercepts. Since the assumption of diminishing returns to capital has been remained, each economy will still converge to its steady state income level. However, the income gaps across economies need not reach some positive value. Some economists interpret that the innovation-based growth theory predicts a conditional convergence as well. But the convergence is conditional on more elements than the augmented Solow-style models. That is, convergence is conditional not only on factor accumulation, i.e. capital accumulation and population growth, but also on technology accumulation. However, in our opinion, this type of conditional convergence makes no sense. Systematically, it implies income divergence.

With the assumption of diminishing returns to capital, the relationship in the equation 2.12, i.e. $g_{y_i} = f\left(y_i, y_i^*\right)$, still holds. That means, the different growth rates across economies should be attributed to their different initial economic positions and the different values of elements in the vector q, which account for the different steady state income levels across economies. However, several new elements have to be added in the familiar vector q. Now, the vector q has elements $\left(A_0, s_k, n, s, a, e, f, S_R\right)$.

Limitations of Innovation-based Growth Theory

There exist two counterfactual assumptions in the innovation-based growth theory. Firstly, except for the possible capital mobility driven by the returns, each economy (country or region) has been treated as if it were an island unto itself. In reality, countries (or regions) trade with one another, communicate with one another and learn from one another. Hence, it is natural to think about whether the increased exchange of goods and ideas has effects on the host economy. Secondly, in the innovation-based growth theory, the source of technological progress is restricted to innovation or invention. In practice, many countries, especially the developing countries, enhance their technological levels through technological adoption or imitation from other countries. As stated in Barro and Sala-I-Martin (1997), for the reason that imitation is typically cheaper than invention, most countries therefore prefer to copy rather than invent. At this point, technology diffusion is then logically a potential force behind economic growth.

To fully understand the growth difference and income disparity, the growth theory of technological catch-up has relaxed these two assumptions and included the interaction and technological diffusion among economies in its theoretical framework.

2.3.3 Growth Theory of Technological Catch-Up

Alexander Gerschenkron (1952, 1962) is generally acknowledged as the initiator of the theory of technological catch-up, although some of the basic ideas have been expressed earlier by others (see, for instance, Veblen, 1915).

The basic hypothesis of the growth theory of technological catch-up is that the greater the relative disparity in development levels between a country at the outset of a process of industrialization and the already industrialized part of the world, the faster the rate at which the backward country can catch up. Of course, the disparity must not be too wide for the thesis to hold. Stone Age communities suddenly confronted with modern industrial civilization can only disintegrate or produce irrational cultural responses such as a "cargo cult" (Findley, 1978). Where the difference is less than some critical minimum, admittedly difficult to define operationally, the hypothesis does seem attractive and worth consideration.

Economic historians, such as Abramovitz (1986) have proposed that technological differences are the prime cause for differences in GDP per capita across countries and the above-mentioned "catch-up" hypothesis is based on technology diffusion. Here, technological diffusion is understood as the process that less-developed economies, which are backward in the level of technology, adopt advanced technology invented in the advanced economies. Under such circumstances, "backward" countries in technology would tend to grow faster than the technological leaders, in order to close the gap between the two groups. Stated more definitely, the proposition is that in comparisons across countries the growth rates of productivity in any long period tend to be inversely related to the initial levels of productivity. This potential faster growth of the technologically backward country has always been labelled in growth literature as "the advantage of backwardness" (Abramovitz, 1986)[40].

According to Abramovitz (1986), the central idea is simple enough. It has to do with the level of technology embodied in a country's capital stock. Imagine that the level of

[40] To be noticed, the theory of technological catch-up does not ignore the role of capital accumulation. For example, Abramovitz (1986) proposed that the sharing of growth benefits by industrialized countries and developing countries involves the sharing of both technology and investment.

labour productivity was governed entirely by the level of technology embodied in capital stock. In a “leading country”, to state things sharply, one may suppose that the technology embodied in each vintage of its stock was at the very frontier of technology at the time of investment. The technological age of the stock is, so to speak, the same as its chronological age. In an otherwise similar follower whose productivity level is lower, the technological age of the stock is high relative to its chronological age. The stock is obsolete even for its age. When a leader discards old stock and replaces it, the accompanying productivity increase is governed and limited by the advance of knowledge between the time when the old capital was installed and the time it is replaced. Those who are behind, however, have the potential to make a larger leap. New capital can embody the frontier of knowledge, but the capital it replaces is technologically superannuated. So, the larger the technological and, therefore, the productivity gap between leader and follower, the stronger the follower’s potential for growth in productivity; and, other things being equal, the faster one expects the follower’s growth rate to be. Followers tend to catch up faster if they are initially more backward. Viewed in the same simple way, the catch-up process would be self-limiting because as a follower catches up, the possibility of making large leaps by replacing superannuated with best-practice technology becomes smaller and smaller. A follower’s potential for growth weakens as its productivity level converges towards that of the leader.

Besides, backwardness carries an opportunity for modernization in disembodied, as well as in embodied technology. Disembodied technology can be understood as the industrial and commercial organizations, which can be transferred through investment, trade and even “learning by watching”.

However, the inverse correlation between the initial productivity levels and their subsequent productivity growth record does not imply that it does not matter much whether or not a particular country had free markets, a high propensity to invest, or used policy to stimulate growth. Many economists (e.g. Gerschenkron, 1962; Nelson 1981; Nelson and Wright 1992; etc.) propose that growth catch-up or technological diffusion is by no means automatic. The causes of failure to adopt the “best” available technology may arise from: 1. failure to invest in physical capital, in which the technology is embodied; 2. lack of human capital; 3. lack of channels to adopt the best available technology; 4. adverse incentives to make technological progress due to political, commercial, industrial and financial institutions. Therefore, it is implied that the successful technological adoption requires a significant amount of effort and institution building. Kazushi and Rosovsky (1973) coined the term "Social Capability" to designate those factors constituting a country's ability to import or engage in technological progress.

Some economic historians and growth economists have tried to model the mechanism of technology diffusion formally and relate it to growth patterns empirically (e.g. Singer and Reynolds, 1975; Abramovitz, 1986; Maddison, 1982, 1991; Baumol, 1986; and Barro and Sala-I-Martin, 1997; etc.). However, their models have neglected the impact of social capabilities on technological diffusion and economic growth.

For example, Barro and Sala-I-Martin (1997) has constructed a model that combines elements of endogenous growth with convergence implications. The economy analyzed in his model is initially backward in the level of technology due to some historic reasons or shocks. It is further assumed that this economy is far removed from the technological frontier of the advanced economies analyzed in the innovation-based growth model, so that it prefers to copy instead of invent because of the relative low cost of imitation. It has been derived that in the long run, the world growth rate is driven by innovations in the technologically leading economies. Followers grow faster during the transitional path and converge toward the leaders because imitation is cheaper than innovation over some range. As the pool of uncopied innovations diminishes, the cost of imitation tends to increase, and the followers' transitional growth rates tend accordingly to decline. The catch-up process follows the partial adjustment mechanism. With this mechanism, the catch-up dynamics for an economy can be stated as: holding other variables constant, growth rate of technology levels equals the speed of catch-up times percentage gap between the economy's current technology level and its steady state position, i.e. the technology frontier[41].

However, in the model of Barro and Sala-I-Martin (1997), the mechanism of technology diffusion has not been explicitly modeled. That is, the speed of catch-up or the imitation

[41] This partial adjustment mechanism has also been analysed in Nelson and Phelps (1966), Benhabib and Spiegel (1994), Bernard and Jones (1996).

ability of the follower economy has not been explained. Since technology diffusion is by no means automatic so that the analysis on the mechanism of technology diffusion across economies will help to understand the different speed of imitation and the subsequent difference in income levels across economies.

Until recently, based on the framework of innovation-based growth models, Jones (2002) has tried to model the mechanism of technological diffusion and provided some new implications for growth difference and income disparity. His model has considered the impact of social capabilities on technological diffusion. Specially, he has taken the stock of human capital as the proxy for social capabilities. We present here the formal model by Jones (2002) concerning the mechanism of technological adoption and its impacts on economic growth.

Basic Settings of the Model

As in Romer (1990), the economy consists of three sectors: a final-goods sector, an intermediate-goods sector, and a research sector. But the technology level, i.e. the number of available intermediate goods depends on the ability to imitate and adapt rather than innovate in the research sector. Therefore, the technological progress stems exclusively from technological adoption.

Suppose, the final goods sector produces a homogenous output good, Y, using raw Labour, L, and a range of intermediate goods. For simplicity, it is assumed that human capital is used only in the research sector and the raw labour is only used in the final sector. This simplification would not change the implications of the model. The production function takes the usual form:

$$Y = K^{a}\,(AL)^{1-a} \qquad 2.34$$

The accumulation functions of K and L is as usual as well:

$$\dot{K} = sY - s\,K \qquad 2.35$$

and

$$\dot{L}/L = n \tag{2.36}$$

The model differs from the innovation-based growth models in terms of the accumulation of technology. As assumed above, the accumulation of technology is modelled as a function of the stock of human capital, and the gap between the current technology level and the world technology frontier. The function form is as:

$$\frac{\dot{A}}{A} = m \bullet e^{yU} \bullet \left(\frac{T}{A}\right)^{g} \tag{2.37}$$

In this equation, U denotes the amount of time an individual spends accumulating skill instead of working; T denotes the world technology frontier. m is a constant representing the productivity parameter. It is assumed that m, y >0 and $0 < g < 1$.

The technology frontier is assumed to evolve because of investment in research by the advanced economies in the world. The technology frontier expands at a constant rate[42], g:

$$\frac{\dot{T}}{T} = g \tag{2.38}$$

Steady-state Properties of the Model

The steady-state growth rate of the economy is:

$$g_{y*} = g_{k*} = g_{A*} = g_{T*} = g \tag{2.39}$$

The growth rate of the economy is given by the growth rate of technology accumulation and this growth rate is tied down by the growth rate of the world technology frontier.

[42] The growth rate of the technology frontier is exogenous in this model but endogenous in the innovation-based growth model.

Using the fact that $g_{A^*} = g$, it is known from equation 2.37 that

$$\left(\frac{A}{T}\right)^* = \left(\frac{m}{g}e^{yU}\right)^{1/g} \qquad 2.40$$

The steady-state level of per capita income is:

$$y^* = \left(\frac{s}{n+g+s}\right)^{a/1-a} A^* = \left(\frac{s}{n+g+s}\right)^{a/1-a} \left(\frac{m}{g}e^{yU}\right)^{1/g} T^* \qquad 2.41$$

Implications for Growth Difference and Income disparity

According to equation 2.12, $g_{y_i} = f\left(y_i, y_i^*\right)$, the growth rate of an economy depends not only on its initial economic position, y_i, but also on the distance between y_i and y_i^*. According to equation 2.41, in the model of technological catch-up, the different rates of economic growth across economies could be attributed to the different values of elements in the vector (y_i, s_i, n_i, U_i). The different growth rates across economies should be not only attributed to their different initial technological levels (y_i), but also to their different rates of factor accumulation (s_i and n_i) and different levels of social capability (U_i).

Different from the innovation-based growth models, which predict that different economies have different steady state growth rates, the theory of technological catch-up predicts that, in the long run, all economies grow at the rate of technological progress in the leading places. Since all the economies have the same steady state growth rates, growth and income convergence predicted by the theory of technological catch-up has a conditional sense. This type of conditional income convergence is similar with that of the augmented Solow growth model. In the augmented Solow growth model, the different intercepts of those linear development trends depend on different rates of factor accumulation. In the theory of technological catch-up, the different intercepts depend on different social capabilities across economies as well. Therefore, one of the reasons for lack of *b* -unconditional convergence between industrialised and less-developed countries as depicted in Figure 2.3, could be the lack of social capabilities in some less-developed countries, which have prevented their effective adoption of existing technologies and their catch-up with the income levels in the developed countries.

2.3.4 Limitations of New Growth Theory

Virtually all scholars of productivity growth agree on the central role of technological progress. Therefore, compared with the neoclassical growth theory, the new growth theory has made great progress in respect of its treatments of technological progress as an economic process and its efforts to formalise the mechanisms of this process. However, there are still two defects in the framework of this theory.

Firstly, characteristics and determinants of capital accumulation, another driving force of economic growth, remain poorly studied in both the neoclassic and new growth theories. In all of these theories, investment is assumed to be given by saving of households at full employment. One consequence of this assumption is that when a rise occurs in the propensity to save, the theory entails an instantaneous equal increase in the ratio of investment to output, and hence an increase in the rate of capital accumulation. To some economists (e.g. Kaldor, 1960, 1961; Robinson, 1962; etc.), this assumption is quite illegitimate and the investment should not be governed by full-employment saving. Instead, capital accumulation is driven by investment, so that it is investment spending by firms that determines the rate of capital accumulation.

Secondly, both the neoclassic and new growth theories have ignored the fact that lines of causation do not run only one way in an economic system. These theories have drawn conclusions about the growth difference and income convergence after examining the impacts of capital accumulation and technological progress on economic growth. But how will these conclusions change when the feedback effects of economic growth on capital accumulation and technological progress are considered? In our view, mutual causation and interdependence through multiple feedback loops are the rule of an economic system and any serious attempts at modelling the economic progress must take note of this fact.

In contrast with the neoclassic and new growth theories, growth theory of cumulative causation has shown how cumulative causation between all economic factors is fundamental in explaining international and interregional disparities of growth performance. Our empirical investigations on the sources of regional growth difference and income disparity in China will be based mainly on the theory of cumulative causation. Since we will present the principle of cumulative causation and its impacts on economic growth detailedly in Chapter 4, in the next section we just introduce the main hypotheses of this theory for growth difference and income disparity briefly.

2.4 Growth Theory of Cumulative Causation

The concept of cumulative causation as a process in which the subsequent occurrences reinforce the initial conditions was initially developed by Veblen (1915), although it was not until Myrdal (1957) that it was applied to explain the different performance of countries and regions in terms of growth and development. Myrdal (1957) argued that the neoclassic theory with an unrealistic assumption of stable equilibrium can not provide much of an explanation in causal terms of how the facts of economic inequalities have come into existence and why there is tendency for the inequalities to grow. In his view, cumulative causation is a more adequate hypothesis than stable equilibrium for the theoretical analysis of an economic process.

The concept of cumulative causation involves a self-reinforcing circular interaction among economic variables in an economy. Hence, an initial increase in some variable X induces supporting changes in the vector of variable Z, which promotes further increase in X, and so on. For example, interpreted in terms of equation 1.5, it can be proposed that the increase in per capital income induces supporting changes in the capital accumulation and technological progress, which promotes a further increase in per capita income.

The main hypothesis of the growth theory of cumulative causation is the assumption of circular and cumulative causation between all factors in an economic system resulting in self-sustaining (or, self-reinforcing) “virtuous cycle” or “vicious cycle” of economic growth.

Myrdal's *circular and cumulative causation* thesis proposes that the creation of a favoured region may have its origin in a historical accident but there is a natural tendency for all economic activities with higher than average returns and the know how with all the social amenities that go with these to cluster within such a core region with *backwash effects* on unfavoured regions. There may be some centrifugal *spread effects* (along the lines of trickle-down effects) and *counteracting effects* in the situation of a core of economic expansion; but these do not point to the achievement of regional equality, if market forces alone were left to decide the outcome.

Specifically, the *initial comparative advantages* create the initial stimulus for better economic development in a particular location. Then, a process of cumulative causation occurs as *acquired advantages* are developed and reinforce the area's development. The process of cumulative causation can be interpreted such that growth-induced new technologies, improvements in infrastructure, skilled workforce, easy communication, the feeling of growth and elbow room, and the spirit of new enterprises, etc., will fortify and sustain its continuous growth. When spatial interaction increases, the process of cumulative causation will be reinforced as the dominance of backwash effects compared with spread effects and counteracting effects. The *backwash effects* may occur because, when spatial interaction increases, skilled workers, investment and new technologies move to the growing area, the core, while the peripheral areas are inundated by manufactured goods from the core, thus preventing the development of a local manufacturing base there. The *spread effects* may occur because, as the core expands, it may stimulate surrounding areas to develop due to increased consumer demand and technological diffusion. The *counteracting effects* may be caused by an increase in wages and public expenditure and a decrease of technological adoptive capacity after a prolonged period of economic expansion in the favoured region. Which of these effects will actually hold out at the end as the central tendency would depend on their relative strength. Most proponents of the theory of cumulative causation argue that the backwash effects tend to dominate the spread effects and counteracting effects internationally or interregionally.

If the hypothesis of cumulative causation holds, one could say that the foremost reason for the great regional disparity in growth rates is just that long ago, perhaps caused by accident or by initial comparative advantages such as location, minerals or labour, there had arisen small disparity in growth rates among regions.

Additionally, in contrast with the neoclassical growth theory and the theory of technological catch-up, which suggest that regional inequality will disappear, the theory of cumulative causation postulates that regional inequality is an inevitable outcome of capital accumulation and profit maximisation; market forces tend to increase rather than decrease regional inequality.

2.5 Concluding Remarks

Based on hypotheses derived from formal theoretical models, both the neoclassic and new growth theories (except the AK-version growth model) predict that the rate of economic growth in an economy can be expressed by equation 2.12:

$$g_{y_i} = f\left(y_i, y_i^*\right) \qquad 2.12$$

where g_{y_i} is the growth rate of per capita income in the economy i, y_i is the current level of per capita income in the economy, and y_i^* is the steady-state level of per capita income. Given the steady-sate income level y_i^*, an increase in current income y_i decreases its growth rate because of diminishing returns (i.e. $\left(\partial g_{y_i}\right)/\left(\partial y_i\right) < 0$). Given the current income level y_i, an increase in the eventual equilibrium level of output y_i^*, as a consequence of favourable changes of elements in vector q, will increase the growth rate of output (i.e. $\left(\partial g_{y_i}\right)/\left(\partial y_i *\right) > 0$).

In the Solow growth model, y_i^* is assumed to be the same across economies. Therefore the different growth can only be attributed to different y_i. Specifically, the economy with a lower income level (capital scare economy) tends to grow faster than the economy with a higher income level (capital rich economy). In the augmented Solow growth model, y_i^* is allowed to be different across economies. The level of y_i^* depends on the elements of (A_0 , g , s_k , s_h , n , s , a). The different initial economic position combined with different levels of investments in physical capital s_k , human capital s_h , and the different rates of population growth n are sources of growth difference. In the innovation-based growth model, different y_i^* across economies depends not only on different rates of factor accumulation but also on different rates of technological progress. The rate of technological progress depends on the amount of resources devoted to innovation activities and the allocation of resources to innovation is determined by the appropriability of returns to innovation. The theory of technological catch-up argues that the technological progress comes not only from innovation but also imitation. Therefore, the different levels of y_i^* across economies depend also on their different social capabilities that constitute a country's ability to import technological progress.

According to these models, there are essentially two main driving forces behind convergence in per capita income, i.e. diminishing marginal productivity of capital in the neoclassic growth model and the technological diffusion in the theory of technological catch-up. Sala-I-Martin (1996) argued that, among the proposed potential explanations for cross-economy findings of income convergence, these two forces seem to be the ones which survive scrutiny. In contrast, the AK-version models, innovation-based growth models and the growth theory of cumulative causation predict systematically income divergence due to their beliefs in the constant returns of capital, different innovative abilities across economies, and the self-sustaining "virtuous cycle" or "vicious cycle" of economic growth, respectively.

Although both the neoclassic and new growth models have undoubtedly provided us with important insights into the process of economic growth and technical progress, both of them have ignored the fact that lines of causation do not run only one way in an economic system. In our view, mutual causation and interdependence through multiple feedback loops are the rule of an economic system and any serious attempts at modelling the economic system must take note of this fact. Therefore, our empirical studies of factors accounting for regional growth difference and income disparity in China will be carried out within an analytical framework constructed mainly based on the growth theory of cumulative causation. The insightful proposals of new growth theory concerning the mechanisms of technological innovation and adoption will be considered in this framework as well.

Since a precise specification of the mechanism of cumulative causation generating the virtuous/vicious circle appears to be missing, we will formalize the process of cumulative causation and conceptualize relevant variables in Chapter 4 to provide foundations for empirical studies in Chapter 5 and 6. Before we proceed with these tasks, in Chapter 3 we will firstly review and evaluate main methodologies and results of previous empirical studies with a view to demonstrate their deficiencies and identify opportunities for further improvements.

Chapter 3 Evaluation of Previous Empirical Studies

3.1 Introduction

Purely theoretical models cannot deal with the vast majority of questions raised in the fields of economics adequately, since politically feasible answers to these questions require empirical foundations. Can the neoclassical growth model - with decreasing returns to capital, perfect competition, and exogenous technology - fully explain the cross-country variation in levels and growth rates of per capita income? Or, as proposed by the new growth theories, are the different rates of technological progress the main cause of regional growth difference and income disparity? Are the causal relationships between economic growth, capital accumulation and technological progress actually bidirectional as proposed by the growth theory of cumulative causation? Because the policy implications of different theories differ markedly, assessing the empirical relevance of alternative models is an important task.

The objective of empirical studies is to verify the extent to which a theoretical framework is able to explain regional growth patterns in the real world. Specifically, empirical studies compare the hypotheses embodied in the theory with actual data with the help of statistical and econometric techniques.

Actually, the empirical studies play such a crucial role that our understanding of variation in growth rates and income levels will not be complete or even biased without empirical examinations. We can take an example to illustrate the importance of empirical studies. It is well known that the fact that countries appear not to be converging to a common level of per capita income, as depicted in Figure 2.3, has been cited as an objection to the traditional Solow growth model and its assumption of exogenous technology. If we just evaluate it along theoretical lines, then this objection is not compelling, since the predictions of the augmented Solow growth model consists with this regularity very well. The augmented Solow growth model argues that the absolute income convergence is conditional on the different rates of savings and population growth across countries. Actually, the critique on the Solow growth model and its assumption of exogenous technology progress, which helped to motivate the theories of endogenous growth, comes from its empirical inadequacy when the model is brought to the data. We will discuss these inadequacies later in this chapter.

This chapter aims to give an evaluation of the growing empirical literature on regional growth patterns with a view of identifying opportunities for further improvements. This dissertation is exactly motived by the dissatisfaction with the previous empirical studies. Generally, previous empirical studies in growth literature can be divided into four groups according to their methodologies and underlying theoretical frameworks, namely:

- growth accounting exercise;
- Barro-style regressions based on neoclassical growth theory;
- regressions based on new growth theory;
- and mixed growth regressions.

Aside from the third approach, the other three approaches have been used in previous empirical studies on the regional growth difference and income disparity in China.

3.2 Growth Accounting Exercise

From the late 1950s onwards, empirical research on factors affecting long-run growth grew steadily. Similar to the way the post-war work on national accounts decomposed GDP into its constituent parts, the empirical research on growth attempted to decompose growth of GDP (so-called “growth accounting”).

Solow (1957) devised a framework for distinguishing the contributions of labour, capital and technological progress to economic growth. Whilst critics have questioned the validity of the aggregate production function approach (Hicks, 1960), it remains nonetheless a useful conceptual starting point (Shaw, 1992).

3.2.1 Technological Progress and Total Factor Productivity

In growth theories, technological progress is used as a shorthand expression for any kind of shift in the production function. It may be the result of innovative activities or technological imitations. In empirical studies, especially in the growth accounting exercises, it is interpreted as the increase of total factor productivity (TFP).

TFP is a very old and perhaps obsolete concept in economic growth and development. Most authors trace back its origin to Solow's (1957) empirical work. In fact, the concept of TFP, defined as the ratio between real product and real factor inputs, was first introduced by Tinbergen (1942) in an article written in German. Obviously Solow was not aware of Tinbergen's work when he wrote his 1957 article[43].

It is very important to bear in mind that TFP is a "residual", a catch-all sum indicating the part of output growth that cannot be explained by increases in factor inputs. Technological progress is only a part of the residual. For this, there are several big reasons. One is that the measure of factor inputs is incomplete. The whole intangible side of total capital accumulation is neglected. There are also the productivity gains attributable to a better allocation of resources and economies of scale. All these missing elements are unmeasured and difficult to measure but still embedded in this residual. It is clearly not a measure of the advance of applied knowledge alone.

3.2.2 Methodology

Generally speaking, there are two approaches to measuring TFP: the explicit use of an aggregate production function for econometric estimations, and the national income or growth accounting approach which uses discrete data and assumes an aggregate production function implicitly.

The econometric approach begins with the specification of a production function, say, of the Cobb-Douglas constant-returns to scale type:

[43] Tinbergen's paper was not published in English until 1959. Many others had developed the TFP concept and measured TFP before Solow (e.g. Johnson, 1950; Kendrick, 1956; Abramovitz, 1956; Rutton, 1956; etc.). For an interesting historical note, see Griliches (1996).

$$Y_t = A_t K_t^{a} L_t^{1-a} \quad 3.1$$

where Y_t, K_t and L_t are output, capital input and labour input at time t respectively. A_t is the technology parameter governing the shift of the production function. a is the output elasticity of capital and $(1-a)$ that of labour.

A simple starting point is to define A_t in the following way:

$$A_t = A_0 e^{gt} \quad 3.2$$

which means that technology grows at a constant exponential rate of g. Then, we have:

$$Y_t = A_0 e^{gt} K_t^{a} L_t^{1-a} \quad 3.3$$

Taking the logarithm on both sides, we have the following estimation equation:

$$\ln Y_t = \ln A_0 + gt + a \ln K_t + (1-a) \ln L_t \quad 3.4$$

It will be a simple matter to estimate g and the output elasticity if we have time-series data for Y, K and L. Knowing g, we can ascertain the contribution of technological change to the growth of output.

The growth accounting approach of measuring TFP gives more room for decomposition of the contribution of factor inputs and technical change to economic growth. It also makes it possible to study cases where data are available for the beginning and end of a period only. It must however be pointed out that in essence there is no real difference between the Cobb-Douglas production function estimation and the growth accounting approach as far as the underlying methodology is concerned. The growth accounting method is to use the factor shares in national income as weights when combining the individual factor inputs to form an index of total factor input, and to define that part of output growth which can not be explained by increases in factor input as TFP.

Following Solow (1957), let us assume a general neo-classical production function:

$$Y = F(K, L, t) \qquad 3.5$$

Differentiating it with respect to time and rearranging, we have:

$$\frac{dY/dt}{Y} = \frac{(\partial F/\partial K)K}{Y} \bullet \frac{dK/dt}{K} + \frac{(\partial F/\partial L)L}{Y} \bullet \frac{dL/dt}{L} + \frac{(\partial F/\partial t)}{Y} \qquad 3.6$$

$\frac{(\partial F/\partial t)}{Y}$ is the proportional rate of shift of the production function. It is therefore technical change or TFP. Under neo-classical assumptions, $\frac{(\partial F/\partial K)K}{Y}$ and $\frac{(\partial F/\partial L)L}{Y}$ are factor shares of capital and labour respectively. Denoting factor shares of capital and labour in income respectively by S_k and S_l, we can rewrite equation 3.6 as:

$$TFP = \frac{dY/dt}{Y} - S_k \bullet \frac{dK/dt}{K} - S_l \bullet \frac{dL/dt}{L} \qquad 3.7$$

Equation 3.7 can therefore be used to calculate the sources of growth, i.e. the contribution to growth by capital, labour and TFP. It can easily be proved that equation 3.6 is in fact the same as the Cobb-Douglas production function expressed in log-linear form as long as the factor shares remain constant over the period of the study. In other production function forms, the weights S_k and S_l will change over time, that is, different weights must be used in calculating TFP at different moments of time.

We have outlined the basic framework of the growth accounting exercise. Many attempts have been made to improve this methodology in the past. Some attention was diverted to the related studies of quality measurement of capital and labour inputs, which is often labelled as embodiment hypothesis. Some attention was diverted to further decomposition of TFP.

The embodiment hypothesis received significant attention in the earlier literature on productivity studies. Soon after his 1957 seminal paper on TFP, Solow (1959) developed a vintage-capital model to deal with embodied technological change. This was followed by others (Phelps, 1962; Matthews, 1964; Jorgenson, 1966; among others). Studies soon came to a halt because of the many inherent problems in the estimation of the rate of embodied technological change. In most cases, the estimations involved the assumption of some arbitrary values of the parameters. Sometimes, the method of trial and error was used. Moreover, in terms of empirical results, the embodied technological change was usually insignificant. If we follow Nelson's (1964) deviation that embodiment is represented by changes in the average age of capital, we find that in practice, such changes are usually small and so the effect of embodiment can not be of great significance (see also Denison, 1964). Similarly, the embodiment hypothesis can be applied to labour input. Most growth accounting studies have made adjustments to the age-sex composition of the labour force and also the level of education attainment.

Many empirical economists have tried to decompose further the increase of TFP into technological progress and improvements of technological efficiency. Here, improvements of technological efficiency indicate the reduction of the difference between the observed and potential productive ability. Technological progress indicates the advancement of potential productive ability. There are generally two methods to make such decomposition. The first method, labelled often as the "production frontier technique", was first proposed by Farrell (1957) and popularised by Aigner *et al* (1977), Meeusen and Broeck (1977), among others[44]. Isolation of changes in efficiency and technological progress is also embodied in the Malmquist productivity approach.[45]

3.2.3 Previous Studies

The first cross-country study in the growth accounting tradition was by Domar *et al* (1964), which considered the growth of five developed capitalist countries in the 1950s. The residual obtained after deducting for the contribution of capital and labour turned out to be large and varied across countries. The growth rate of these residual in Germany and Japan are higher than those of the U.S., Canada and the U.K. It was also concluded that the growth of the residual, as a rough measure of technological progress,

[44] Comprehensive surveys of efficiency measurement techniques are documented in Fried, Lovell, and Schmidt (1993) and Lovell (1996), for instance.
[45] The name of Malmquist (1953) productivity index was introduced by Caves, Christensen, and Diewert (1982). The approach has become popular largely due to Faere, Grosskopf, Lindgren, and Roos (1992).

and the growth of output were positively and mutually interrelated: rapidly growing countries were apt to enjoy faster technological progress; conversely, technological progress was a major cause of their growth. In this study, it was tries to test the hypothesis that gross investment may be an important vehicle for the introduction of technological progress. And there may be such a mutual relationship that rapid technological progress may call forth large investment. The results indicated that the correlation did not look very impressive.

The first study that combined the growth accounting exercise with the concept of convergence across countries was that of Denison (1967). The 1967 study considered the growth of ten capitalist economies from 1950 to 1963. After deducing the contributions of factor growth, what remains - so called TFP growth - is then further reduced by taking into account structural change in the employment mix and better utilization of economies of scale (through growth of markets and reduced barriers of trade). The final residual is then divided into two parts: technological progress and catch-up, respectively.

Denison (1967) adopted the neoclassic assumption of technology as a public good. The contribution of technological progress is assumed to be the same everywhere, and equal to the "reduced residual" for the U.S. What remains when "technological progress" in this sense is accounted for, is attributed to technological catch-up. From the size of the calculated residuals, Denison inferred that technological catch-up must have been important and the observed convergence in productivity levels could be attributed to technological catch-up, i.e. the positive impact on growth from the "opportunities of backwardness".

Empirical studies on TFP came more or less to a halt after the mid-1970s. It is only since the early 1990s that we have seen a revival of studies on TFP across economies.[46] Many empirical economists have relied on the growth accounting exercise to assess the relative importance of capital accumulation or technology accumulation in explaining the differences in growth rates and income levels either across countries or across regions within a country. The cross-countries studies include Dowrick and Nguyen (1989), Wolff (1991), Collins and Bosworth (1996), Chen (1997), Kohli (1997), Sarel

(1997), Senhadji (1999), Iwata, Khan and Murao (2002), among others.[47] All the studies find that the TFP levels and growth rates are different across countries. Besides, Wolff (1991) finds that catch-up in TFP among the "Group of Seven"[48] was evident between 1870 and 1979. Dowrick and Nguyen (1989) found convergence of TFP among OECD countries.

The growth accounting methods have also been used to examine the sources of growth difference across provinces and regions in China (e.g. Ezaki and Sun, 1999; Wu, 2000; Liu and Yoon, 2000, among others). Great variation in rates of technological progress across provinces in China has been found. Specifically, the coastal region has a higher TFP increase than the inland region. The gap in GDP growth between coastal and inland regions is mainly because TFP growth has accelerated more quickly in the coastal region than in the inland region.

3.2.4 Evaluation

To evaluate the growth accounting exercise, we must understand clearly the meaning of technological progress as it is defined and estimated. The technological progress is disembodied and Hicks-neutral in these exercises. Disembodied technological progress means that it is not embodied in factor inputs but takes place in the form of better methods and organization that improve the efficiency of both new and old factor inputs. Any technical progress embodied in factor inputs is assumed to be properly specified and accounted for in the aggregation of each input. Hicks-neutral technical progress has the effect of increasing the efficiency of both capital and labour to the same extent. On the other hand, Harrod-neutral technical change is labour-augmenting and Solow-neutral technical change capital-augmenting. Therefore, we must interpret TFP with great caution in the context of technical change as a source of economic growth. Even if it is small, the role of technology could have been important because embodied technical change might have been significant. Alternatively, it may be small because the production function is not specified correctly, failing to take into consideration the

[46] The World Bank is largely responsible for this. See World Bank (1993); Nehru (1994), etc.
[47] Felipe (1999) and Easterly and Levine (2001) have provided informative surveys.
[48] They are Canada, France, Germany, Italy, Japan, UK and USA.

alternative forms of neutrality. Conversely, a large TFP may be due to significant effects of economies of scale and resource reallocation.

Furthermore, there are two implicit assumptions in the growth accounting exercise. The first one is that technology progress is completely dissociated from the process of investment and capital accumulation, and vice versa. The second one is that there is only a unidirectional influence of capital accumulation and technological progress on economic growth. Therefore, if these three elements are interdependent, performing growth accounting would be a disputable exercise. Actually, there are many possible sources of interdependence between productivity growth, capital accumulation and technical progress, which will be demonstrated detailedly in Chapter 4.

As a result, from a methodological point of view, we share the view with Kaldor (1957) that it was pointless and artificial to try to distinguish either between investment and technical change, or between shifts in the production function and movements along it. As a theoretical conceptualization and for pedagogical purposes, it is perfectly valid to distinguish between capital accumulation and technological progress. But the contributions from technological progress and factor growth are empirically indistinguishable. In the words of Nelson (1981):

> Consider the sources of a well made cake. It is possible to list a number of inputs—flour, sugar, milk, etc. It is even possible to analyse the effects upon the cake of having a little bit more or less of one ingredient, holding the other ingredients constant. But it makes no sense to try to divide up the credit for a good cake to various inputs.

In addition, even the growth accounting exercise could tell us the relative importance of capital accumulation and technological progress in explaining growth difference, but it has not answered the question on income convergence and divergence. Besides, TFP is not a policy variable. Without exploring the sources of capital accumulation and technological progress and their connections with economic policies, we cannot provide reasonable policy recommendations to speed up both growth and income convergence. However, as stated in Fagerberg (1994), the main contribution of the growth accountants was to show that the neoclassical theory had very little explanatory power for “why growth rates differ” across countries.

3.3 Barro-style Regression

Since the study of Barro and Sala-I-Martin (1991, 1992) and MRW (1992), the regression equation derived formally from the neoclassical growth model, labelled often as Barro-style regression, has occupied the centre stage of empirical research on growth difference and income convergence, and it is virtually impossible to review and evaluate the literature without bringing this equation into picture. Besides, it is also needed to introduce necessary notions.

3.3.1 Derivation of Regression Equation

The exercise involves first the derivation of the law of motion around the steady state and then translation of this motion into an estimable regression equation.

The Law of Motion around the Steady State

We can express equation 2.11 in the Solow growth model in terms of $\ln \tilde{k}_t$ as

$$g_{\tilde{k}} = \frac{d \ln \tilde{k}_t}{dt} = s\tilde{k}_t^{-(1-a)} - (n + g + s) \qquad 3.8$$

Using a first order Taylor Series expansion around the steady state

$$g_{\tilde{k}} \simeq \left(\frac{\partial g_{\tilde{k}}}{\partial \ln \tilde{k}_t} \bigg| \ln \tilde{k}_t = \ln \tilde{k}^* \right) \left(\ln \tilde{k}_t - \ln \tilde{k}^* \right) \qquad 3.9$$

we see that $g_{\tilde{k}}$ is approximately the product of the difference between $\ln \tilde{k}_t$ and $\ln \tilde{k}^*$ and the derivative of $g_{\tilde{k}}$ with respect to $\ln \tilde{k}_t$ at $\ln \tilde{k}_t = \ln \tilde{k}^*$. Differentiating $g_{\tilde{k}}$ with respect to $\ln \tilde{k}_t$ gives

$$\frac{\partial g_{\tilde{k}}}{\partial \ln \tilde{k}_t}\bigg|_{\ln \tilde{k}_t=\ln \tilde{k}^*} = -(1-a)\bullet s \bullet e^{-(1-a)\ln \tilde{k}_t} \qquad 3.10$$

where $s \bullet e^{-(1-a)\ln \tilde{k}_t} = (n+g+s)$ is the steady state condition. The substitution of equation 3.10 into equation 3.9 gives an approximation of $g_{\tilde{k}}$ in the neighbourhood of the steady state. We write this as

$$g_{\tilde{k}} = -l\left(\ln \tilde{k}_t - \ln \tilde{k}^*\right) \qquad 3.11$$

where

$$l = (1-a)(n+g+s) \qquad 3.12$$

Thus, we derive an explicit expression of the speed of convergence. It indicates how rapidly the capital per effective unit of labour approaches its steady state value. The solution to the differential equation 3.11 is

$$\ln \tilde{k}_{t_2} = \left(1-e^{-lt}\right)\ln \tilde{k}^* + e^{-lt}\ln \tilde{k}_{t_1} \qquad 3.13$$

where t_1 denotes the initial period, t_2 the subsequent period, and $t = t_2 - t_1$. Subtracting $\ln \tilde{k}_{t_1}$ from both sides of equation 3.13, equation 3.14 suggests an income dynamic process in the form of a partial adjustment mechanism

$$\ln \tilde{k}_{t_2} - \ln \tilde{k}_{t_1} = \left(1-e^{-lt}\right)\left(\ln \tilde{k}^* - \ln \tilde{k}_{t_1}\right) \qquad 3.14$$

We can verify that the speed of convergence of $\tilde{y}_t$ is the same as for $\tilde{k}_t$

$$g_{\tilde{y}} = \frac{d \ln \tilde{y}_t}{dt} \simeq -l\left(\ln \tilde{y}_t - \ln y^*\right) \qquad 3.15$$

With the differential equation solution to 3.15 given by

$$\ln \tilde{y}_{t_2} = \left(1 - e^{-l\,t}\right) \ln \tilde{y}^{*} + e^{-l\,t} \ln \tilde{y}_{t_1} \qquad 3.16$$

Subtracting $\ln \tilde{y}_{t_1}$ from both sides of equation 3.16, equation 3.17 specifies the partial adjustment mechanism for the income dynamic process

$$\ln \tilde{y}_{t_2} - \ln \tilde{y}_{t_1} = \left(1 - e^{-l\,t}\right)\left(\ln \tilde{y}^{*} - \ln \tilde{y}_{t_1}\right) \qquad 3.17$$

In the standard partial adjustment model, the target value of the dependent variable is determined by the explanatory variables of the current period. In the present case, elements that determine $\tilde{y}^{*}$ are assumed to be constant for the entire intervening time period between t_1 and t_2 and hence represent the values for the current year as well. The target income can be obtained from equation 2.8 as

$$\ln \tilde{y}^{*} = \left(\frac{a}{1-a}\right)\left(\ln s - \ln\left(n + g + s\right)\right) \qquad 3.18$$

Deriving Growth Equation for Econometric Regression

In actual implementation, we have to work with output per capita. Therefore, equation 3.17 has to be reformulated in terms of output per capita. A per capita formulation will enable us to test the model empirically. In order to reformulate equation 3.17 in this way, recall that we can express output per effective unit of labour as

$$\ln \tilde{y}_{t_2} = \ln\left(\frac{Y_{t_2}}{A_{t_2} L_{t_2}}\right) = \ln\left(\frac{Y_{t_2}}{A_{t_1} e^{gt} L_{t_2}}\right) = \ln\left(\frac{Y_{t_2}}{L_{t_2}}\right) - \ln A_{t_1} - gt \qquad 3.19$$

Substituting equation 3.18 and 3.19 into equation 3.17 provides us with an expression for per capita output growth

$$\ln y_{t_2} - \ln y_{t_1} = -\left(1-e^{-l\,t}\right)\ln y_{t_1} + \left(1-e^{-l\,t}\right)\ln A_0 + g\left(t_2 - e^{-l\,t}t_1\right) + \left(1-e^{-l\,t}\right)\frac{a}{1-a}\ln s - \left(1-e^{-l\,t}\right)\frac{a}{1-a}\ln\left(n+g+s\right) \qquad 3.20$$

Note that the above derivation of equation 3.20 is done entirely on the basis of the accumulation process within an economy, and there is no reference to what is happening across economies. This shows that equation 3.20 focuses on the transitional growth dynamics of one country or one region to its steady state income path. It would, therefore, seem natural and proper to estimate the speed of convergence to the steady state in equation 3.20 on the basis of time series data for a particular country.

However, empirical researchers have been, instead, estimating equation 3.20 using cross-section data. The main reason for this is that, from the beginning, the hypothesis of convergence within an economy in the Solow growth model has been transferred to convergence across economies with the assumption of the same steady state growth rates and income levels across economies. And growth researchers are more interested in the question whether poorer countries are narrowing their gap with the richer countries than whether an individual country is closing the gap between its own current and steady state level of income. From this conceptual point of view, cross-section data is the natural place to look for growth difference and income convergence.

3.3.2 Previous Studies

The existing empirical studies based on equation 3.20 can be classified into two methods according to the underlying econometric methodology. The first is the cross-sectional method, used by for example, Barro and Sala-I-Martin (1991, 1992) and MRW (1992). The second is the panel data method, used by for example, Islam (1995), Caselli, Esquivel and Lefort (1996, henceforth CEL), Lee, Pesaran and Smith (1997, 1998, henceforth LPS) and Nerlove (2000).

Cross-Sectional Estimation of the Growth Equation

Some economists, who base their empirical studies on the theoretical framework of the Solow growth model, hold that, for the industrialized countries or regions within one country, the assumption that their economies have similar technology levels, investment rates, and population growth rates may not be a bad one. That means, in their empirical studies, the elements (A_0 , g , s , n , s , a) in vector q are assumed be equal across countries over a sample period. Thus equation 3.20 is rewritten into an econometric equation as:

$$g_{y_i} = a + b\, y_{i,t_1} + u_i \qquad 3.21$$

where $g_{y_i} = \ln y_{i,t_2} - \ln y_{i,t_1}$, denotes the growth rate of real per capita GDP over a time period of length $t_2 - t_1$, and y_{i,t_1} is the initial level of real per capita GDP at t_1, and $i = 1.....N$ denotes the index of income units (regions or countries). $b < 0$ in this equation implies b -unconditional convergence. Here, y_{i,t_1} is interpreted as a proxy of capital-labour ratio. Of particular interest is the intercept term a, which is the sum of six homogenous terms across the economies. Based upon equation 3.20, we can write a as:

$$a = \left(1 - e^{-l\,t}\right) \ln A_0 + g\left(t_2 - e^{-l\,t} t_1\right) + \left(1 - e^{-l\,t}\right) \frac{a}{1-a} \ln s - \left(1 - e^{-l\,t}\right) \frac{a}{1-a} \ln\left(n + g + s\right)$$

The studies by Barro and Sala-I-Martin (1991, 1992, 1995) and Sala-I-Martin (1996) have examined the tendency of income convergence among countries and among regions within a country based on cross-section data. They find that the estimated value of b is significantly negative, which means that b -unconditional convergence occurs in a number of regions including US states, Japanese prefectures and European countries.

For a broad sample of countries, the b -absolute convergence fails to occur. Therefore, some studies relax the assumption of the same steady state income levels across economies and allow for differences of the elements in vector q . Based on the Solow augmented model, the accumulation of human capital is also considered. equation 3.20 is then rewritten as

$$g_{y_i} = a + b\, y_{i,t_1} + cX_i + u_i \qquad 3.22$$

where X_i is a vector of $\ln s_i$ and $\ln\left(n_i + g + s\right)$, c is a vector of coefficients of X_i. Here, s_i includes investments on both physical and human capital. Intercept a may now be written as $a = \left(1 - e^{-l\,t}\right)\ln A_0 + g\left(t_2 - e^{-l\,t}\, t_1\right)$. However, given that identification of parameters is based solely upon cross-sectional evidence, the homogeneity of $\ln A_0$ and g in a is enforced.

The inclusion of the vector X_i in the regression equation makes a major difference in the results across the broad cross section of countries. As in MRW (1992), for example, using the percentage of the working age population in secondary schools as a proxy for human capital, the study, based on equation 3.22, finds that, when these additional variables are held constant, the relation between the growth rate of per capita GDP and the log of initial real per capita GDP becomes significantly negative, as predicted by the neoclassical models. Other variables also have coefficients of plausible magnitude and the model has a satisfactory degree of fitness (an adjusted R-Square of 0.78). It is then concluded that the augmented Solow model provides a satisfactory explanation for cross-economic variation in growth rates and income levels.

Panel Estimation of the Growth Equation

However, Islam (1995) and CEL (1996) question the validity of this finding. The essence of their arguments is that studies such as Barro and MRW are based on the assumption that the initial state of technology A_0 is homogenous across countries. Such an assumption implies that the aggregate production function is parametrically identical across countries. This kind of strict homogeneity of production function is not realistic, Therefore, some empirical economists, such as Islam (1995) and CEL (1996), switch to the panel framework with multiple observations per cross-sectional unit. Their estimations are based on the equation

$$g_{y_{i,t}} = a_i + b\, y_{i,t_1} + cX_{i,t} + u_{i,t} \qquad 3.23$$

The panel estimations control the unobservable and unmeasurable part of A_0 in the form of individual country effects a_i.

Many empirical studies aimed at finding the sources of regional growth difference and income disparity in China are based on equation 3.23 (e.g. Chen and Fleisher, 1996; Gundlach, 1997; Yao and Weeks, 2003; among others). Using the augmented Solow growth model with panel data, these studies find evidence of conditional convergence of per capita GDP across China's provinces. Convergence is conditional on capital accumulation (both physical and human capital) and employment growth.

3.3.3 Evaluation

Most of the empirical studies based on the Barro-style regression are variations of a common theme: a cross-section regression of labour productivity growth against initial GDP per capita, the growth of the labour force, the investment ratio and/or some proxy for human capital. In particular, these studies have assumed a homogenous production technology across economies. Although some authors have used the panel data method to eliminate unobserved country-specific initial technology effects, the method also assumes a homogenous growth rate of technological progress. But none of these studies have bothered to examine the robustness of this crucial assumption.

The assumption of a common rate of technological progress in all 98 countries over a 25-year period, as in the study of MRW (1992) is simply indefensible. From an econometric perspective, if technological progress varies by country but is treated as part of the unobserved error term, then ordinary least squares estimates of equation 3.22 and 3.23 will be biased.

The assumption of a common rate of technological progress across economies came from the assumption of the Solow growth theory. As we have put in Chapter 2, the initial objective of the Solow growth model was to examine the mechanism of economic growth within an economy. Therefore the assumption of an exogenous rate technological progress would not affect the final propositions. Actually, all theory depends on assumptions that are not quite true. That is what makes it a theory. The art of successfully theorizing is to make the inevitable simplifying assumptions in such a way that the final results are not sensitive. A "crucial" assumption is one on which the conclusion depends sensitively, and it is important that crucial assumption be reasonably realistic. When the results of a theory seem to flow specifically from a special crucial assumption, and if the assumption is dubious, then the results are suspect.

We argue that something like this is true of the neo-classical explanation for growth difference and income disparity across economies. The crucial assumption is the same level of technology and the conclusion is that when different economies have similar growth rates of capital stock and labour force, their income tends to converge.

There are two ways to show why we cannot assume the same technological levels and growth rates across economies. The first method is to do the growth accounting exercise, which has been introduced in Section 3.2. The second is to use the method of Romer (1994), Lucas (1990), and King and Rebelo (1993) in order to derive the counterfactual saving rate differences across countries. Consider a very simple version of the neoclassical model and let output take the simple Cobb-Douglas form[49]:

$$Y = AK^{a} L^{1-a} \qquad 3.24$$

In this expression, Y denotes net national product, K denotes the stock of capital, L denotes the stock of labour, and A denotes the level of technology, which is a function of time signalling the standard assumption in neoclassical or exogenous growth models: the technology improves for reasons that are outside the model. Assume that a constant fraction of net output, s, is saved by consumers each year. Because the model assumes a closed economy, s is also the ratio of net investment to net national product. Because

[49] See, Romer (1994).

we are working with net (rather than gross) national product and investment, sY is the rate of growth of the capital stock. Let $y = Y/L$ denote output per worker and let $k = K/L$ denote capital per worker. Let n denote the growth rate of the labour force. Finally, let g_x denote the exponential growth rate of variable x. Then the behaviour of the economy can be summarized by the following equation:

$$
\begin{aligned}
g_y &= a\,g_k + g_A \\
&= a\left[sA^{1/a}y^{(a-1)/a} - n\right] + g_A
\end{aligned}
\qquad 3.25
$$

The first line in this equation follows by dividing total output by the stock of labour and then calculating the rates of growth. The second line follows by substituting in an expression for the growth rate of capital stock per worker as a function of the investment rate s, the growth rate of the labour force n, the level of the technology A, and the level of output per worker, y.

Outside of the steady state, the second line of the equation shows how variation in the investment rates and in the levels of output per worker should translate into variation in the rates of growth. The key parameter is the exponent a on capital in the Cobb-Douglas expression for output. Under the neoclassical assumption that the economy is characterized by perfect competition, 1-a is equal to the share of total income that is paid as compensation to labour, a number that can be calculated directly from national income accounts.

Pick a country like the Philippines that had output per worker in 1960 that was equal to about 10 percent of output in the United States. As depicted in Figure 2.3, the United States and the Philippines had similar growth rates during the period from 1960 and 1985. We can now perform the following calculation. In the sample as a whole, a reasonable benchmark for $1-a$ is 0.6. This means that in the second line of the equation, the exponent $(a-1)/a$ on the level of output per worker y should be on the order of about –1.5. Under the assumption of the same rates of technological progress in the United States and Philippines, the equation suggests that the United States would have required a savings rate that is about 30 times larger than the savings rate in the

Philippines for these countries to have grown at the same rate. The evidence shows that this predicted savings rate for the United States is too large.

Therefore, the neoclassical growth model fails to provide a framework accounting for the growth difference and income disparity across economies. Given a plausible disparity in investment rates, this model generates much less income disparity than is found in the data. Only if the share of reproducible capital is near one does a plausible disparity in investment rates generate as much income disparity as in the data. But then the implied divergence is inconsistent with the development experience of income convergence across many economies. If we are to account for both the huge observed income disparity and development miracles, it seems that a new theoretical framework must be used in the empirical studies.

3.4 Empirical Studies based on New Growth Theory

3.4.1 Methodology

With the growth in theoretical interest in technology change as an economic progress, there have been some empirical studies to examine on how well the new growth models empirically explain growth differentials. These studies can be roughly divided into two groups, namely, studies based on the innovation-based growth theory and studies based on the theory of technological catch-up.

The innovation-based growth theory involves intentional innovative activities. A proper empirical test would probably require a system of equations, including one equation for the technology-producing sector. This would involve the use of technology statistics. A less ambitious approach would be to test a reduced-form equation, using elements affecting the output of innovative activities as possible explanatory variables for technological progress and economic growth. According to the innovation-based growth models, these elements include the growth rate of researchers and a set of productivity parameters. Many institutions could affect the value of these productivity parameters, such as the size of the market, the degree to which the technology can be privately appropriated, the protection of intellectual properties, and so on.

In most empirical studies, indicators of technological inputs such as the ratio of R&D expenditure to GDP or the ratio of engineers and scientific personnel to other employees are treated as a proxy for output of innovative activities. These studies tend to regress real GDP per capita not only on investment in physical and human capital but also on the investment or manpower engaged in R&D activities using cross-section data at the firm, industry, and national level.

The theory of technological catch-up predicts that the technological backward economy tends to grow faster than the technological advanced economy. However, this potential of faster growth is conditional on "social capabilities". Most advocates of this theory have brought these hypotheses to economic history and have found that the "advantage of backwardness" does exist. Veblen (1915) applied his hypothesis to Germany versus England, and Gerschenkron (1962) used it in a broader framework embracing England at one extreme and Russia at another, with France, Germany, and Italy in between.

As noted, much of the catch-up literature is descriptive, with a strong emphasis on historical analysis. However, some authors supplement their arguments by statistical tests. Until recently, these tests tended to include only one independent variable: GDP per capita. That means, the equation in these studies takes the same form as equation 3.21, i.e.

$$g_{y_i} = a + b\, y_{i,t_1} + u_i \qquad 3.21'$$

However, y_{i,t_1} in equation 3.21' is treated as a proxy for the technological level and hence the scope for technological catch-up.

3.4.2 Previous Studies

Many empirical studies have demonstrated that R&D expenditure makes an important contribution to growth. Lichtenberg (1992) found a positive and significant coefficient on R&D intensity (the ratio of R&D expenditure to GDP) in explaining growth in GDP per capita between 1960 to 1985 in 98 countries. Using a cross-country analysis, Pianta (1995) investigated the role played in the growth process by R&D expenditure and physical investment, finding that high rates of physical investment need to be combined with other investment, most notably in R&D activities. A similar conclusion was reached in the paper by Gittleman and Wolff (1995). It is worth noting that neither Pianta (1995) nor Gittleman and Wolff (1995) identified any particular causality between innovation and growth; they pointed out rather a two-way process of growth being fostered by innovation, which itself is induced by economic development. However, Gittleman and Wolff (1995) found that R&D activity is significant in explaining cross-national differences in growth only among the more developed countries. Among middle income and less developed ones, the effects are insignificant.

Empirical studies based on equation 3.21', including Singer and Reynolds (1975), Abramovitz (1986), Maddison (1982, 1991), and Baumol (1986), have shown that a large part of the actual difference in growth rates between the OECD countries in the post-war period can be statistically explained by differences in the scope for catch-up, i.e. that convergence in productivity levels took place.

These results have been criticized by Delong (1988) as an example of an "ex post selection bias": while long-run convergence in productivity levels can be established for the richest countries today (the OECD countries), it does not hold for the richest countries of the previous century. Responding to this criticism Baumol, Batey and Wolff (1989) extended the sample to all countries for which data were available. It was shown that although the group of convergence countries probably extends beyond the OECD area, there is little support for convergence when all developing countries are included. In an attempt to explain this finding, Baumol, Batey and Wolff (1989) included an education variable into the regression, which was used as a proxy for the social capability. This changed the result. The scope for catch-up regained its significance as a source of difference in growth rates, but conditional on educational efforts.

3.4.3 Evaluation

The complex and intangible nature of the process and content of technological innovation and transfer means that measuring the levels or results of these activities is very difficult. Normally the empirical studies have to make a compromise between one side's need for definiteness and the other side's sense of complexity. Therefore, despite the fact that technological innovation does not come just from formal R&D expenditure but from many other related activities, such as production engineering, design, quality control, learning by doing, etc., it does not seem unreasonable to use R&D measures frequently as a surrogate for all these activities which helps to promote new and improved products and processes.

However, explicit consideration of technological change has ramifications both in terms of innovation and technology transfer. Especially in developing economies, technological adoption sometimes plays a more important role than innovation in driving economic growth. To some extent, the lack in considering technological adoptive activities is the reason why Gittleman and Wolff (1995) found that R&D activity is significant in explaining cross-national differences in growth only among the more developed countries. Among middle income and less developed ones, the effects are insignificant.

Up to now, most empirical studies aimed at examining the impact of technological adoption or technological catch-up on economic growth have included only one independent variable, i.e. GDP per capita, in their regression equations. Here, the initial level of GDP per capita is treated as a proxy for the initial technological level and hence the scope for technological catch-up.

Such a simple catch-up model with one independent variable, as displayed in equation 3.21', is not sufficient to identify relevant factors involved in the process of technological transfer and hence to explain difference in growth performances, because the potential of faster growth is conditional on "social capabilities". Other economic, social and institutional factors emphasized by the proponents of the theory of technological catch-up must be taken into account.

3.5 Mixed Growth Regression

3.5.1 Methodology and Previous Studies

Since the mid-1980s, with the creation of new data sets with information for many economic variables in many countries during long periods of time (Maddison, 1982; Summers und Heston, 1988, 1991), a vast literature used cross-country regressions to search for empirical linkages between growth rates and a variety of economic policy, political and institutional indicators (see, for example, Kormendi and Mequire, 1985; Grier and Tullock, 1989; Blomstrom, Lipsey and Zejan, 1992; etc.). The specification of the regression equation in these studies is not derived directly from some growth theory. Rather, most investigators choose only a small number of explanatory variables depending on their research interests. For example, many authors who examine the relationship between measures of fiscal policy and economic growth ignore the potential of the importance of trade policy, while those authors who study the empirical ties between trade and growth commonly ignore the role of fiscal policy. Using cross-sectional data, these regressions have the following common form[50]:

$$g_{y_i} = a + cX_i + mM_i + u_i \qquad 3.26$$

where X is a set of variables always included in the regression, such as the investment rate, the initial level of real GDP per capita and the stock of human capital, etc. These variables are chosen based on past empirical studies and economic theories. M is a vector of variables of interests. c and m are coefficients for X and M. These regressions, i.e. capital accumulations plus macroeconomic policy variables as the right hand side variables, are often labelled as mixed growth regression.

Many empirical economists have used this type of regression to investigate the sources of growth difference across provinces in China. In Chen and Fleisher (1997), FDI is included in M; in Chen and Feng (2000) are education and openness; in Demurger (2001) is infrastructure; in Sachs *et al* (2002) are geographic factors; in Lin and Liu

[50] When panel data are used, the regression equation takes the form as: $g_{y_{i,t}} = a_i + cX_{i,t} + mM_{i,t} + u_{i,t}$.

(2000) is fiscal decentralisation, among others. All of these studies find a statistically significant relationship between growth and the variables of their interests.

3.5.2 Evaluation

These mixed regressions are not very appropriate according to Fischer (1993). As presented above, the basic regression includes factor accumulations as regressors. The effects of macroeconomic policy variables are usually studied by adding them as right hand side variables to the basic regression. The resultant regression therefore presents severe difficulties of interpretation when used to examine the role of policy variables or other indicators in the growth progress. Presumably, the interpretation of such equations is that conditional on the rate of factor accumulation, other variables affect growth. But it is hard to conceive of variables that would not affect growth through their effect on factor accumulations as well as through other routes, mostly the rate of technological progress. And this is especially true of many macroeconomic policy variables. Since some variables explain both growth and investment, the policy variable-augmented growth regression has no straightforward interpretation.

As for Levine and Renelt (1991, 1992), they argued that, given that over 50 variables have been found to be significantly correlated with growth in at least one regression, readers may be uncertain as to the confidence they should place in the findings of any one study. Levine and Renelt (1992) examined the sensitivity of past findings in the mixed growth regressions to small alterations in the explanatory variables and concluded that almost all results are fragile.

3.6 Concluding Remarks

As presented above, empirical studies on the issue of regional growth difference and income disparity in China were mainly based on the framework of neoclassical growth theory. The growth accounting exercises found great variation in rates of technological progress across provinces in China. Specifically, the coastal region has a higher TFP increase than the inland region. The growth performance in the coastal region is better mainly because TFP growth has accelerated more quickly in the coastal region than in the inland region. The Barro-style regressions concluded that the augmented Solow model provides a satisfactory explanation for regional variation in growth rates and income levels. In other words, different rates of capital accumulation (including both physical and human capital) and population growth are causes of the different growth performance among regions in China. Some empirical studies adopted the method of mixed growth regression and found that many macroeconomic policy variables have also contributed to the uneven growth performance among regions in China, such as openness and fiscal decentralisation, etc.

The review of previous empirical studies suggests to us that important forces underlying the regional growth difference and income disparity in China remain unaddressed by the empirical growth literature.

We argue that the growth accounting exercise is not an appropriate tool for exploring sources of growth difference and income convergence. Firstly, it is not possible to distinguish the contributions of technological progress from factor accumulation empirically, because these two driving forces of economic growth are interdependent and complementary. For example, technological progress may come from "learning by doing" as capital accumulates. And technological improvements typically raise the productivity of capital and thereby induce additional investments. Secondly, although the growth accounting exercise has emphasized the contribution of technological progress to economic growth, it fails to explore further the sources of technological progress. Moreover, TFP is not a policy variable. Without exploring the sources of technological progress and their connections with economic policies, we cannot provide reasonable policies to speed up both growth and income convergence.

In the Barro-style regressions and mixed growth regressions, the role of technological progress is almost completely forgotten. Technology, at best, is allowed to index differences in an initial multiplicative factor, and all economies are assumed to accumulate technology at the same rate. In such a capital-based world, differences in growth rates stem from differences in capital accumulation. Technological choices, through adoption and innovation, are completely assumed away in explaining both relative output levels and growth rates, hence convergence.

Actually, technological progress is featured prominently in almost every other analysis of economic growth except in the empirical literature on growth difference and income disparity. Economic historians, growth accountants, technologists, and advocates of the new growth theory all emphasize the importance of technology for understanding growth, development and convergence. To the extent that technological innovation and adoption is important for economic growth, most empirical studies on regional growth difference to date are misguided.

There are some empirical studies trying to identify factors accounting for different rates of technological progress based on the new growth theory. We argue that the mechanisms of technological transfer, one of the most important driving forces of economic growth in developing economies, remain poorly investigated in these studies. A simple technological catch-up model with one independent variable is not sufficient in explaining the differences in growth rates since it fails to examine the impacts of social capabilities on technological adoption and economic growth. Although Baumol, Batey and Wolff (1989) have used an education variable as a proxy for social capability, they have ignored other aspects of social capabilities proposed by economic historians.

In addition, previous studies tend to take investment in either physical capital or human capital as given, i.e., as an independent variable, without analysing its structure and underlying forces. The claim, that investment is exogenous, is most implausible for it implies a unidirectional causality operating from capital accumulation to productivity increase, with no significant feedback in the opposite direction. Indeed, I am surprised that most empirical studies on growth issues should resort to such an argument without any further verification. As shown by theoretical analyses in Chapter 4 and by econometric tests in Chapter 5, there is a bidirectional causal relationship between investment and productivity increase. Under these circumstances it is clear that the relationship can only be represented in a mathematical form by a set of simultaneous equations; and, as corollary, statistical estimates of the parameters of any single equation will be liable to serious error if that equation is considered in isolation.

This dissertation is mainly motivated by these dissatisfactions with previous empirical studies. In our view, to find the sources of regional growth difference and income disparity in China and to give sound policy recommendations for the reduction of income gaps, we should identify the underlying factors affecting the two well-accepted driving forces of economic growth, i.e., capital accumulation and technological progress. Furthermore, we should examine the interactive relationships between these factors and economic growth in a circular economic system. It is also necessary to give for each of these factors quantitative measures of its ability to influence each of the others and to be influenced itself by changes in other factors within this system or by changes in exogenous forces.

Chapter 4 A New Testable Analytic Framework of Cumulative Growth

4.1 Introduction

The review of previous empirical studies suggests to us that important forces underlying variations in growth rates and income levels across economies remain unaddressed. In order to find the sources of regional growth difference and income disparity in China and to give sound policy recommendations for the reduction of regional income gaps, we should identify the underlying factors affecting the two well-accepted driving forces of economic growth, i.e., capital accumulation and technological progress. Furthermore, we should examine the interactive relationships between these factors and economic growth in a circular economic system. It is also necessary to give for each of these factors quantitative measures of its ability to influence each of the others and to be influenced itself by changes in other factors within this system or by changes in exogenous forces.

We will accomplish these tasks within an original testable analytical framework, which is constructed based mainly on the theory of cumulative causation. We echo the view by Myrdal (1957) that mutual causation and interdependence through multiple feedback loops among economic factors are the rule of an economic system and any serious attempt at modelling the economic system must take note of this fact. In our framework, hypotheses proposed by the theory of cumulative causation in respect to the sources of growth difference and income disparity will be formalised more precisely. The insightful ideas concerning sources of technological progress proposed by the endogenous growth theories will also be incorporated into this framework. We will draw from this framework a number of conceptualised variables and structural relationships, which should enable the hypotheses and their consequences to be confronted more easily with empirical evidence.

There were already some attempts to formalise the process of cumulative causation and apply it to the analysis of accumulation and growth. For example, Kaldor (1970), Dixon and Thirlwall (1975), Skott (1985), and Setterfield (1997) have modelled bidirectional relationships between economic growth and export expansion. Schueler (2000) has formalised interactive relationships between profit rate, capital accumulation and productivity increase. We add to the literature of cumulative causation in two main ways. Firstly, except for the cumulative relationships between capital accumulation and economic growth, we will formalise determinants of technological progress and their cumulative relationships with economic growth and capital accumulation precisely in our framework. Secondly, making use of some econometric techniques, we will test the hypothesized cumulative relationships between capital accumulation, technological progress and economic growth to Chinese statistics. The results of these tests will provide empirical foundations for our policy recommendations for a balanced regional growth pattern in China.

In this chapter we will present the outline of our analytical framework and describe the factors accounting for variations in growth rates and income levels. In the following chapter we will make a detailed analysis of statistical associations between these factors and productivity growth. The rest of this chapter is organised as follows. In Section 4.2 we introduce main hypotheses proposed by the growth theory of cumulative causation and previous formulations of these hypotheses. In Section 4.3, we sketch the main outline of our analytical framework. The following three sections analyze the cumulative relationships between economic growth and capital accumulation, technological innovation, and technological adoption, respectively. Section 4.7 makes some concluding remarks.

4.2 Growth Theory of Cumulative Causation

4.2.1 Cumulative Causation vs. Stable Equilibrium

The concept of cumulative causation as a process in which the subsequent occurrences reinforce the initial conditions was initially developed by Veblen (1915), although it was not until Myrdal (1957) that it was applied to explain the different performance of countries and regions in terms of growth and development[51]. The concept of cumulative

[51] In Myrdal (1957), it was argued that the principle of cumulative causation would very likely be applicable in all fields of a society (economic, sociological, political, and psychological, etc.) and an

causation involves a self-reinforcing circular interaction among economic variables in an economy. Hence, an initial increase in some variable X induces supporting changes in the vector of variables Z, which promotes further increase in X, and so on.

Myrdal (1957) argued that neoclassic theory with an unrealistic assumption of stable equilibrium can not provide much of an explanation in causal terms for how the facts of economic inequalities have come into existence and why there is tendency for the inequalities to grow. In his view, cumulative causation is a more adequate hypothesis than stable equilibrium for the theoretical analysis of an economic process.

Myrdal argued that stable equilibrium is an unrealistic assumption because, in its uncomplicated form, it implies the notions that every disturbance provokes a reaction within the system, directed toward restoring a new state of equilibrium, and that action and reaction will meet in one and the same time-space. An economic system which is not at rest is for this reason always moving towards equilibrium. Implied in the stable equilibrium notion is the idea that, when a change calls forth other changes as a reaction, these secondary changes are counter-directed to the primary change. For example, an exogenous reduction in the stock of capital in a given country will cause prices for capital assets to increase and will therefore induce an offsetting increase in investment.

Myrdal expounded the idea that, on the contrary, in the normal case there is no such tendency towards automatic self-stabilisation in the economic system. The system is by itself not moving towards any sort of balance between forces, but is constantly on the move away from such a situation. In the normal case, a change does not call for the countervailing changes but instead, supporting changes, which move the system in the same direction as the first change, but much further. Because of such circular causation an economic process tends to become cumulative.

Such a cumulative process can, of course, be stopped. One possibility is that new exogenous changes may occur, which have the direction and the strength necessary to bring the system to a rest. The position of balancing forces which thus becomes established is, however, not a natural outcome of the play of the forces within the

adequate diagnosis of economic problems might entail reaching into all of these fields. But growth literature discussions have so far concentrated on macroeconomic aspects of cumulative causation.

system. The position is, furthermore, unstable. Any new exogenous change will, by the reactions in the system, again start a cumulative process away from this position in the direction of the new change. Alternatively, the position of rest may have been achieved by policy interferences, planned and applied with the intention of stopping the movement. This is, of course, the very opposite of a natural tendency towards equilibrium, endogenous to the system.

4.2.2 Main Hypotheses

Myrdal (1957) has explained the backwardness of some economies compared with others with the growth theory of cumulative causation. It is basically dualism applied to nations and regions of those nations, with regards to differences in income, employment, growth and industrialisation.

The main hypothesis of the growth theory of cumulative causation is the assumption of circular and cumulative causation between all factors in an economic system. By circular causation and cumulative effects, a region superior in productivity and income will become more superior, while a region on an inferior level will tend to be held down at that level or even to deteriorate further – as long as matters are left to the free unfolding of market forces. That is, the process of cumulative causation tends to result in a self-sustaining (or, self-reinforcing) “virtuous cycle” or “vicious cycle” of economic growth.

Myrdal proposed that the creation of a favoured region may have its origin in a historical accident but there is a natural tendency for all economic activities with higher than average returns and the know how with all the social amenities that go with these to cluster within such a core region with *backwash effects* on unfavoured regions. There may be some centrifugal *spread effects* (along the lines of trickle-down effects) and *counteracting effects* in the situation of economic expansion in the core region; but these do not point to the achievement of regional equality, if market forces alone were left to decide the outcome.

Specifically, initial comparative advantages create the initial stimulus for better economic development in a particular location. Then, a process of cumulative causation occurs as acquired advantages are developed and reinforce the area's development. The process of cumulative causation can be interpreted such that growth-induced new technologies, improvements in infrastructure, skilled workforce, easy communication, the feeling of growth and elbow room, and the spirit of new enterprises, etc., will fortify and sustain its continuous growth. If left to themselves, those regions which had not been touched by the expansionary momentum could not afford to keep up a good road system. They would have fewer schools and their schools would be grossly inferior. And all other public utilities in these unfavoured regions would be inferior, thus increasing their competitive disadvantages.

When spatial interaction increases, the inequalities are accentuated by migration, capital movements and trade. The localities and regions where economic activity is expanding will attract new immigration from other parts of the country. As migration is always selective, at least with respect to the migrant's age and skill, this movement by itself tends to favour the rapidly growing communities and disfavour the others.

Capital movements tend to have a similar effect of increasing inequality. In the centres of expansion, increased demand will spur investment, which in turn will increase incomes and demand and cause a second round of investment, and so on. In the other regions, the lack of new expansionary momentum has the implication that, demand for capital for investment remains relatively weak. Studies in many countries have shown how the banking system, if not regulated to act differently, tends to become an instrument for siphoning off the savings from the poorer regions to the richer and more progressive ones where returns on capital are high and secure.

Trade operates with the same fundamental basis in favour of the richer and progressive regions against the other regions. The freeing and widening of the markets will often confer such competitive advantages on the industries in already established centres of expansion, which usually work under conditions of increasing returns. The development of industries in these well developed regions may ruin the existing industries of the underdeveloped ones.

Myrdal referred to all relevant adverse changes, caused outside that locality, as the "*backwash effect*" of economic expansion in a locality. Under this label, the effects via migration, capital movements and trade are all included.

Against the backwash effects there are, however, also certain centrifugal "*spread effects*" of expansionary momentum from the centres of economic expansion to other regions. It is natural that the whole region around a nodal centre of expansion should gain from the increasing outlets of agricultural products and raw materials. There also may be technological knowledge spillovers from regions with a more productive modern sector towards less developed regions.

Additionally, there may be factors inherent in the situation of a centre of economic expansion which tends to retard or, when it has reached a certain level of development, even to reverse the cumulative process. These so-called "*counteracting effects*" of economic expansion may be that, in a centre of expansion, wages and the remuneration of other factors of production will be driven up to such a high level that other regions get a real chance to compete successfully. Or a prolonged period of economic expansion may have saddled a prosperous region with a very large stock of old capital equipment which is tempting not to discard as rapidly as it would be advantageous in a period of swift technological development.

In no circumstance, however, do the spread effects and counteracting effects establish the assumptions for an equilibrium analysis. In the marginal case the three kinds of effects will balance each other and a region will be "stagnating". But this balance is not a stable equilibrium, for any change in the forces will start a cumulative movement upwards and downwards.

Myrdal argued that the backwash effects tend to dominate the spread effects and counteracting effects, if market forces alone were left to decide the outcome. Internationally, differences in legislation, administration, and more generally in language, in basic valuations and beliefs, in levels of living, production capacities and facilities, make national boundaries much more effective barriers to the spread of expansionary momentum than any demarcation lines within one country can be. But even within a country, empirical observations indicate that regional disparity of economic development is still a long-standing problem. Especially, disparity of income between one region and another is much wider in a developing country than in a developed country. A large part of explanation for this fact may be that, the higher the level of economic development that a region has already attained, the stronger the spread effects will usually be. For a high average level of development is accompanied by improved transportation and communications, higher levels of education, and a more dynamic communion of ideas and values – all of which tends to strengthen the forces for the centrifugal spread of economic expansion or to remove obstacles for its operation. A low average level of development in an under-developed country means that the spread effects (and the counteracting effects as well) are weak there. This means that as a rule the free play of the market forces in a developing country will work more powerfully to create regional inequalities and to widen those which already exist.

Now we can conclude that, if the hypothesis of cumulative causation holds, one could say that the foremost reason for the regional great disparity in growth rates is just that long ago, perhaps caused by accident or by initial comparative advantages such as location, minerals or labour, there had arisen small disparity in growth rates among regions. Additionally, in contrast with the neoclassical growth theory and the theory of technological catch-up, which suggests that regional inequality will disappear, the theory of cumulative causation postulates that regional inequality is an inevitable outcome of capital accumulation and profit maximisation; market forces tend to increase rather than decrease regional inequality.

4.2.3 Formal Theory and Appreciative Theory

The growth theory of cumulative causation differentiates itself from the neoclassic and new growth theories in respect not only of their different hypotheses for growth mechanisms but also of their different theorizing approaches. Based on a diverse body of evidence, the growth theory of cumulative causation, expressed verbally instead of using formal models, generates neither a set of equations to be solved for equilibrium nor sharp quantitative predictions. It is no more than a conceptual framework for thinking about growth.

Nelson and Winter (1982) distinguish between two levels of analysis in economic theorizing: formal and appreciative. In a recent paper Nelson describes this distinction as follows:

> Because the subject matter and the operative mechanisms of economics are so complex, theorizing in economics tends to proceed at least on two levels of formality, not one. We have called these levels appreciative theory and formal theory. Appreciative theorizing tends to be close to empirical work and provides both guidance and interpretation. Mostly it is expressed verbally and is the analyst's articulation of what he or she thinks is going on. Appreciative theory generally refers to observed empirical relationships, but goes beyond them, and lays a causal interpretation on them. While appreciative theorizing tends to stay relatively close to the empirical substance, formal theorizing almost always proceeds at some intellectual distance from what is known empirically, and where it generally appeals to data for support it generally appeals to "stylised facts". If the hallmark of appreciative theory is story-telling that is close to the empirical nitty-gritty, the hallmark of formal theorizing is an abstract structure set up to enable one to explore, find and check, logical connections. (Nelson, 1994)

The formal theory, characterized with a very specific dynamic model, which can be explicitly solved for equilibrium, can provide us with a better analytical tractability than the appreciative theory. Besides, in these models, explicitly conceptualised variables can ease the statistical measurements and empirical tests. But the analytical tractability and clarity are achieved at a substantial cost. To construct such formal models, artificial assumptions are inevitably made for purely technical reasons. As a result, when it comes time to compare the model with actual data, there is at best a distant and elastic connection between the variables manipulated in the model and those that we should actually measure.

The appreciative theory is less abstract, more descriptive, and closer to practice and to real world context, compared with the formal models. The appreciative theory makes use of a diverse body of evidence and avoids formal models. Based on this type of theory, one can make informed conjectures about how the economy will behave, but none of these conjectures is verified rigorously here. What this loose kind of framework can do is to detail a list of possible variables to consider and a set of possible interactions to look for based on insightful observations. Without assumptions used often in formal theoretical models, the framework has provided a more comprehensive understanding of this real world in process.

Obviously, the growth theory of cumulative causation is a typical representation of the appreciative theory. There is a trade-off between comprehensive analyses of the real world and analytical tractability and empirical testability. Myrdal admitted that it is very difficult to fit his theory into a neat econometric model because there are too many variables and relations between them to permit that sort of simplification. But he argued that this does not mean that particular problems could not be treated in this way, provided that the variables and assumptions were selected on the basis of essential facts and relations. He further suggested that, ideally, the scientific solution of an economic problem should be postulated in the form of an interconnected set of quantitative equations, describing the movement – and the internal changes – of the system studied under various influences that are at work. He submitted that the working out of such a complete and quantitative solution should be the aim of research endeavours.

4.2.4 Previous Formulations of Cumulative Causation

Since the establishment of the growth theory of cumulative causation by Myrdal in the 50s, there have been already some attempts to formalize the hypothesis of cumulative causation and apply it into the analysis of economic inequalities. These formalisations can be roughly divided into two branches. The first branch has devoted efforts to model the cumulative relationship between economic growth and export expansion. The second branch has emphasized the cumulative relationship between productivity increase and capital accumulation.

Economic Growth and Export Expansion

Kaldor’s (1970) paper on the determinants of regional growth disparity entailed a definitive adherence of Kaldor with the cumulative causation theories of development in line with Myrdal (1957). Kaldor's basic idea was that growth is demand led and, in particular, export led. The growth of output due to the growth of exports would induce a higher increase in the growth of productivity that would feed through into lower rates of growth of prices. This would improve price competitiveness, allow for higher growth of exports and, thus, start the process again.

Following Kaldor, recent appeal to the process of cumulative causation has been concentrated in models of accumulation and growth in the context of interregional trade. Formal models of this application can be found in, for example, Dixon and Thirwall (1975), Skott (1985), and Setterfield (1997). For any given region, the discrete time form of the model can be written as:

$$g_Y = x\, g_E \qquad 4.1$$

$$g_E = h_d g_{p_d} + h_f g_{p_f} + z\, g_Z \qquad 4.2$$

$$g_{p_d} = g_w - g_y + g_r \qquad 4.3$$

$$g_y = g_y{}^a + \Lambda g_Y \qquad 4.4$$

Equation 4.1 states that the growth of output g_Y is a linear function of the growth of exports g_E. Equation 4.2 is a typical export demand function expressed in growth rates, where the growth of exports depends on the growth of domestic prices p_d, foreign prices p_f and the income of the 'rest of the world' Z, with h_d, h_f and z being the respective elasticities. Equation 4.3 is the expression for the rate of growth of domestic prices, which is derived from $p_d = {}^{wr}\!/_{y}$, where w is the level of wage rate, y is the labour productivity and r is one plus the percentage mark-up over unit labour costs. Finally, equation 4.4 is the expression for the rate of growth of productivity g_y derived from the Verdoorn Law relationship, g_y^a being the autonomous productivity growth.

The model is block recursive, and its solution for the equilibrium rate of growth of output is:

$$g_Y = g_y \frac{\left[h_d(g_w - g_y^a + g_r) + h_f(g_{p_f}) + z(g_Z)\right]}{1 + x h_d \Lambda} \qquad 4.5$$

Productivity Increase and Capital Accumulation

When investigating the sources of regional productivity differentials in China, Schueler (2000) argued that, on the one hand, it is really investment ratio which plays the crucial role in determining the economic development. On the other hand, productivity can be seen as a main factor determining the investment ratio. Therefore, the higher the productivity the more that can be produced in the region for the purpose of increasing the capital stock; the higher the capital stock, the higher the regional capital intensity and, hence higher productivity. Lower regional productivity leads to a small investment ratio which in turn contributes to a relatively small growth of the capital stock of the backward region and as a consequence to even greater disparities between regional productivity.

This argument assumes implicitly that the relation between wages and productivity in a region determines the regional profit rate and thus the main market incentive for deliberate investments in this region. By its definition, the profit rate p can be expressed as:

$$p = \frac{(1-R)}{k} = \left(1 - \frac{w}{y}\right) : k \qquad 4.6$$

Here, r is the wage ratio (ratio of wage to GDP); k is the capital-output ratio; w is the wage rate; and, y is the labour productivity.

Schueler (2000) has assumed a constant k between regions for a lack of data of capital stock. Under this assumption, to the extent that productivity increase is not offset by rising wages, higher productivity may also mean higher profits which may in turn raise demand by causing firms to invest more. In this way, differences in wages and productivity are also reflected in different profit rates between regions. When the wages between regions differ less than productivities do, it is expected that the backward region with lower productivity tends to have also a lower profit rate, which results in a lower investment rate and further lower productivity increase.

4.3 A New Analytical Framework of Cumulative Growth

Although previous formulations of cumulative growth have identified circular and cumulative causations between some factors in an economic system, they have failed to consider one important driving force of economic growth, i.e. technological progress.

In our view, a story of growth that neglects technological progress is both ahistorical and implausible. Surely the earth's (relatively) fixed stocks of land, natural resources, and raw labor would impart diminishing returns to accumulated inputs if those inputs were forever combined to produce a fixed set of goods by unchanging methods. Economic historians, growth accountants, technologists, and advocates of the new growth theory all emphasize the importance of technology for understanding growth, development and convergence. Econometric estimates of aggregate production functions confirm our suspicion that returns to physical capital, human capital, and other accumulable factors are far from constant.

However, there is no need to choose between models that emphasize technology and that emphasize capital accumulation. Even in a world, in which technological progress provides the engine of long-run growth, accumulation will play an independent role during a (perhaps prolonged) transitional phase. And when the incentive for capital deepening abates, capital accumulation may still act as the "transmission of growth", as when new ideas must be embodied in machinery and equipment before they give rise to tangible products.

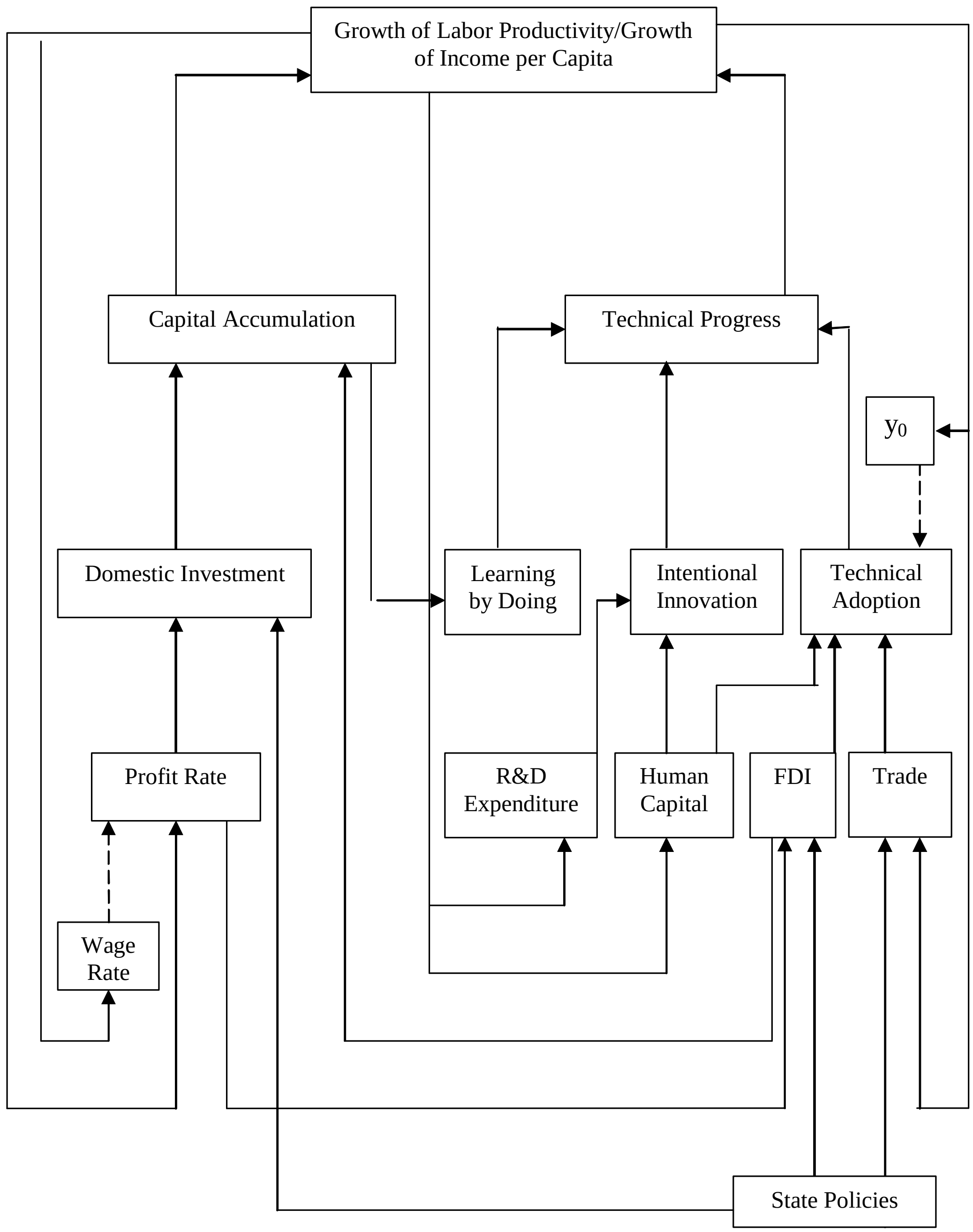
Since both capital accumulation and technological progress are important for economic growth, we depict most of the conceivable relationships and processes between capital accumulation, technological progress and economic growth precisely in our analytical framework.

Figure 4.1 gives a schema of our analytical framework. A central feature of this framework is the identification of key circular and cumulative processes in an economic system and the role of various variables in these processes. The arrows show the major lines of causation from one variable to the next. A solid line indicates that a rise in the first variable leads to a rise in the second, while a dashed line indicates an inverse relationship.

As depicted in Figure 4.1, the growth of labour productivity or income per capita is driven by both capital accumulation and technological progress. Here, capital accumulation means the accumulation of physical capital alone, since we will consider the role of human capital in the sight of technological progress. However, in our view, as a theoretical conceptualization and for pedagogical purposes, it is perfectly valid to distinguish between capital accumulation and technological progress; but the contributions from technological progress and capital accumulation are empirically indistinguishable.

In the following three sections, we will identify the underlying factors of capital accumulation and technological progress. Furthermore, we will examine the interactive relationships between these factors and economic growth in a circular economic system.

Figure 4.1: **Schematic Representation of Cumulative Growth**



4.4 Investment and Productivity Increase

It is widely acknowledged that capital accumulation is crucial in shaping the pace and form of economic growth, but there is less than a full agreement about which factors drive investment[52]. While the debate over the theoretical deviation of an appropriate investment function continues, empirical studies have converged on a limited set of explanatory variables. Foremost among these is the measure of profitability.

The inclusion of a profit term as a determinant of investment spending is compelling both theoretically and empirically. The assumption that firms behave, and thus invest, so as to maximize profit is widely held. Jan Tinbergen (1939) argues that "it is almost a tautology to say that investment is governed by expectations of profits". The investment function of Kaldor (1961) gives the investment rate as a function of the rate of profits in the previous period. Asimakopulos (1989) points to the central role of profits in the accumulation models of Michal Kalecki and Joan Robinson. A study by OECD (1980) argues that:

> Investment decisions are, of course, basically driven by profit expectations. Profits expected from investment are not directly observable, however, so that they must be proxied by variables to affect them. In this sense, theories explaining investment can be considered to be in reality theories explaining expected profits.

What current information might shape investors' expectations of future profits? The current rate of profit is surely a reasonable candidate. In the study by Koechlin (1992), equations that regress the current after-tax rate of profit on the lagged rate of profit (and a constant term) for seven OECD countries indicate that current profit is a good predictor of future profit. Further, several empirical studies have found profits to be a significant determinant of the rate of capital accumulation. The study by OECD (1980) has estimated investment equations for nine OECD countries. The coefficient of the profit rate (lagged one year) is significant in each equation. Helliwell *et al.* (1985) include a profit term in their investment estimates for Japan, Germany, France, and Italy,

[52] Clark (1979) and Kopcke (1985) provide a concise review of the investment literature and empirical tests of the literature's most influential models.

and in each case its coefficient is statistically significant. Bowles *et al.* (1986) find two separate measures of profitability to be significant in their estimates of an investment function for the United States.

As proposed in Schueler (2000), by its definition, the profit rate p can be expressed as:

$$p = \frac{(1-r)}{k} = \left(1 - \frac{w}{y}\right) : k \qquad 4.6$$

This formula leads to the following argument: among three variables k, w, and y, when two other variables being constant, the higher the productivity level, or the lower the wage rate and capital-output ratio, the higher the rate of profit on investment. Normally, it is found empirically that there are little variations in capital-output ratio across economies. And the increase of productivity will also induce an increase of the wage rate. But when the growth rate of the wage rate is lower than that of labour productivity, a higher profit rate is always expected.

The positive effect on the profit rate of higher productivity is most marked when there is a surplus of labour to weaken the bargaining power of workers, so that higher productivity is translated into lower costs rather than higher wages. As productivity rose so did profits and investment, and the economies moved on to a path of self-sustaining growth.

It is argued, however, that this “virtuous cycle” would not last forever and would be broken when labour reserves became exhausted and wages were forced up by the resulting shortage of workers. This is exactly one of the counteracting effects proposed by Myrdal (1957).

The above-mentioned profit-oriented principle is applicable for investment spending by private agents (firms or individuals). However, state policies may also affect investment in a region. For example, to support the development of state-owned enterprises (SOEs), the central or local governments may exert pressure on state-owned banks to investment in SOEs without considering profitability. Or the state may give preferences to foreign investors in some regions for some strategies of regional development, which will also affect the flow of FDI in these regions.

4.5 Domestic Innovation and Productivity Increase

It is by now incontrovertible that differences in per capita income cannot be explained simply by differences in the capital-labour ratio. The different rates of technological progress are also a main cause of growth difference across economies. Virtually all scholars of productivity growth now agree on the central role of technological progress. New growth theory has in fact only belatedly incorporated into neoclassical models the realistic assumption which had become commonplace among economic historians and neo-Schumpeterian economies. For example, Landes (1969) describes the role that new technologies played in spurring the industrial revolution, while Rosenberg (1972) provides a comprehensive survey of the relationship between technological advances and American economic growth since the early 1800s.

Now it comes to the question of what the factors accounting for the different rates of technological progress are. According to new growth theory, technological progress may stem either from learning-by-doing (called also as externality of investment; see Romer, 1986; and Lucas; 1988); or intentional innovative activity (see Romer, 1990); or technological adoption from other technological-advanced economies (see Abramovitz, 1986; Barro and Sala-I-Martin, 1997). In reality, all these three factors contribute to the technological progress in an economy. We discuss domestic intentional innovation and learning-by-doing in this section. The mechanisms of technological adoption will be formalized in Section 4.6.

4.5.1 Intentional Innovative Activity

Innovation as the Engine of Technological Progress

Many growth economists, such as Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1992), Stockey (1992), and Jones (1995) propose that technological advance results from purposive innovative activities by profit-maximizing agents (firms or inventors) in the economy.

Some might argue that technology is driven by science, which may proceed at a pace and in a direction that is largely independent of economic incentives. But few scholars of industrial innovation accept this view. The commercial exploitation of scientific ideas almost always requires a substantial investment of resources in the innovation sectors. This is the conclusion of countless studies of particular industries and innovations, including those on machine tools (Rosenberg, 1963), aircraft (Constant, 1980), synthetic chemicals (Freeman, 1982), metallurgy (Mowery and Rosenberg, 1989), and semiconductors (Dosi, 1984), to name but a few.[53] According to these studies, firms have invested in innovative activities when they have seen an opportunity to earn profits with innovated technologies. In such a setting, the institutional, legal, and economic environments that determine the profitability of these investments must surely affect the pace and direction of technological change.

National Innovation System and Innovative Capability

A variety of national institutions could powerfully affect relative rates of technological innovation and hence of economic growth. The Japanese experiences have drawn attention to the role of "national innovation systems" in supporting the domestic innovative activities. The concept of a national innovation system (NIS) was developed by Freeman (1987) to analyse post-war Japanese economic policy and growth[54], and has been applied to a broader cross-section of economies in more recent work (Lundvall, 1992; Nelson, 1993). A country's NIS comprises the network of public and private institutions that fund and perform R&D, translate the results of R&D into commercial innovations and effect the diffusion of new technologies. More concretely, a NIS includes the public agencies that support and/or perform R&D; a nation's universities, which may perform research and play an important role in the training of scientists and engineers; firms within an economy that invest in R&D and in the application of new technologies; any public programmes intended to support technology adoption; and an array of laws and regulations that define intellectual property rights.

[53] For a survey, see Grossman and Helpman (1991).

[54] However, as the author would be the first to agree that the idea actually goes back at least to Friedrich List's concept of "The National System of Political Economy" (1841), which might just as well have been called "The National System of Innovation".

Despite the fact that many related factors affect the innovative capability in an economy, in empirical studies measures of R&D expenditure and human capital were used very frequently as surrogates for all these activities which helped to promote new and improved products and processes.

However, the production of new technology may not be seen as a simple matter of inputs and outputs. There is probably an irreducible exogenous element in the R&D process, at least exogenous to the economy. Fields of research open up and close down unpredictably, in economics as well as in science and technology. This is reflected, for instance, in the frequency with which research projects end up by finding something that was not even contemplated when the initial decisions were made. But we can not deny that more R&D investment combined with a higher level of human capital in an economy means more potential emergences of innovations and technological advance.

Productivity Increase and Innovative Capability

The allocation of resources to innovation is determined within most growth models on a profit-maximizing basis. To make innovation worthwhile, it must be possible to appropriate returns to cover the fixed costs of research. In general, anything which enhances the appropriability of returns to innovation increases R&D investment by private agents. The Grossman-Helpman's model (1991) itself allows various factors to draw more resources into innovation. Innovation and the growth rate depend positively on the size of the market, the productivity of labour in research, and the degree of market power in selling the products resulting from innovation. These are mostly intuitively appealing features; thus, a wider market means larger fixed costs of research can be covered by expected sales and more talented and/or better educated researchers will lower the costs of innovation. A country's patent system effectively protects the innovators' property rights over their new invention.

We argue, therefore, that an economy with a higher level of labor productivity and income per capital tends to have a better institutional system, a huge size of market, and more educated labor force, which will in turn increase its innovative capability and hence rate of economic growth.

4.5.2 Learning-by-Doing

It is an important fact of life that many new or improved products and processes have little to do with the R&D activity, but originate in some other way, for instance, from the accumulation of small suggestions coming from production workers, process engineers, and even customers. Therefore, Arrow (1962) and Romer (1986) advanced the hypothesis that, to some extent, technical change in general may be ascribed to experience, that it is the very activity of production which gives rise to problems for which favorable responses are selected over time.

The question is that of choosing the economic variable which represents “experience”. In growth literature, cumulative gross investment, i.e., cumulative production of capital goods was taken as an index of experience. Each new machine produced and put into use is capable of changing the environment in which production takes place, so that learning takes place with continually new stimuli. Therefore, in our framework, we treat technological progress resulted from learning-by-doing as a by-product of capital accumulation.

4.6 Technological Adoption and Productivity Increase

4.6.1 Significance of Technological Adoption

Except for domestic innovative capabilities, many economists view different abilities of technological adoption as another important source of large disparities in technological progress across countries, especially across technological-backward developing countries. For example, Romer (1993) argues that many nations are poor, in large part, “…because their citizens do not have access to the ideas that are used in industrial nations to generate economic values.”

Compared with cost resulting from innovation activities, there is empirical evidence suggesting that imitation cost is substantially lower. For example, Mansfield, Schwartz and Wagner (1981) found that the ratio of imitation costs to innovation costs in a sample of 48 product innovations is relatively low. Teece (1997) examined 26 international technology transfer projects and discovered that technology transfer costs averaged 19% of total project costs.

Therefore, the notion that technological adoption is essential to the growth process would seem to be fairly intuitive, especially for developing countries. Hence, many mechanisms which might advance the flow of knowledge from one economy to the next should provide a positive, or in the least, a non-negative spur to economic growth.

Economists who are familiar with different national experiences seem to be convinced that the determinants of cross-national flows of ideas about production are of decisive importance in influencing aggregate outcomes. It is not possible, for example, to read the story of how Taiwan moved from a position with essentially no industrial base to become the fourth-largest producer of synthetic fibres in 1981 (Wade, 1990) without being impressed by the importance of the specific joint ventures and licensing agreements undertaken with firms from the US and Japan. Similarly, the development of electronics industry in Taiwan was decisively influenced by the government's decision to induce foreign electronics firms to set up assembly operation in a free trade zone opened specifically for this purpose.

The decisive role played by flows of technology becomes most evident when one descends further to the industry level. The advantage of micro-level or case-study evidence is that one can confidently resolve mechanisms of action and causal chains. An illustrative example can be briefly mentioned here. A recent world bank study of the bicycle industry shows how firms from the US, HK and Taiwan are in the process of rapidly converting the bicycle industry in China from a low-technology, low quality producer of bikes for the domestic market into the world's largest exporter of bicycles (Mody *et al.*, 1991). It is quite clear that foreign bicycle firms showed the Chinese firms about the kinds of bicycles that would sell on foreign markets, undertook much of the design work, and taught workers specific skills such as quality control.

4.6.2 Mechanisms of Technological Adoption

As presented in Chapter 2, from the theory of technological catch-up we can sum up two mechanisms of technological adoption.

Advantage of Backwardness

Firstly, the technological adoption involves the so-called “advantage of backwardness”, meaning that, the further an economy is from the technological frontier, the greater the rate of technical progress possible from such adoption. The rate of technological progress in a relatively “backward” economy is an increasing function of the gap between its own level of technology and that of the “advanced” economy. This implies that there is a tendency of income convergence across economies through technological diffusion.

Social Capabilities

Secondly, the process of technological diffusion and income convergence is not automatic. “Being backward” does not itself guarantee that an economy will have a higher growth rate than other advanced economies and hence the income level between them will converge. Other factors must be present, such as economic integration with advanced economies, an educated work force in the host market, a suitable product mix and other suitable institutions. Economic historians refer to these conditions as “social capabilities”. Economies characterized by a large technology gap and a low “social capability” run the risk of being caught in a low-growth trap.

Under the assumption that the technological progress in an economy stems exclusively from technological adoption, according to the above-mentioned mechanisms, the rate of technological progress can be formulized in equation 4.7 as:

$$\frac{\dot{A}}{A} = c * \left(\frac{T}{A}\right)^{g} \qquad 4.7$$

In this equation, c denotes the level of “Social Capabilities”. It is a function of many factors, which have positive effects on social capabilities. T denotes the world technology frontier, which can be understood as the A in the innovation-based growth model. That means the innovative activities in the advanced economies determine the level of world technology frontier. We assume that $0 < g < 1$.

It is worth noticing that the last term on the right hand side of equation 4.7 suggests that the change in A is a geometrically weighted average of the frontier technology level and the current level. This equation makes clear the assumption of the “advantage of backwardness” as mentioned above. If c remains the same across economies, the economy with lower A at the outset will have a higher rate of technological progress. This is the reason why we draw a dashed line from y_0, the initial level of productivity, to the technological adoption in Figure 4.1.

4.6.3 Proxies for Social Capabilities

To further understand the mechanisms of technological adoption and to test the hypotheses in the theory of technological catch-up to empirical statistics, we must identify proxies for social capabilities. We propose to use three measurable variables as constitutions of the social capabilities in an economy, namely, international trade (export and import), foreign direct investment (FDI), and human capital. The first two variables reflect the approachability of foreign advanced technologies. The last one reflects domestic adoptive capabilities.

In reality, firms in developing economies have three main channels for obtaining new technology. These include: (1) the purchase of technological superior equipment; (2) foreign direct investment; and (3) obtaining licenses for domestic production of new products or the use of new processes. Because data on the destination and growth of technology licensing flows in China are much scarer than those for FDI and trade. We consider only the trade and FDI in our framework. Besides, there is some statistical evidence and a growing subjective sense that licensing is decreasing as an option for closing technology gaps (see Pack and Page, 1994; Freeman, 1995). Therefore, our simplification for empirical considerations will not have many consequences.

International Trade: Export and Import

Except for the role of trade surpluses which fuels growth in demand for national output and income, trade competitiveness can also facilitate the technological adoption and remove supply constraints.

An important channel for inward technology transfer involves the embodied technology transfer that occurs through the import of advanced capital goods. The importance of embodied technology transfer for South Korean industrial development has been emphasized by Dahlman and Brimble (1990). Except for the role of import, of particular relevance for developing nations, growth in export income can help remove foreign exchange constraints and facilitate the import of critical capital goods.

Trade itself may help the process of technological dissemination, if foreign exporters suggest ways that their wares can be used more productively or foreign importers indicate how local products can be made more attractively to consumers in their country.

The literature has highlighted the role of trade in technology spillovers from developed countries to less developed countries (e.g. Coe and Helpman, 1995; Coe, Helpman and Hoffmaister, 1997; Keller, 1997; etc.). The primary assumption in the papers of Dollar, Wolff, and Baumol (1988), Grossman and Helpman (1991, 1991a), and Marin (1995) is that trade between countries acts as a conduit for the dissemination of knowledge. For example, Marin (1995) provided empirical evidence showing that Austria's relatively fast growth during the post-war period has been induced by knowledge spillovers from its trading partners, particularly Germany. As stated by Grossman and Helpman (1991),

> It is plausible to suppose that the foreign contribution to the local knowledge stock increases with the number of commercial transactions between domestic and foreign agents. That is, we may assume that international trade of tangible commodities facilitates the exchange of tangible ideas….It seems reasonable to assume therefore that the extent of the spill-overs between any two countries increases with the volume of their international trade.

Foreign Direct Investment (FDI)

Many economists proposed that, though technology diffusion can take place through a variety of channels, FDI by multinational corporations (MNCs) is considered to be the most effective channel for the access to advanced technologies by less-developing countries (LDCs).

As stated in Findley (1978), while the “book of blueprints” in some abstract sense may be open to the world as a whole, even if one may have to pay a stiff price to look at some of the pages, new technology generally requires demonstration in the context of local environments before it can be transferred effectively. It is in this sense that FDI can play an important role in the process of technology diffusion.

The imported capital goods may embody many new technologies. But successful development also requires a mechanism for ensuring adequate flows of the large quantity of disembodied ideas that are used in production. MNCs can do this through FDI. A viewpoint that now is quite widely accepted is that FDI does not represent simply a pure transfer of “capital”, but the transfer of a “package”, in which capital, management and new technology are all combined.

FDI may boost the productivity of all firms in the host economy - not just those receiving foreign capital (Rappaport, 2000). FDI affects the local economy in three ways. The first, which we will call an “extension effect”, is due to the increased diversity of goods produced by the local intermediate goods sector, which leads to increased specialisation by producers of inputs. The second is a spill-over effect. Local firms may increase their productivity by observing nearby foreign firms or becoming their suppliers or customers or through labour turnover as domestic employees move from foreign to local firms. FDI can improve the efficiency of local enterprises through direct competition in the domestic market as well.

Many studies on economic growth have highlighted the role of FDI in the technological progress of developing countries. Findlay (1978) postulated that FDI increases the rate of technical progress in the host country through a “contagion” effect from more advanced technology, management practices, etc. used by the foreign firms. Based on data on FDI flows from industrial countries to 69 developing countries, Borensztein, Gregorio, and Lee (1998), have tested empirically that FDI is in fact an important vehicle for the transfer of technology, contributing to growth on a larger scale than domestic investment. De Gregorio (1992) showed, in a panel data of 12 Latin American countries, that FDI is about three times more efficient than domestic investment. Blomstrom, Lipsey, and Zejan (1996) also found a strong effect of FDI on economic growth in LDCs. Using data on 29 manufacturing industries over the period 1993 to

1998 in the Shenzhen SEZ, Liu (2002) estimated the effects of FDI on the productivity level and rate of productivity growth among manufacturing industries. The empirical results show that FDI generates large and significant spill-over effects and domestic sectors are the main beneficiaries.

Human Capital

A number of the findings from the extensive literature on domestic technology transfer are relevant to international technology transfer. For example, the exploitation of external technology requires the creation within the firm of some "absorptive capacity", i.e. the ability to understand an externally sourced technology and apply it internally (Cohen and Levinthal, 1989). Therefore, we argue that the creation of a domestic "absorptive capacity" is essential to an economy's exploitation of technologies transferred from abroad.

This capacity includes a broad array of skills of the labor force in an economy, reflecting the need to to know which technology is available for purchase or copy, to deal with the tacit components of the transferred technology, as well as the frequent need to modify a foreign-sourced technology for domestic applications. As a result, the stock of human capital in the host economy limits its adsorptive capability.

Therefore, applications of the more advanced technologies require the presence of a sufficient level of human capital in the host economy. Many economists argue that there is a strong complementary effect between FDI and human capital, that is, the contribution of FDI to economic growth is enhanced by its interaction with the level of human capital in the host economy (see Nelson and Phelps, 1966; Benhabib and Spiegel, 1994; Borensztein *et al.*, 1998; etc.).

Empirically, many economists take years of schooling as a proxy for human capital, although clearly individuals also learn skills outside of formal education. They find significantly positive impacts of human capital on the technological progress and economic growth (see Nelson and Phelps, 1966; Benhabib and Spiege, l994; Easterly *et al*., 1994; and, Bernard and Jones, 1996; etc.).

Other Institutions

Many economic historians suggest that the social capabilities include a significant amount of political, commercial, industrial, and financial institutions (Abramovitz, 1986; Romer, 1993; etc.). If the government does not provide the basic infrastructure required for market exchange, for example, if the financial system fails to offer an effective payments system or to match borrowers and lenders, if market prices are distorted by an unstable monetary and exchange rate regime, if the government neither provides basic physical infrastructure nor lets the private sector provide it, and if, in extreme cases, property rights flow from the barrel of a gun, it is no surprise that the gains from technological catch-up can not be realised.

Due to the multifarious nature of these institutions and their measurements, little empirical studies have included them in their analyses. For our empirical studies, we do the same thing as other empirical studies in this respect. Since our task is to identify the sources of regional growth difference within China, and most political, financial, and commercial institutions are the same across provinces and regions, it makes sense to concentrate on other aspects of the social capabilities, which vary greatly across provinces and regions, such as the volume of international trade, flow of FDI, and the stock of human capital.

4.6.4 Productivity Increase and Social Capabilities

As presented above, in our analytical framework, there are four factors affecting the rate of technological adoption of an economy, namely, the initial productivity level, the volume of international trade, the flow of FDI, and the stock of human capital. Except for the initial productivity level, the other three factors tend to form some specific cumulative cycle with the growth of productivity in an economy.

As already proposed in Kaldor (1970), as faster-than average growth of productivity tends to be associated with falling relative costs and thereby with a falling relative price, the growth of productivity tends to strengthen the trade competitiveness of goods in an economy and hence, raise its exports. The growth in export income can help remove foreign exchange constraints and facilitate the import of critical capital goods, which will contribute to the adoption of advanced technology from outside economies.

With respect to FDI, not only can FDI stimulate the growth of productivity as a main source of capital accumulation and conduit of technological transfer, but productivity growth in an economy can also affect the inflow of FDI. Rapid economic growth in the host economy will build confidence of overseas investors at the expected profit rate. Additionally, rapid economic growth, accompanied by an increased higher per capita income, will create huge opportunities for both industrial and consumer goods in the host market. All of these factors will stimulate the inward FDI. Furthermore, rapid economic growth will usually create a high level of capital requirement in the host economy, and hence the host economy will demand more FDI by offering confessional terms for FDI to attract overseas investors.

Furthermore, an economy with better economic performance tends to have more resources for investment in the human capital through the investment in its education and training systems and attract more educated persons to immigrate from other economies.

Besides the increase of wage rate, we may treat the initial level of productivity in an economy as another reflection of the “counteracting effects” proposed by Myrdal (1957). Myrdal argued that a prolonged period of economic expansion may have saddled a prosperous region with a very large stock of old capital equipment which is tempting not to discard as rapidly as it would be advantageous in a period of swift technological development. This negative effect of the initial development level of an economy on its following rate of technological progress has also been labelled as the “advantages of backwardness” by proponents of the technological catch-up theory. That is, as a follower catches up, the possibility of making large leaps by replacing superannuated technology with best-practice technology becomes smaller and smaller. A follower’s potential for growth weakens as its productivity level converges towards that of the leader. To be noticed, the negative effects of the increased wage rates and the higher initial productivity level are conditional on other economic factors in our framework. That is, when other factors are the same across economies, then the economy with a higher wage rate or higher initial productivity level tends to have a lower growth rate of productivity.

4.7 Concluding Remarks

In the previous three sections, we have formalized the process of cumulative causation and put forward hypotheses about the underlying factors of productivity increase in an economy. These factors and their relationships with the productivity increase are presented in Figure 4.1.

We can see that mutual causation and interdependence between economic factors are the main characteristics of our analytical framework. In our analytical framework, capital accumulation and technological progress are two driving forces of economic growth. But the distinction between these two forces is just for the convenience of expression. Empirically it makes no sense, because the two forces are interrelated with each other.

The investment in physical capital, consisting of domestic investment and FDI, is mainly driven by the profit rate, which is determined positively by the increase of productivity and negatively by the increase of wage rate. Normally, the wage rate increases with the level of productivity. But when the growth rate of wages is lower than that of labour productivity, a higher profit rate is always expected. The investment may also be affected by state policies for some strategic reasons.

Technological progress may come from experience (or, learning-by-doing) represented by the cumulative production of capital goods, intentional innovative activities, and technological adoption from outside economies. Measures of R&D expenditure and human capital are used as surrogates for all activities which help to promote new and improved products and processes. The inward FDI and international (or, interregional trade) are treated as two effective channels of technological transfer. The rate of technological adoption depends also on the adoptive capability in the host economy, which is represented by the stock of human capital.

In the field of economics, there is always a trade-off between the completeness of descriptive analysis and the testability to statistics. This trade-off can not be avoided in our study as well. Therefore, although there may be other related factors of NIS in an economy affecting its innovative capability and other political, commercial, industrial, and financial institutions affecting its adoptive capability of technology, we concentrate on the relevant factors that are statistically measurable. We argue that, since our task is to identify the sources of regional growth difference within China and most institutions are the same across provinces and regions, such a treatment does make sense empirically.

As proposed by Myrdal, there may be factors inherent in the situation of a centre of economic expansion which tend to retard or, when it has reached a certain level of development, even to reverse the cumulative process. In our framework, these so-called "counteracting effects" of economic expansion include the expansion of wages, which reduces the profit rate, and the higher initial development level, which is detrimental to the technological adoption.

In the next two chapters, with the help of statistical and econometric techniques, the extent to which such a framework is able to explain regional growth patterns in China will be verified empirically to Chinese statistics.

Chapter 5 Sources of Regional Growth Difference and Income Disparity: Hypotheses Test to Chinese Statistics

In the last chapter, we formalized the process of cumulative causation in our analytical framework and proposed some economic factors as the driving forces of productivity increase in an economy. Our analytical framework incorporates some additional dimensionalities relative to previous literature of cumulative causation that deal with the issue of growth difference and income disparity. Specifically, except for the cumulative relationships between capital accumulation and economic growth, we have formalized determinants of technological progress and their cumulative relationships with economic growth and capital accumulation precisely in our framework. In this chapter and the following chapter, the extent to which such a framework is able to explain the regional growth pattern in China will be verified empirically to Chinese statistics.

The rest of this chapter is organised as follows. In the first section, based on our analytical framework, we will outline the main hypotheses about the sources of unbalanced regional development in China during the reform period. In Section 5.2 we will introduce three statistical and econometric techniques adopted by our empirical studies. The three techniques are: (1) the analysis of statistical correlation between productivity increase and relevant economic factors at the regional and provincial levels; (2) the Granger-causality test; and (3) the multiple-regression test. Section 5.3 deals with data issues. In Section 5.4, 5.5, and 5.6 we will apply the above-mentioned three techniques to the test of hypotheses. Section 5.7 gives some concluding remarks.

5.1 Hypotheses about Sources of Regional Growth Difference and Income Disparity in China

The stylised facts described in Chapter 1 indicate that, during the reform period, provinces in the coastal region have experienced higher growth rates than those in the inland region. If mechanisms of economic process in our analytical framework hold, the higher growth rates in the coastal region should be attributed not only to higher rates of capital accumulation, but also to higher rates of technological progress, both of which may result from either the free play of market forces or preferential state policies, or both.

Specifically, the coastal provinces with initial better growth performance at the onset of economic reform tend to fortify and sustain their continuous growth with more favourable profit expectations, higher investment rates, and more abilities to innovate and adopt advanced technology. In the inland provinces, the “backwash effects” have dominated the “spread effects” and “counteracting effects”, which result in deteriorating economic situations and continuing poor economic performance. Therefore, in contrast with neoclassical growth theory and the theory of technological catch-up, which suggest that regional inequality will disappear, the theory of cumulative causation postulates that regional inequality tends to increase rather than decrease when market forces alone are left to decide the outcome.

However, while the poor provinces in the inland region failed to catch up with the rich ones in the coastal region, the initially poor provinces in the coastal region have caught up with the rich three municipalities successfully. Especially, five provinces, i.e. Zhejiang, Fujian, Guangdong, Jiangsu, and Shandong, have had double-digit average annual growth rates, which is much higher than that of the three municipalities.

There are two reasons for such a reversion of the circular and cumulative process. The first one is the “counteracting effects” of economic expansion. As proposed by Myrdal, there may be factors inherent in the situation of a centre of economic expansion which tend to retard or, when they have reached a certain level of development, even to reverse the cumulative process. These so-called “counteracting effects” of economic expansion include the expansion of wages, which reduces the profit rate, and the higher initial development level, which is detrimental to technological adoption. The second reason is the effects of state policies. During the reform period, the gradual strategy of economic reform adopted in China brought about many preferential policies in the coastal provinces, especially in the two provinces of Guangdong and Fujian, where the first four special economic zones (SEZs) were established. We argue that, to some extent, the effects of state policies during the reform period are more considerable than the “counteracting effects”, because both the surplus of labour in China and the huge gap between the domestic technological level and the technological frontier in the world tend to weaken the effects of the latter. Chapter 6 will analyse the effects of state policies on regional growth patterns during the reform period in China detailedly.

5.2 Three Methodologies

To test the hypotheses outlined in the above section, or to verify, to which extent our analytical framework is able to explain the regional growth pattern in China, we adopt three statistical and econometric techniques in our empirical studies. They are: (1) the analysis of statistical correlation between productivity increase and relevant economic factors at the regional and provincial levels; (2) the Granger-causality test; and (3) the multiple-regression test.

If hypotheses are capable of empirical verifications, one would hope to find some sign of them in the aggregate data. Specifically, in the Chinese economic context, since the provinces in the coastal region have experienced continuously higher growth rates than the inland region during the reform period, it is reasonable to expect that, compared with the inland provinces, the coastal provinces have had a higher level of investment rate, profit rate, R&D expenditure, human capital, international trade and FDI during the reform period. Therefore, in Section 5.4, we will firstly present the statistical observations of these relevant factors at the regional and provincial levels, with a view to see whether these factors are correlated with the growth of labor productivity statistically.

However, correlation does not necessarily imply causation in any meaningful sense of that word. The econometric graveyard is full of magnificent correlations, which are simply spurious or meaningless. Interesting examples include a positive correlation between teachers' salaries and the consumption of alcohol and a superb positive correlation between the death rate in the UK and the proportion of marriages solemnized in the Church of England. We use the approach of Granger-causality test to examine the mutual causal relationships between the productivity increase and those relevant factors. Granger-causality test was first developed by Granger (1969) and then further applied by Sims (1972) and others. Now, it is the most widely used operational

definition of causality in econometrics. In Section 5.5, we will describe the methodology of Granger-causality test and apply it in the Chinese economic context.
As reviewed in Chapter 3, most empirical studies on growth issues, such as Barro-style regressions and mixed growth regressions, have based their specifications of econometric equations on the assumption that there is a one-way causal relationship from some variables to productivity increase. However, if there is a bidirectional causal relationship between these variables and productivity increase, statistical estimates of the parameters of any single equation will be liable to serious errors. Under the circumstance of mutual causality and interdependence, it is clear that the relationship between variables can only be represented in a mathematical form by a set of simultaneous equations. In Section 5.6, the multiple-regression of simultaneous equations will be applied to our test of hypotheses. In fact, the application of simultaneous equations as an instrument to deal with the manner of operation of economic forces has already been proposed by Myrdal (1957):

> Ideally the scientific solution of a problem like the Negro problem should thus be postulated in the form of an interconnected set of quantitative equations, describing the movement – and the internal changes – of the system studied under the various influences which are at work. … I submit that the working out of such a complete and quantitative solution should be the aim of our research endeavours.

5.3 Data Issues

The most important and difficult part of the empirical study on the Chinese economy is indeed the preparation of reliable statistical data. Prior to the beginning of the economic reform in 1978, the concepts of modern economic analysis didn’t play a formal role inside the country. As for econometrics, neither was it part of the academic curriculum nor were the statistical materials for empirical model building to be found. In the 80s a significant amount of statistical data gradually began to flow out. But generally speaking, the statistical data of the Chinese economy are unsatisfactory and require careful treatment.

As depicted in Figure 4.1, to carry out our hypotheses tests, we need a database consisting of statistical data for the following nine economic variables, i.e. labour productivity; stock of physical capital or capital stock; domestic investment; FDI; profit rate; wage rate; R&D expenditure; stock of human capital; and international trade. Our database is constructed from a variety of official Chinese sources published by the State Statistical Bureau (SSB). Except the stock of physical and human capital, the statistical data for the other seven variables are reported in the statistical yearbooks or other books published by the SSB. The database is on an annual basis and covers 28 provinces under consideration.

5.3.1 Stock of Physical Capital

Data on the capital stock of China and its regions was not reported in any source. So, in most empirical literature, equivalent measures are constructed using different methods. In general, there are three methods used often in growth literature. The first method assumes that the economy under study is continually at a steady state with a constant capital-output ratio. The second two methods use the standard perpetual inventory method of estimating capital stock with different guesses at the initial capital stock. The advantage of the steady-state estimate is that we do not have to assume anything about the initial capital stock; its disadvantage is that it assumes a constant capital-output ratio. In contrast, the perpetual inventory method requires an initial capital stock number; its strength is that it does not require assumptions about the ratios we want to study.

Steady-state Estimate

The steady-state estimate of the capital stock is based on the assumption that the capital-output ratio is constant, which implies that $dK_t / K_t = dY_t / Y_t$. Consequently, since $dK_t = I_t - s\,K_t$, then $dK_t / K_t = I_t / K_t - s$, where I_t is gross investment and s is the capital's depreciation rate. We also define the growth rate $g_Y = dY_t / Y_t = I_t / K_t - s$. Let the investment rate is $i = I_t / Y_t$, the steady-state capital-output ratio for the economy is

$$k = i / (s + g_Y) \qquad 5.1$$

Given estimates of the investment rate, i, growth rate g_Y, and depreciation rate, s, of the economy, we can compute the steady-state capital-output ratio, hence the capital stock.

Perpetual Inventory Method with Initial Capital being Zero

The standard perpetual inventory method of estimating capital stock uses the formula:

$$K_t = K_{t-1}(1-s) + I_t \tag{5.2}$$

Setting $K_0 = 0$ and having the estimates of depreciation rate, s, we can get the capital stock by accumulating investment series I_t simply. The advantage of this approach is its simplicity. The disadvantages are that (1) this method does not produce a useful time-series of capital stock since the importance of the initial capital-stock estimate diminishes to what may be considered negligible levels very slowly, and (2) we can probably compute a better guess of the initial stock than zero.

Perpetual Inventory Method with Initial Capital estimated

The second perpetual inventory method attempts to derive a better initial capital estimate than zero. The capital stock in the first period K_1 is assumed to be the sum of all past investments:

$$K_1 = \int_{-\infty}^{1} I_t dt \tag{5.3}$$

Since we do not have investment series for the period before $t=1$, it is assumed that, the investment series for the period before $t=1$ have approximately the same exponential time trend q as the investment series for the period $1 \le t \le \tilde{t}$:

$$I_t = I_0 e^{qt} \tag{5.4}$$

Here, I_t is the real gross investment. Substituting I_t in equation 5.3 with the expression of equation 5.4, the capital stock in the first period then is

$$K_1 = \int_{-\infty}^{1} I_t dt = \frac{I_0 e^q}{q} \qquad 5.5$$

I_0 and q are available by linear regression of the following equation:

$$\begin{aligned} &\ln I_t = a + q * t \\ &t = 1, 2, \ldots \tilde{t} \end{aligned} \qquad 5.6$$

The constant term a is $\ln I_0$. The capital stock is then measured using

$$\begin{aligned} &K_t = K_{t-1}(1 - s) + I_t \\ &t = 2, \ldots \tilde{t}, \ldots \end{aligned} \qquad 5.7$$

where K_t is the real capital stock at period t, and s is the depreciation rate.

In our studies, capital stock is calculated using the perpetual inventory method with the initial capital stock being estimated. Specifically, we initiate the capital stock in 1952 by assuming that the real investment growth recorded during the period from 1952 to 1977 extends into the infinite past.[55] Therefore the sample period for the estimation of equation 5.6 is from 1952 to 1978. Having the estimated value of $\ln I_0$ and q, the capital stock in 1952 and hereafter are given by equation 5.5 and 5.7 with a 5 percent depreciation rate assumed.[56] To verify the rationality of the assumption of a 5 percent depreciation rate, we compare the value of depreciation of capital stock calculated by the above-mentioned method with that published officially in the SSB (1999). The values of depreciation of capital stock from these two sources are very similar, which

[55] The reason to assume the same investment trend during the period before the establishment of China and the period from 1952 to 1977, lies in the fact that during both periods the Chinese economy, hence, the investment was troubled by chaos and severe depressions. Since the initiation of economic reform in 1978, investment has increased steadily. Therefore we can not include the time after 1978 into the sample period for the estimation of equation 5.6.

[56] Most empirical literature on growth issues in China, such as Chow (1993) and Wu (2000), have constructed the capital stock using a rate of 5% for capital depreciation.

proves that the method and assumption adopted for the calculation of capital stock in this dissertation are reasonable.

For the calculation of capital stock, we need a series of fixed investment from 1952 to 2001. The construction of such a series deserves a further description. Since we have only the data of fixed investment at a current price from 1952 to 2001 and a price index of investment since 1990, we have to still construct a series of real investment before 1990. We generate a series of investment at the fixed price from the nominal investment series in "National Income used" from 1952 to 1990, which was only available in the CYS before 1993. "National Income used" is composed of two elements, i.e. "Consumption" and "Investment". For "National income Used" and "Consumption", both nominal and real series are available. From these two series, we can then generate a series of real investment.

5.3.2 Stock of Human Capital

The measurement of human capital deserves a further description here. To implement the model, we restrict our focus on human capital investment in the form of education – thus ignoring investment in health, among other things. Despite this narrowed focus, measurement of human capital presents still great practical difficulties.

It would be appropriate to include investment in human capital in conjunction with physical capital investment. We do not do this because data on the actual magnitude of human capital investment are very difficult to construct. To do so for China would be an extremely time consuming and expensive project. We therefore have elected to use the impact of human capital investment as the proxy for the investment itself.

The human capital indicators generally used in the empirical literature are the secondary school enrollment rate and the average schooling years of the population[57]. The school enrollment rate as a measure of investment in human capital has been used in recent international cross-section studies of the empirics of growth (see Barro and Sala-I-

[57] Other variables have been also used as proxies for human capital. For example, in Grundlach (1997), the number of newspapers, magazines and books published divided by the labour force is expected to proxy the accumulated investment in human capital. The assumption underlying this concept is that the provincial supply of written information is correlated with the provincial quantity of human capital.

Martin, 1991, 1992, etc.). The general idea behind this measure is that variations in the fraction of the population devoted to formal education reflect variations in investment in human capital.

In the case of China, we do not have statistics on the average schooling years of the population at provincial levels. In this research, we use three measures of human capital, i.e. (1) the number of labor force having completed secondary education as a proportion to total labor force; (2) the number of people having completed secondary education as a proportion of total population; and (3) the percentage of graduates of primary schools entering secondary schools.

The data for the first and third measures of human capital are available in the statistical yearbooks from 1996 and 1985, respectively. The annual time series of the number of people having completed secondary education can be constructed on the basis of the population census of 1982, which provided information on the population by educational levels and by provinces in that year. Using the annual number of graduates at various educational levels, and making the assumption that there is no “depreciation” of human capital, we construct the second measure for human capital in each province.

5.3.3 Other Data Issues

For the nine variables involved in our empirical studies, the database covers all 28 provinces under consideration. But only part of our database covers the whole reform period since 1978 in all provinces. Specifically, before 1985 no data are available for the geographical distribution of FDI. Provincial data reflecting different provincial investment on R&D activities, as represented either by the ratio of R&D expenditure to GDP or the R&D expenditure per capita, are available only since 1995. Data for the provincial wage rate and profit rate are not available until 1993. As mentioned above, before 1996, 1982, 1985, no data are available for the three measures of human capital at the provincial level respectively.

Furthermore, following the theoretical line, a province can benefit from advanced technology both in foreign countries and in other provinces within China. Since we do not have data on inter-provincial investment and trade activities, we assume at this point that the technological adoption of a province is exclusively from other countries. That means we assume that technological diffusion does not occur among provinces within China. We will relax this assumption and examine the significance of inter-provincial diffusion process until Section 5.6.3.

5.4 Statistical Correlation between Productivity Increase and Relevant Economic Factors

If the mechanisms of economic process in our analytical framework hold in the Chinese economic context, since the provinces in the coastal region have experienced continuously higher growth rates than those in the inland region during the reform period, it is reasonable to expect that, compared with the inland provinces, the coastal provinces have had not only higher rates of capital accumulation, but also more abilities of technological innovation and adoption. Statistically, we should find that the productivity increase is correlated with the statistical observations of the following relevant economic factors, i.e. rate of capital accumulation, domestic investment rate, FDI, profit rate, R&D expenditure, stock of human capital, and volume of international trade. In the next three subsections, we will present the statistical observations of these economic factors at provincial and regional levels and examine the correlated relationships between them and productivity increase.

5.4.1 Productivity Increase and Capital Accumulation

In Table 5.1 we have shown the statistical observations of productivity increase, capital accumulation and other indicators by provinces and regions. In the first column we have listed and divided 28 provinces into two regions. The row of “Average” shows the population-weighted average value of the corresponding economic indicator.

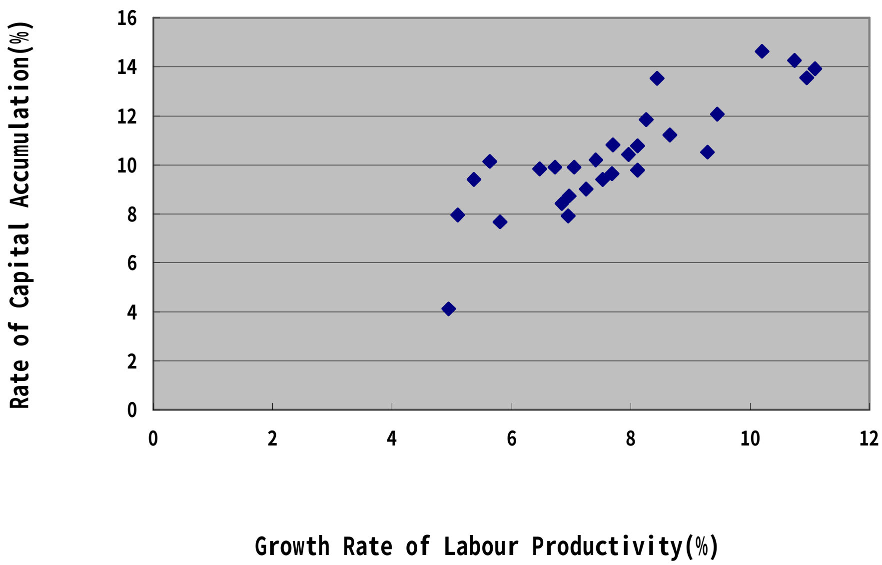
Table 5.1: **Productivity Increase and Capital Accumulation by Provinces and Regions during the Reform Period (1978-2001)**

	Growth Rate of LP (%)	Growth Rate of Capital Stock per capita (%)	Domestic Investment /GDP (%)	FDI/GDP (%)	Profit Rate (%)	Wage Rate (yuan/person)	LP (yuan/person)
Coast:							
Beijing	8.26	11.85	41.34	4.89	18.6	7993	16842
Tianjin	7.96	10.42	37.46	6.52	19.7	6478	13654
Shanghai	8.44	13.53	34.03	5.44	23.7	7170	20698
Hebei	8.11	10.78	29.84	1.03	24.2	3735	6806
Liaoning	6.84	8.42	25.37	2.54	28.4	5035	10734
Jiangsu	11.08	13.93	29.41	4.02	28.0	5436	10923
Zhejiang	10.95	13.56	27.22	1.59	33.7	4773	10229
Fujian	10.19	14.64	26.19	7.91	32.3	5186	10095
Shandong	9.45	12.07	30.12	2.12	33.9	3970	8721
Guangdong	10.74	14.27	28.49	8.85	36.0	6057	12512
Average:	9.58	12.51	29.26	4.49	27.8	5583	12121
Inland:							
Shanxi	6.94	7.92	31.70	0.60	21.2	3067	5943
Jilin	7.24	9.02	26.72	1.20	21.7	4707	7723
Heilongjiang	5.37	9.41	25.80	0.86	25.2	3561	7951
Anhui	7.70	10.81	23.91	0.74	32.3	2642	4870
Jiangxi	8.11	9.784	26.53	1.03	23.3	3228	5044
Henan	7.41	10.21	28.19	0.67	20.3	2669	4324
Hubei	9.28	10.52	24.66	1.23	25.9	4323	7556
Hunan	7.04	9.91	20.79	1.10	25.5	2871	4525
Guangxi	6.47	9.83	25.45	2.20	20.0	2971	4391
IMongolia	7.68	9.64	28.75	0.35	18.7	3740	6337
Sichuan	7.52	9.40	23.75	0.81	24.7	2178	3993
Guizhou	5.81	7.68	31.80	0.34	16.6	1622	2518
Yunnan	6.72	9.91	30.97	0.37	27.0	1811	3960
Shaanxi	6.96	8.72	34.38	1.49	17.1	2598	4311
Gansu	4.94	4.12	30.02	0.37	20.7	1720	3089
Qinghai	5.09	7.95	44.62	0.22	12.2	3169	5054
Ningxia	5.63	10.14	40.58	0.31	15.1	2507	4544
Xinjiang	8.65	11.22	41.94	0.26	17.3	4319	8342
Average:	7.21	9.50	27.14	0.88	23.3	2859	5004

Note: LP is the abbreviation of labour productivity.
Sources: Comprehensive Statistical Data and Materials on 50 Years of New China, SSB (1999); China Statistical Yearbook (SSB, 2002, 2001, 2000) and author's calculations

The second and third columns show the growth rate of labor productivity and capital stock per capita by provinces and regions during the period 1978-2001. We put the data in these two columns into a scatter diagram, which brings the correlated relationship between these two variables into focus. Figure 5.1 shows clearly that the growth rate of labour productivity and the growth rate of capital stock per capita are positively correlated. The correlation coefficient between these two variables is 0.86.

Figure 5.1: Productivity Increase and Capital Accumulation by Provinces during the Reform Period



In the fourth and fifth columns of Table 5.1 are the ratios of domestic fixed investment and FDI to GDP during the reform period 1978-2001. From these two columns we know that the different rates of capital accumulation by provinces and regions result from the uneven distribution of domestic investment and FDI among provinces and regions. The coastal provinces have attracted more domestic investment and FDI than the inland provinces for capital accumulation.

The average level of profit rate, wage rate and labor productivity by provinces and regions during the period from 1993 to 2001 are shown in the last three columns in Table 5.1. In Chapter 4, we have proposed that, except for the influence of state policies, the investment activities are driven by the profit rate. Since we will analyse the influence of state policies on regional economic development detailedly in Chapter 6, here we examine only the statistical correlations between the profit rate, capital accumulation and productivity increase. It is obvious that the provinces with a higher level of profit rate have attracted more investment inflows. As a result, these provinces have achieved higher rates of capital accumulation and productivity increase.

Figure 5.2: Capital Accumulation and Profit Rate by Provinces during the Reform Period

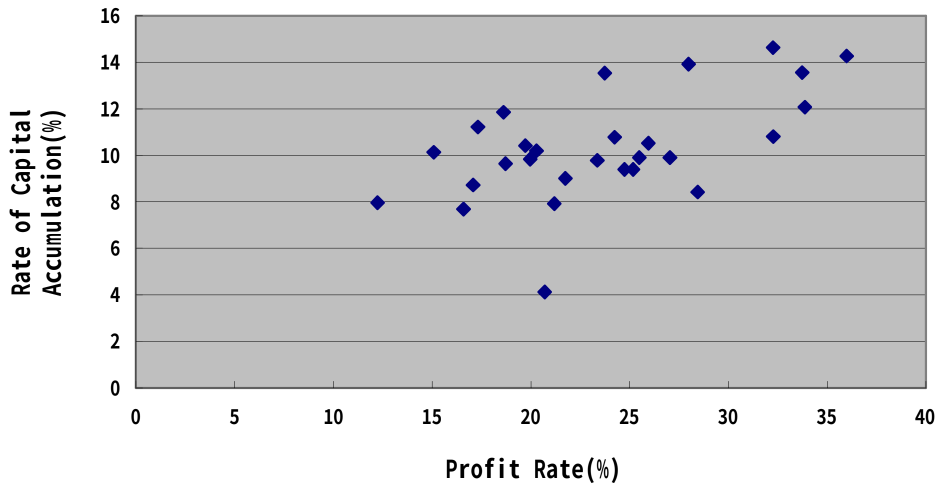
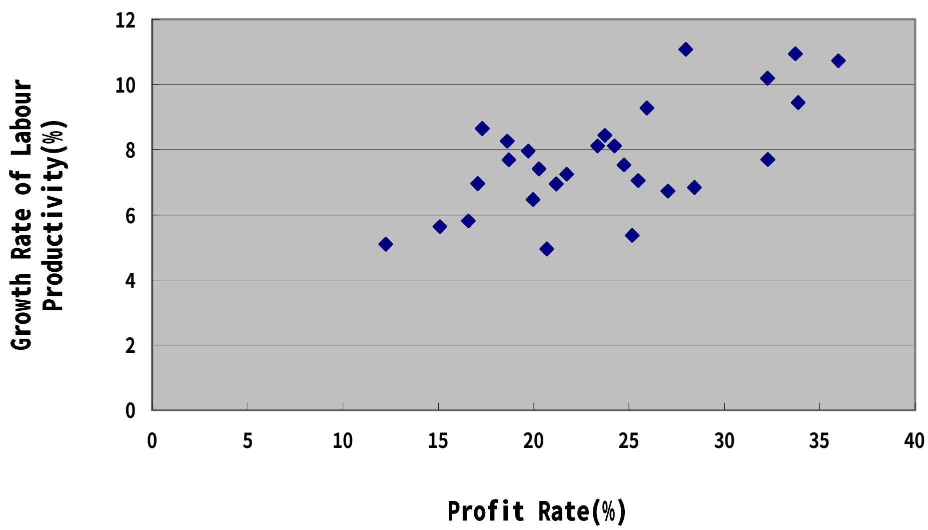


Figure 5.3: Profit Rate and Productivity Increase by Provinces during the Reform Period



As displayed in Figure 5.2 and 5.3, the level of profit rate in a province is positively correlated with the rates of capital accumulation and labor productivity. The correlation coefficients are 0.57 and 0.67 respectively. As depicted in Figure 4.1, the correlation between the profit rate and productivity increase can also be interpreted by the following fact that, as long as the increase of wage rate is less than that of labor productivity, then the increase of productivity may also mean a higher profit rate. As shown in the last two columns in Table 5.1, although a province with a higher level of labor productivity tends to have a higher wage rate, the disparity of wage rates among provinces and regions are less than that of labor productivity, which means that the higher productivity is translated into lower costs rather than higher wages. Therefore, as productivity rises, so do profits and investment. And the economy moves on to a path of self-sustaining growth, as predicted by our analytical framework.

5.4.2 Productivity Increase and Technological Innovation

Besides the capital accumulation, technical progress is another driving force of productivity increase. Since we have argued in Chapter 3 that it is impossible to measure the technical progress or TFP using the growth accounting exercise, we will examine indirectly the correlative relationships between productivity increase and the economic factors underlying the technical progress. In this and the following subsections we consider the factors contributing to the technological innovative and adoptive abilities of an economy successively.

Technological innovations, i.e. improved or new products and processes, may come from either the experience or intended R&D activities, or both. The first factor, i.e. experience or learning by doing is perhaps not so difficult to apply empirically. In growth literature, cumulative gross investment, i.e., cumulative production of capital goods was taken as an index of experience. Basically, we should expect the extent of learning by doing and, hence productivity increase, to be a function of capital accumulation. The correlative relationship between productivity increase and capital accumulation has been confirmed by Figure 5.1.

In empirical studies, measures of R&D expenditure and human capital were very frequently used as surrogates for all those factors contributing to the productivity of R&D activities. In Table 5.2 we have shown the statistical observations of productivity increase, R&D expenditure and human capital by provinces and regions.

Table 5.2: **Productivity Increase, R&D Expenditure and Human Capital**

	Growth Rate of LP (%)	R&D/GDP (%)	R&D per capita (yuan/person)	Human Capital(1) (%)	Human Capital(2) (%)	Human Capital(3) (%)
Coast:						
Beijing	8.26	9.29	1154	90.01	53.94	98.85
Tianjin	7.96	2.64	267	75.71	77.98	95.85
Shanghai	8.44	3.68	705	84.28	80.19	99.58
Hebei	8.11	0.71	32	62.45	65.67	84.06
Liaoning	6.84	1.78	121	70.32	78.06	91.94
Jiangsu	11.08	1.46	112	59.49	64.68	85.33
Zhejiang	10.95	0.72	61	53.41	68.29	88.38
Fujian	10.19	0.51	37	48.62	56.91	75.88
Shandong	9.45	1.09	70	57.31	63.74	81.48
Guangdong	10.74	1.03	95	61.69	71.61	85.59
Average:	9.58	1.40 (1.07*)	129 (75*)	66.33	68.12	88.69
Inland:						
Shanxi	6.94	1.12	41	68.05	73.37	83.05
Jilin	7.24	1.41	64	66.94	76.13	91.12
Heilongjiang	5.37	1.07	56	67.78	75.26	86.77
Anhui	7.70	0.88	31	48.48	52.29	78.10
Jiangxi	8.11	0.73	22	50.28	61.71	75.56
Henan	7.41	1.01	31	62.25	59.86	73.60
Hubei	9.28	1.55	71	57.93	65.41	79.22
Hunan	7.04	0.97	33	55.86	70.06	78.42
Guangxi	6.47	0.72	22	50.93	61.01	75.43
Imongolia	7.68	0.64	22	58.50	66.09	84.13
Sichuan	7.52	1.93	61	44.83	64.59	#
Guizhou	5.81	0.88	15	36.25	45.03	63.51
Yunnan	6.72	0.75	23	32.45	44.28	65.35
Shaanxi	6.96	3.93	121	57.32	64.62	84.58
Gansu	4.94	1.93	49	45.34	50.83	82.11
Qinghai	5.09	1.41	48	36.14	50.98	89.19
Ningxia	5.63	1.41	45	52.28	53.31	88.56
Xinjiang	8.65	0.73	35	56.62	63.56	82.81
Average:	7.21	1.30	45	52.93	61.94	77.37

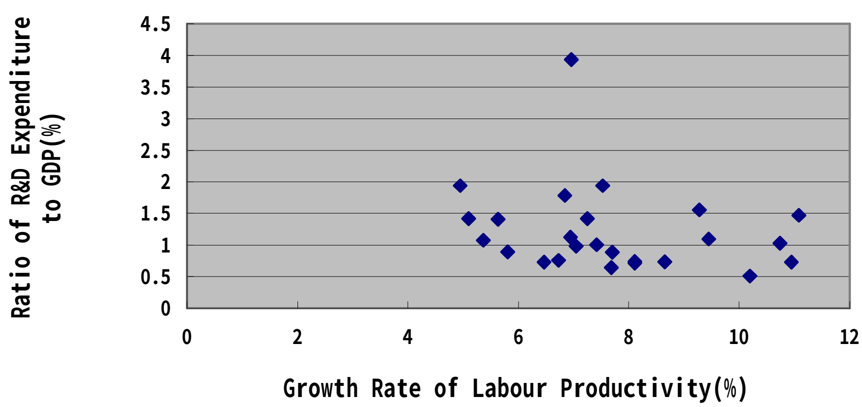
Note: the value with * is the average level of R&D expenditure in the provinces except the three municipalities of Beijing, Tianjin and Shanghai.
Sources: see Table 5.1

We use the ratio of R&D expenditure to GDP and R&D expenditure per capita to reflect different provincial investment on R&D activities. The third and fourth columns are the average value of provincial and regional R&D expenditure during the period 1995-2001.

Compared with other provinces, the three municipalities under the direct control of the central government, i.e. Beijing, Tianjin, and Shanghai, have possessed much more

R&D resources. To some extent, this fact should be explained by administrative rather than economic reasoning, because most of the national institutions of R&D and universities are located in these three municipalities administratively. In other provinces except these three municipalities, although the coastal provinces with higher rates of productivity increase have higher levels of R&D expenditure per capita than the inland provinces on average, the role of R&D activities on economic growth is limited in the provinces. For example, the ratio of R&D expenditure to GDP and the level of R&D expenditure per capita are lower in some provinces with two digital growth rates than other provinces in the coastal region and even most provinces in the inland region. The ratio of R&D expenditure to GDP in Zhejiang and Fujian of the coastal region are 0.72% and 0.51%, respectively. The values of R&D expenditure per capita in these two provinces are 61 and 37 yuan/person, respectively. The value of the same indicators in Shaanxi and Gansu of the western region are 3.93% and 1.93%, 121 and 49 yuan/person, respectively. However, the economic growth rates of Zhejiang and Fujian are much higher than Shaanxi and Gansu. Figure 5.4 has confirmed this finding.

Figure 5.4: Producitivity Increase and R&D Expenditure by Provinces during the Reform Period

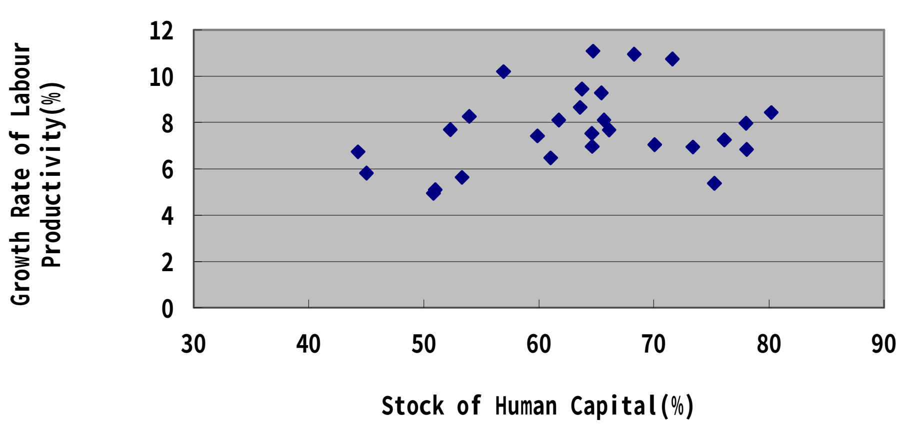


In Figure 5.4 we have depicted the correlative relationship between productivity increase and the ratio of R&D expenditure to GDP in the provinces except Beijing, Tianjin and Shanghai. There isn't an obvious positive correlative relationship between these two variables. The coefficient of correlation between them is -0.23.

The stock of human capital in a province are represented by three measures, i.e. (1) the number of labour force having completed secondary education as a proportion to total labour force; (2) the number of people having completed secondary education as a proportion of total population; and (3) the percentage of graduates of primary schools entering secondary schools. The last three columns are the average stock of human capital in provinces and regions during the period 1996-2001, 1982-2001 and 1985-2001 respectively.

As shown in Table 5.2, at the regional level, the region with more people (labour force) having completed secondary school and with a higher enrolment rate of secondary schools tend to have higher growth rates of labour productivity. The correlation coefficient between the growth rate of labour productivity and the three measures of human capital are 0.25, 0.28 and 0.08 respectively. Since the correlative relationship between productivity increase and the third measure of human capital is not as obvious as that of the other two measures and the sample period of the first measure is too small for any econometric analysis, we adopt only the second measure of human capital in the subsequent empirical analyses. Figure 5.5 depicts the correlative relationship between productivity increase and the stock of human capital as represented by the number of people having completed secondary education as a portion of total population.

Figure 5.5: Productivity Increase and the Stock of Human Capital by Provinces during the Reform Period



As reflected by the value of the correlative coefficient, the correlative relationship between productivity increase and the measure of human capital are also not as obvious as that between productivity increase and physical capital at the provincial level. The stock of human capital is lower in most provinces with two digital growth rates than other provinces in the coastal region and even most provinces in the inland region. But, if we consider the fact that many of the educated labor force in the inland region have migrated to the coastal provinces during the last two decades, which is not reflected in the statistical data in Table 5.2, we should conclude that the stock of human capital may play an important role to promote economic growth in the coastal provinces.

5.4.3 Productivity Increase and Technological Adoption

Except for the domestic innovative capabilities, many economists view different abilities of technological adoption as an important source of large disparity in technological progress across countries, especially technological-backward developing countries. Hence, many mechanisms which might advance the flow of knowledge from one economy to the next should provide a positive, or in the least, a non-negative spur to the economic growth.

As presented in Chapter 4, the mechanisms of technological adoption involve the so-called “advantage of backwardness” and “social capabilities”. The term “advantage of backwardness” means that the further an economy is from the technological frontier, the greater the rate of technical progress possible from such adoption. This implies that there is a tendency of income convergence across economies through technological diffusion. But the process of technological diffusion and income convergence is not automatic and unconditional. “Social capabilities” determine the extent to which an economy can take advantage of the advanced technologies existing in the advanced economies. We use international trade, FDI inflows, and the stock of human capital as proxies for social capabilities in an economy. Social capabilities at provincial and regional levels are summarized in Table 5.3.

Table 5.3: **Productivity Increase and Social Capabilities by Provinces during the Reform period**

	Growth Rate of LP (%)	y(1978) (yuan/person)	FDI/GDP (%)	FDI per capita (yuan/person)	Trade/ GDP (%)	Trade per capita (yuan/person)	Human Capital(2) (%)
Coast:							
Beijing	8.26	3971	4.89	628	54.28	9105	53.94
Tianjin	7.96	3480	6.52	752	43.96	4312	77.98
Shanghai	8.44	4573	5.44	942	50.82	8854	80.19
Hebei	8.11	1601	1.03	56	8.35	265	65.67
Liaoning	6.84	3316	2.54	222	26.73	1420	78.06
Jiangsu	11.08	1452	4.02	349	17.47	1329	64.68
Zhejiang	10.95	1324	1.59	125	15.89	1333	68.29
Fujian	10.19	1530	7.91	594	51.66	1869	56.91
Shandong	9.45	1629	2.12	131	14.88	730	63.74
Guangdong	10.74	1624	8.85	750	91.77	6682	71.61
Average:	9.58	1907	4.49	340	32.58	2590	68.12
Inland:							
Shanxi	6.94	1722	0.60	30	4.96	160	73.37
Jilin	7.24	2361	1.20	69	10.05	368	76.13
Heilongjiang	5.37	3226	0.86	64	7.01	295	75.26
Anhui	7.70	1210	0.74	26	5.07	150	52.29
Jiangxi	8.11	1216	1.03	38	5.72	133	61.71
Henan	7.41	1059	0.67	24	3.64	87	59.86
Hubei	9.28	1460	1.23	74	6.30	206	65.41
Hunan	7.04	1337	1.10	43	5.37	134	70.06
Guangxi	6.47	1350	2.20	70	9.50	202	61.01
IMongolia	7.68	1628	0.35	17	6.30	223	66.09
Sichuan	7.52	1057	0.81	26	4.36	121	64.59
Guizhou	5.81	857	0.34	6	3.69	61	45.03
Yunnan	6.72	1125	0.37	12	6.78	166	44.28
Shaanxi	6.96	1253	1.49	48	6.76	191	64.62
Gansu	4.94	1358	0.37	8	3.92	84	50.83
Qinghai	5.09	2276	0.22	11	4.07	116	50.98
Ningxia	5.63	1655	0.31	13	7.46	210	53.31
Xinjiang	8.65	1623	0.26	15	7.33	303	63.56
Average:	7.21	1387	0.88	35	5.64	160	61.94

Sources: see Table 5.1

The third column in Table 5.3 is the initial level of labor productivity in 1978. Obviously, at the national level, there is no absolute income convergence among regions and provinces. But within the coastal region, the provinces with lower initial levels of labor productivity (such as, Zhejiang, Fujian, Shandong, Guangdong, Jiangsu) have successfully achieved higher growth rates of labor productivity, because they have more adoptive capabilities for advanced technologies compared with the provinces in the inland region, which is reflected by the statistical observations of FDI, international trade and human capital at the provincial levels.

The fourth and fifth columns in Table 5.3 are the ratio of FDI inflow to GDP and the level of FDI per capita respectively during the period 1985-2001 and the sixth and seventh columns are the ratio of international trade to GDP and the level of international trade per capita respectively during the period 1978-2001. Obviously, there was a highly uneven geographical distribution of FDI and international trade during the reform period, which corresponds with the distribution of growth performance. The correlation coefficient between the growth rate of labor productivity and the ratio of FDI to GDP is 0.58. The correlation coefficient between the growth rate of labor productivity and the ratio of international trade to GDP is 0.51. Hence, it is reasonable to conclude that FDI and international trade might provide a positive spur to the economic growth.

5.5 Granger-causality Test

The statistical analyses in Section 5.4 indicate that there are correlative relationships between the growth of labor productivity and the proposed economic factors by our analytical framework, i.e. the rate of capital accumulation, R&D expenditure, human capital, inflow of FDI and international trade. However, correlation does not necessarily imply causation in any meaningful sense of that word. And it can not tell causal directions between two economic variables statistically. Therefore, until now, we have not ascertained the mutual causal relationships between the growth of labor productivity and these economic factors. In this section, we use the approach of Granger-causality test to accomplish this task.

5.5.1 Methodology of Granger-causality Test

Granger-causality analysis was first developed by Granger (1969) and then further applied by Sims (1972) and others. Now, it is the most widely used operational definition of causality in econometrics.

Standard Granger-causality Test

Granger (1969) defined the causality such that *x* causes *y* if the prediction of *y* can be improved with the help of past values of *x*, and vice versa. Based upon the definition of Granger causality, a simple bivariate autoregressive model is specified as:

$$y_t = c + \sum_{i=1}^{p} a_i y_{t-i} + \sum_{j=1}^{q} b_j x_{t-j} + u_t \qquad 5.8$$

or,

$$x_t = c + \sum_{i=1}^{r} g_i x_{t-i} + \sum_{j=1}^{s} d_j y_{t-j} + v_t \qquad 5.9$$

where y and x are analysed variables; u and v are serially uncorrelated white noise residuals; p , q , r and s are lag lengths for each variable in each equation. To determine the causal orderings, the Granger test employs the F-statistics. The reported F-statistics is the Wald statistics for the joint hypothesis:

$$b_1 = b_2 = \ldots b_q = 0 \qquad 5.10$$

or,

$$d_1 = d_2 = \ldots d_s = 0 \qquad 5.11$$

The null hypothesis is therefore that x does not Granger-cause y in the first regression and that y does not Granger-cause x in the second regression. Granger causality may run from x to y if the past values of x have significant effects on y in equation 5.8. For the one-way causality from x to y, a sufficient condition would be that the effects of y should be insignificantly different from zero in equation 5.9, but not in equation 5.8. A feedback relationship can be supported if the null is rejected in both equations.

Granger-causality test can be run in EViews either in an object of “Group” or “Equation” (“Pool”)[58]. The object of “Group” consists of two series of considered variables x and y. As you select the view of “Granger Causality” in this object, you will first see a dialog box asking for the number of lags to use in the test regressions. In general it is better to use more lags, since the theory is couched in terms of the relevance of all past information. You should pick a lag length, l, that corresponds to reasonable beliefs about the longest time over which one of the variables could help predict the other. EViews runs bivariate regressions of the form for all possible pairs of (x, y) series in the “Group”:

$$y_t = c + \sum_{i=1}^{l} a_i y_{t-i} + \sum_{j=1}^{l} b_j x_{t-j} + u_t \qquad 5.8'$$

and

$$x_t = c + \sum_{i=1}^{l} a_i x_{t-i} + \sum_{j=1}^{l} b_j y_{t-j} + v_t \qquad 5.9'$$

The reported F-statistics is the Wald statistics for the joint hypothesis:

$$b_1 = b_2 = ...b_l = 0 \qquad 5.10'$$

Obviously, the selection of lag lengths in these two equations is considerably arbitrary if we use the “Group” object to run the Granger-causality test. An alternative is to run the Granger-causality test using an object of “Equation” or ”Pool”, so that we can select the optimal lag lengths for equation 5.8 and 5.9 using some statistical methods.

Optimal Lag Lengths

Because economic theory is often not very explicit about the lag lengths in time series relationships, atheoretical statistical methods that allow data themselves to select

[58] The object “Equation” is used for the Granger-causality test of time series data. The object “Pool” has to be used when panel data are adopted in the Granger-causality test.

appropriate lag lengths are often used in the literature (e.g. Hsiao, 1979, 1981; Jin, 2002). The following three methods can be used to select appropriate lag lengths for x and y in equation 5.8 and 5.9, i.e. Akaike Info Criterion (AIC), Schwarz Criterion (SC) and Final Prediction Error (FPE) Criterion. Both the value of AIC and SC are reported by the output of regression procedures if the "Equation" object in EViews is used, whereas the value of FPE has to be calculated manually. As a user of each criterion, you select the equation specification with the smallest value of the criterion.

Specifically, taking equation 5.8 for example, the AIC and SC are defined as:

$$AIC = -2L/T + 2k/T \qquad 5.12$$

$$SC = -2L/T + k\log T/T \qquad 5.13$$

where k is the number of estimated parameters, T is the total number of observations used, and L is the value of the log likelihood function using the k estimated parameters.

The FPE is then defined as:

$$FPE(p,q) = \frac{(T+p+q+1)}{(T-p-q-1)} \times RSS(p,q)/T \qquad 5.14$$

where $RSS(p,q)$ is the residual sum of squares estimated with p lags of variable y and q lags of variable x. The first term on the right hand side measures an estimation error and the second term measures a modelling error. As indicated in Judge *et al.* (1985), an intuitive reason for using the FPE criterion is that longer lags increase the first term but decrease the $RSS(p,q)$ of the second term. These two opposing forces are balanced optimally where their product reaches its minimum.

Nonstationarity and Cointegration

Recent development of econometric analysis is associated with the concept of cointegration, the existence of a long-run equilibrium relation between two nonstationary series[59]. Nonstationarity of time series has always been regarded as a problem in econometric analysis. It has been shown in a number of theoretical works that, in general, the statistical properties of regression analysis using nonstationary time series are dubious. If time series are nonstationary, one is likely to finish up with a model showing promising diagnostic test statistics even in the case where there is no sense in the regression analysis.

Failure to account for nonstationarities of time series has far-reaching consequences in interpreting the Granger-causal relationship as well. Engle and Granger (1987) have shown that, if the two time series are nonstationary and appear to be cointegrated, the above-mentioned standard Granger-causality tests are mis-specified and the causality has to be investigated within the framework of an error correction model which incorporates the information provided by cointegration relationships into causality analysis.

A series is defined as stationary if it has a finite mean, finite variance and finite covariance, all of which are independent of time. If one or more of the conditions above are not fulfilled, then a series is nonstationary[60]. A convenient way to achieve stationarity is to difference a nonstationary series one or more time. In this context, the concept of an integrated series is defined following Engle and Granger (1987). A nonstationary series y_t which can be transformed to a stationary sereis by differencing d times is said to be integrated of order d, normally denoted as $y_t \sim I(d)$. Thus, for example, if $y_t \sim I(1)$, the first difference of y_t achieve stationarity, if $y_t \sim I(2)$, the first difference of the first difference of y_t achieve stationarity, this operation will be termed as second (order) differencing.

[59] For a complete description of the issues concerning cointegration, please refer to Charemza and Deadman (1997).

[60] A quite simple example of nonstationarity is as follows. Suppose time series y_t is a random walk series, i.e. $y_t = y_{t-1} + u_t$ and $u_t \sim N(0, d^2)$. If $y_0 = 0$, we have $y_t = \sum_{i=1}^{t} u_i$ and $Var(y_t) = td^2$. As $t \rightarrow$ infinite, $Var(y_t)$ $\rightarrow$ infinite. Therefore, y_t is nonstationary.

Before any sensible regression analysis can be performed, it is essential to identify the order of integration of each variable. A unit root test can be conducted to evaluate whether the time series used are stationary or nonstationary. In EViews, we use the augmented Dickey-Fuller (ADF) method developed by Dickey and Fuller (1979) to perform the unit root test.

However, nonstationary individual series can be cointegrated if the two nonstationary individual series are combined together to create a new stationary time series. In such a case, the formulation in differences may cause model misspecification because a linear combination of nonstationary individual series may itself be stationary in levels. Therefore a cointegration test is also necessary. To be noticed, if two variables are both integrated time series, then, only if their orders are the same, can they be cointegrated. EViews implements the cointegration test using the methodology developed by Johansen (1991, 1995).

In summary, when two variables x and y are both stationary, then the above-mentioned standard Granger-causality test can be used directly to examine the causal relationships between these two variables. When one or both of them are nonstationary but they are not cointegrated, the nonstationary variables have to be converted to be stationary by differencing one or more time, before the standard Granger-causality test can be used to examine the causal relationships. In this case, the variables x and y will enter equation 5.8 and 5.9 with their differenced values. If x and y are nonstationary and appear to be cointegrated, the causality has to be investigated within the framework of an error correction model which incorporates the information provided by cointegration relationships into causality analysis.

5.5.2 Results of Granger-causality Test

In this subsection, we will apply the econometric technique of Granger-causality test to examine the existence of the mutual causal relationship between the growth of labor productivity and the proposed relevant variables by our analytical framework, i.e. the rate of capital accumulation, R&D expenditure, human capital, inflow of FDI and international trade. Specifically, we will examine the existence of the mutual causal relationship between five pairs of variables, i.e. (1) the growth rate of labor productivity

(g_{LP}) and the growth rate of capital stock per capita (g_k); (2) g_{LP} and the ratio of R&D expenditure to GDP (rd); (3) g_{LP} and the stock of human capital (H); (4) g_{LP} and the ratio of FDI inflow to GDP (fdi); and (5) g_{LP} and the growth rate of international trade per capita ($trade$). The reason for selecting the ratio and growth rate as the measure for each economic variable is to avoid the problem of dimension.

Before the performance of the Granger-causality test, we have to identify the order of integration of each variable by the unit root test. Except that H is integrated of order one, all other five variables are stationary. Therefore, it is impossible that g_{LP} is cointegrated with the other five variables and it is better to use the first difference of H in the Granger-causality test.

As previously mentioned, part of our database is available only for a short period during the reform period, which makes the sample size small for each province[61]. In order to increase the sample size and generalize results across cross-sectional units, we perform the Granger-causality test using the panel data. The results of the Granger-causality test for each pair of variables are represented in Table 5.4. The first column in Table 5.4 indicates the pair of variables under consideration. The variable behind the arrow is the dependent variable. The second and the third columns are the independent variables with lag lengths determined by the FPE criterion and their coefficients with t-Statistics. The last column is the value of the F-Statistics. The results of the Granger-causality test show that there are mutual causal relationships between g_{LP} and g_k , fdi , $trade$. There is no casual relationship between g_{LP} and rd .[62] Between g_{LP} and the first difference of H , there exists no causality but between g_{LP} and the level of H there exists a mutual causal relationship.

[61] Suppose that k denotes the number of estimated parameters (including that of the constant term) and T denotes the sample size, i.e. the total number of observations used. To achieve econometric statistics of regression, T should be greater than k +1; however, to achieve reliable econometric statistics of regression, T should be at least greater than 3(k +1).

[62] We have also performed the Granger-causality test between the growth rate of labor productivity and the growth rate of R&D expenditure per capita. There isn't any causal relationship between these two variables either.

Table 5.4: **Results of Granger-causality Test**

Pair of Variables	Independent Variables	Coefficients and t-Statistics	F-Statistics
$g_{LP} \rightarrow g_k$	g_{LP} (L1) g_k (L1) g_k (L2)	0.0703(8.8351)* 0.9994(4.4495)* -0.2217(-5.8437)*	67.7533*
$g_k \rightarrow g_{LP}$	g_{LP} (L1) g_k (L1) g_k (L2)	0.3016(7.2854)* 0.4685(4.2963)* -0.2938(-2.9580)*	45.74092*
$g_{LP} \rightarrow rd$	g_{LP} (L1) g_{LP} (L2) rd (L1) rd (L2)	-0.03647(-0.4212) 0.0155(0.2058) 1.3509(14.8214)* 0.9596(4.5957)*	1.3908
$rd \rightarrow g_{LP}$	g_{LP} (L1) rd (L1) rd (L2) rd (L3)	0.2869(2.9519)* 0.0242(0.5373) -0.2797(-0.3067) 0.3082(0.1744)	1.9411
$g_{LP} \rightarrow d(H)$	g_{LP} (L1) $d(H)$ (L1)	-0.0002(-0.0032) -0.0826(-0.9638)	0.4674
$d(H) \rightarrow g_{LP}$	g_{LP} (L1) g_{LP} (L2) $d(H)$ (L1)	0.2623(2.8996)* 0.1583(1.9568)** 0.0057(0.0524)	0.9520
$g_{LP} \rightarrow fdi$	g_{LP} (L1) g_{LP} (L2) fdi (L1) fdi (L2)	0.0726(4.9250)* -0.0462(-3.2107)* 1.1106(22.4106)* -0.1934(-4.0368)*	82.9839*
$fdi \rightarrow g_{LP}$	g_{LP} (L1) fdi (L1) fdi (L2)	0.4428(9.9272)* 0.6063(3.7766)* -0.4393(-2.8225)*	65.1398*
$g_{LP} \rightarrow trade$	g_{LP} (L1) g_{LP} (L2) $trade$ (L1)	0.476(5.0528)* 0.0832(9.0734)* 0.9700(62.4459)*	14.402*
$trade \rightarrow g_{LP}$	g_{LP} (L1) $trade$ (L1)	0.3388(9.1546)* 0.0241(3.6777)*	60.6685*
$g_{LP} \rightarrow H$	g_{LP} (L1) H (L1) H (L2)	0.0241(2.1916)* 0.7420(14.1471)* 0.8330(8.3753)*	22.1881*
$H \rightarrow g_{LP}$	g_{LP} (L1) H (L1)	0.4653(11.5031)* 0.0535(2.8955)*	79.8711*

Notes: L1, L2…indicate the lagged term which is determined by FPE criterion; the values in the parentheses are the reported t-Statistics; * (**,***) indicates significant at the 1% (5%, 10%) significance level.

5.6 Multiple-regression Test

The Granger-causality tests performed above have revealed that there exist mutual causal relationships between the growth rate of labor productivity and the economic variables proposed by our analytical framework, i.e. the rate of capital accumulation, FDI inflows, the stock of human capital, and international trade. As reviewed in Chapter 3, most empirical studies on growth issues, such as the Barro-style and mixed growth regressions, have based their specifications of growth equations on the assumption that there is a one-way causal relationship from some variables to productivity increase. However, if there are bidirectional causal relationships between these variables and productivity increase, statistical estimates of the parameters of any single equation will be liable to serious errors. Under the circumstance of mutual causality and interdependence, it is clear that the relationship between variables can only be represented in a mathematical form by a set of simultaneous equations. In this section we apply the system of simultaneous equations as an instrument to represent the manner of operation of economic forces proposed in our analytical framework and test its validity by the econometric technique of multiple-regression.

5.6.1 Specification of Equations and Estimation Method

The specifications of simultaneous equations are mainly based on our analytical framework, as depicted in Figure 4.1, and the results of the Granger-causality tests in Section 5.5. Specifically, we estimate the following five equations simultaneously:

$$g_{LP_{(i,t)}} = a_{10(i)} + a_{11} g_{k_{(i,t)}} + a_{12} H_{(i,t)} + a_{13} fdi_{(i,t)} + a_{14} trade_{(i,t)} + a_{15} y_{(i,t-1)} + u_{1(i,t)} \qquad 5.15$$

$$g_{k_{(i,t)}} = a_{20(i)} + a_{21} g_{LP_{(i,t)}} + a_{22} dummy_{(i,t)} + u_{2(i,t)} \qquad 5.16$$

$$H_{(i,t)} = a_{30(i)} + a_{31} g_{LP_{(i,t)}} + u_{3(i,t)} \qquad 5.17$$

$$fdi_{(i,t)} = a_{40(i)} + a_{41} g_{LP_{(i,t)}} + a_{42} dummy_{(i,t)} + u_{4(i,t)} \qquad 5.18$$

$$trade_{(i,t)} = a_{50(i)} + a_{51} g_{LP_{(i,t)}} + a_{52} dummy_{(i,t)} + u_{5(i,t)} \qquad 5.19$$

In these equations, g_{LP} is the annual growth rate of labor productivity, g_k is the annual growth rate of capital stock per capita, H is the number of people having completed secondary education as a proportion of total population, fdi is the ratio of FDI inflows to GDP, $trade$ is the annual growth rate of international trade per capita. The pair of (i,t) represents the cross-section and temporal dimensions of the panel of provinces. y_{t-1} is the real per capita GDP for the preceding period, which is used to reflect the "advantage of backwardness", that is, the further a province is from the technological frontier at the outset, the faster it grows. $dummy$ is a dummy variable coded to take the value of one if the province is in the coastal region, and the value of zero otherwise. The inclusion of such a dummy variable into the equations for the capital accumulation, FDI and international trade is based on the belief that the higher growth rates of domestic investment, FDI inflows and international trade experienced by the coastal provinces should be not only ascribed to their growth performance of labor productivity but also to the influences of state policies with obvious preferences to the coastal provinces. Except that for y_{t-1}, signs of the coefficients for all the variables are expected to be positive.

The availability of provincial data enables us to implement both cross-section regression and panel regression. In our view, the use of cross-section data has two shortcomings. Firstly, the use of cross-section data makes it impossible to control for unobserved economy-specific differences, possibly biasing the results. Secondly, long run averages or initial values for some variables, for example, the inflow of FDI, ignore the important changes that have occurred over time, particularly for a transitional economy. Therefore, it is more proper to use panel dataset, which pools cross-section and time series data, as an alternative approach. Given the small size of the sample (28 observations, when using cross-section regression), it is also preferable to use the database in the form of a panel, so that the statistical analysis will take into account as much of the available information as possible.

Many authors use an annual panel in their research. However, one major problem with using annual data to identify the determinants of long run growth is that short term or cyclical fluctuations could affect the observed relationship between policy variables and growth. Consequently, in our research, we intend to compute the five-year average for

1985 through 2001 and make regression of the equations based on a five-year panel database. Consequently, we have three five-year average observations for each of the 28 provinces. All estimations are carried out with the help of EViews 3.1. Specifically, the simultaneous equations based on panel database are estimated in an object of “System” in the EViews.

5.6.2 Regression Results

Table 5.5 contains the results of econometric estimation. All the independent variables in each equation yield the expected signs at a 1% or 5% significance level. The results have confirmed the conclusions of our analytical framework that economic factors, such as capital accumulation, human capital, FDI inflows and international trade, have positive effects on economic growth; the relationships between the economic performance and these economic factors are mutual causal and interdependent.

Table 5.5: **Results of Simultaneous Estimations (1985-2001)**

Dependent Variables	Independent Variables and Coefficients				
g_{LP}	g_k 0.4308 (7.5096)*	H 0.0347 (1.9022)**	fdi 0.3212 (5.1081)*	$trade$ 0.0067 (2.2358)**	y_{t-1} -0.0007 (-1.9071)**
g_k	g_{LP} 0.2663 (10.8655)*	$dummy$ 2.5064 (9.7757)*			
H	g_{LP} 0.4491 (4.4124)*				
fdi	g_{LP} 0.2082 (7.4713)*	$dummy$ 3.1420 (11.9746)*			
$trade$	g_{LP} 1.2083 (2.7393)*	$dummy$ 2.2938 (4.9708)*			

Notes: The values in the parentheses are the reported t-Statistics; * (**,***) indicates significant at the 1% (5%, 10%) significance level.

The multiple-regression yields also other two interesting results. Firstly, a "conditional convergence" effect has been identified in the Chinese statistics, which has reflected the "advantage of backwardness", that is, other economic conditions being the same, the province with a lower level of economic development at the outset tends to grow faster.

Secondly, the coefficients of the dummy variable in the equations for g_k, fdi and $trade$ indicate that the geographical location of a province has effects on its capital accumulation and technological adoption, and hence on its growth performance. This is exactly the result of the gradual strategy of economic reform in China. During the reform period, the gradual strategy of economic reform adopted in China has brought about many preferential policies in the coastal provinces, especially in the two provinces of Guangdong and Fujian, where the first four SEZs were established. These policies have led to the higher growth rates of domestic investment, FDI inflows and international trade, and hence higher growth rates of labor productivity in the coastal provinces. Without these policies, the coastal provinces with a lower level of economic development at the beginning of the economic reform would fail to catch up with the three municipalities of Beijing, Tianjin, and Shanghai as the result of cumulative causation.

5.6.3 Significance of Inter-provincial Diffusion

As mentioned above in Section 5.3.3., the design of our empirical studies and the specification of the econometric equations until now have been based on the assumption that there is no technological diffusion across provinces within China. Following the theoretical line, a province can benefit from advanced technology both in foreign countries and in other provinces in China. However, technological diffusion must be realised through economic interactions including factor mobility and inter-regional trade. If the local economies are relative closed, it is very possible that the poor provinces in the inland region fail to benefit from the technological diffusion from the rich provinces in the coastal region. Because of the lack of the data on inter-provincial investments and trade activities and the current fragmented situation of the Chinese domestic market, most of the studies on the regional growth difference in China have assumed that provincial economies are independent of each other and there is no technological diffusion among provinces. In this subsection, we will use the econometric technique to examine the validity of this assumption.

In Chapter 1, we introduced that one of the distinguishable characteristics of China's economy during the pre-reform period was its autarkic and relatively closed local economy. There was little factor mobility across provinces because of the regulative restrictions (such as the "Regulation on the Registration of Households"). During the reform period, while China has made great efforts establish economic relationships with the outside world, little measures have been implemented to barriers of inter-provincial economic interaction. Factor mobility across the provinces is still low. Although it has become possible to make unregistered labour migration across regions during the reform period, constraints against interregional unregistered migration are still powerful. The main reason for this is that unregistered migrants lack access to schooling for children, state-run health care and other regional services.

A number of studies have argued that, during the reform period, capital mobility in China as a whole has declined (e.g. World Bank Country Study, 1994; Ma, 1994; Young, 2000; Lin and Liu, 2000; etc.). The World Bank (1994) maintains that there is no evidence to support a convergence of returns to capital across different provinces, suggesting that capital mobility is low.

Young (2000) argued that growing interregional competition between duplicative industries, threatened the profitability of these industrial structures, leading provincial and local governments to impose a variety of interregional barriers to trade. He found compelling evidence to support the idea that interregional trade of China has been relatively restricted since 1978. For example, he observed a divergence in regional prices in the late 1980s, followed by fluctuating rounds of convergence and divergence during the 1990s. Given a fragmented and less developed domestic economy of China, individual provinces may be seen as many independent developing economies.

Lin and Liu (2000) have also found that economic decentralization, especially fiscal decentralization, provides provincial governments with an incentive to block inter-provincial trade. Historically, most of the government revenue was nominally "local revenue", collected by provincial government authorities. During the pre-reform period, the fiscal system of China was characterized by centralized fiscal collection, i.e. all "local revenue" were remitted to the central government and then transferred back to the provinces according to expenditure needs approved by the central government. After 1978, the central government began to allow the provincial government to retain a share of the revenue from local economic activities. The fiscal decentralization provided provincial governments with strong incentives to maximize their own fiscal revenue. Furthermore, there is a crucial fact that it was local governments, and not the central government, that had the standing fiscal ties with enterprises throughout the economy. For example, a large portion of Chinese enterprises including the non-state owned enterprises are under the authority of the provinces rather than the central government. Given autarkic provincial economies with duplicative industries that existed during the pre-reform period, the decentralization of economic and fiscal power to provincial administrative levels has increased their incentives to keep the raw materials within their borders, in order to let the provincial down-stream industries process and gain the value added themselves. Consequently, inter-provincial resource flows are sharply curtailed and provinces rely on internally raised resources. In many cases those provincial enterprises obtained most of their inputs from within the province.

In contrast, Hsueh Tien-tung (1994) reported that during the 1980s the inflow of interregional capital to low income provinces has been as much as 25% or more of their national income, pointing to a considerably high level of inter-provincial capital mobility.

Recent assessments of capital flows within China do not clearly show whether they have happened at all and if so, in which direction. Therefore, we are not sure about whether the capital transfer and technological diffusion have taken placed across provinces. Theoretically, it is widely accepted that ideas and technologies can spread between neighboring countries, notably because proximity is conducive to trade in goods, services and factors, which in turn facilitates the transmission of knowledge. The proximity can facilitate not only the transfer of technology but also learning by observation and by interaction. Therefore, we have reasons to believe that technological diffusion would take place across provinces within in China.

As we mentioned in Chapter 1, the implementation of the current gradual strategy of regional development is partly based on the belief that growth dynamics in the coastal region will be diffused to the inland region. Therefore, it is worthwhile to test whether the individual dynamics of the various Chinese provinces have an effect on collective emulation, since it can help in determining whether the “discriminatory” regional development strategy adopted to stimulate national economic growth did indeed have the desired effect of transmitting growth towards the inland region or not.

To measure the diffusion progress, we used a methodology based on Chua (1993), Easterly and Levine (1997) and Demurger (2000). Firstly, a regional classification system is constructed, linking each province to the set of all its neighbours, as described in Appendix 6. Using this classification, we then calculate an indicator of diffusion for each province, specified as the average of its neighbouring provinces’ values for the variable under consideration. Since it seems likely that the larger a province is, the greater the impact it will have on its neighbours, we weight the diffusion indicator by the labor productivity of the neighbouring provinces for the year $t-1$. Thus the “direct growth contagion” variable (DGC) used for the following analysis is measured for each province by the weighted average of g_{LP} in the n direct neighbouring provinces:

$$DGC_t = \frac{1}{\sum_{i=1}^{n} \log(y_{i,t-1})} \sum_{i=1}^{n} \log(y_{i,t-1}) * g_{LP_{i,t}} \qquad 5.20$$

we add this variable on the right hand side of equation 5.15 to reflects that the technological progress in a province stems from not only technological adoption from foreign countries but also from its neighboring provinces:

$$g_{LP_{(i,t)}} = a_{10(i)} + a_{11} g_{k_{(i,t)}} + a_{12} H_{(i,t)} + a_{13} fdi_{(i,t)} + a_{14} trade_{(i,t)} + a_{15} y_{(i,t-1)} + a_{16} DGC_{(i,t)} + u_{1(i,t)} \qquad 5.15'$$

We then estimate the system of equations 5.15’, 5.16, 5.17, 5.18 and 5.19 simultaneously. The coefficient of variable DGC in equation 5.15’ is 0.451 and the t-Statistics is 3.653, indicating that the coefficient is significantly positive at the 1%

significant level. This result indicates that the provincial capital transfer and technological diffusion have taken placed and the growth dynamics have been diffused across provinces.

5.7 Concluding Remarks

In chapter 4, we have formalized the process of cumulative growth in a circular economic system and proposed some economic factors as the underlying driving forces of productivity increase in an economy. In this chapter, the results of our empirical studies have verified that such a framework is able to explain regional growth patterns in China.

The statistical analysis of correlative relationships and Granger-causality tests have shown that there are obvious mutual causal relationships between the growth rate of labour productivity and the proposed economic variables, i.e. physical capital stock, human capital, FDI inflows and international trade.

The finding, that there is no causal relationship between g_{LP} and rd , seems to contradict with the hypothesis of innovation-based growth theory. However, we should interpret this finding with caution for three reasons. Firstly, it is possible that the technical progress and productivity increase in those coastal provinces with two digital growth rates should be ascribed to their adoptive capabilities of advanced technology from foreign countries. As shown in Table 5.1, FDI inflows in these provinces are much higher than those in the inland provinces. Secondly, R&D expenditure in the western provinces may include most of the military expenditure in R&D carried out by the government and can not reflect the influence of innovative activities on economic productivity. Lastly, because input variables do not reflect the efficiency with which innovative activity is carried out, R&D expenditure may not be proportional to the output of innovative activities.

In the theoretical literature on economic growth and human capital, there is no clear conclusion on the question whether the level of human capital or the increase of human capital affects the growth rate in an economy. The result of our Granger-causality test indicates that there is mutual causality between the economic growth and the level of human capital. But we should interpret this finding with caution, since the unit root test indicates that the level of human capital is nonstationry and the statistical properties of regression analysis using nonstationary time series may be dubious.

Our multiple-regression tests have confirmed the findings of the Granger-causality tests and yielded three other interesting results. Firstly, the significantly negative sign of the variable y_{t-1} has provided empirical supports for the proposed "advantage of backwardness" by the theory of technological catch-up; secondly, with the help of the econometric technique we found that the provincial capital transfer and technological diffusion have taken place and the growth dynamics have been diffused across provinces; thirdly, the significantly positive signs of the dummy variables in the equations for g_k, *fdi* and ***trade*** indicate that the geographical location of a province has effects on its rate of capital accumulation and technological adoption, and hence on its growth performance.

We argue that the positive influence of geographical location of a province on its growth performance reflects the impacts of the gradual strategy of economic reform on the regional growth pattern in China. As depicted in Figure 4.1, domestic investment, FDI and international trade are determined not only by economic factors but also by state policies. The theory of cumulative causation has also proposed that state policy is one of the two reasons for a reversion of the circular and cumulative process. Therefore, an analysis of the characteristics and impacts of state policies during the reform period in China will improve our understanding of the current regional growth pattern. In the next chapter, we will describe the characteristics of main state policies during the reform period in China and investigate their impacts on the geographical distribution of domestic investment, FDI and international trade detailedly.

Chapter 6 State Policies and Regional Growth Pattern in China

The finding of a positive influence of a province's geographical location on its growth performance leads us to believe that the gradual strategy of economic reform with state policies preferred to the coastal region should have impacts on the regional growth pattern in China. The theory of cumulative causation has also proposed that state policy is one of the two reasons for a reversion of a circular and cumulative process. Therefore, an analysis of the characteristics and impacts of state policies during the reform period in China will improve our understanding of the Chinese regional growth patterns. In the first section of this chapter, we will describe the characteristics of the economic policy regime during the reform period in China at first. Then we will investigate the impacts of these state policies on the geographical distribution of domestic investment, FDI and international trade respectively in the subsequent section. Section 6.3 gives some concluding remarks.

6.1 State Policies during the Reform Period: Decentralisation and Opening-up

During the last five decades, the Chinese economy has been subject to two major distinct economic regimes: the pre-reform period 1952-1977 and the reform period after 1978. The pre-reform period can also be referred to as the central planning period or Maoist Period. The major economic policy was a push for a Soviet-style central planning system within all provinces of China. The characteristics of the Chinese economy during this period can be summarised as follows[63]:

- a centrally planned economic system within all provinces of China
- autarkic and closed local economies
- restrictive relations with the outside world

[63] The detailed descriptions of the characteristics of the economic regime during the pre-reform period can be found in Chapter 1.

In 1978, China initiated economic reform with intentions of both improving the functioning of domestic economy and developing economic relations with the rest of the world. According to these intentions, the reform policies are comprised of two main parts: (1) decentralisation; and (2) opening-up. In terms of decentralisation, China has progressively reduced the scope of mandatory planning, decentralised economic decision making to productive entities (individuals and firms) and allowed market forces to operate. With respect to the opening-up policy, China has focused on two aspects: attraction of foreign direct investment (FDI) and international trade liberalization.

6.1.1 Economic Decentralisation

Decentralisation policies have three main objectives: first, to decentralise administrative authorities from central government to local governments; second, to restore a measure of autonomy to productive entities and to give them greater incentives; and three, to introduce market mechanisms in domestic economic relationships.

Decentralisation in the Fiscal System

Since the early 1980s, the Chinese central government began to eliminate the fiscal system of centralized revenue collection and transfer and allow the provincial government to retain a share of the revenue from local economic activities. The provincial government was required only to remit a portion of their budget revenue to the central government. The objective of the decentralization of fiscal management was to increase local governments' responsibility for local economic development and their autonomy in using fiscal instruments to achieve such goals.

Decentralisation in the Agricultural Sector

In the agricultural sector, the system of household responsibility was introduced to replace the previous commune production system. The new system gave each household freedom over land use[64] and decision-making and allowed each household to

[64] Farmers receive the use-rights of land through leasing contracts instead of private ownership. A lease is usually for 15 years.

retain a certain proportion of outputs after fulfilling a production quota set by the government. Such a simple reform method has restored the motives of profit seeking to farmers and encouraged productivity increase successfully. Grain output increased from 305 to 407 million tons over the period from 1978 to 1984. Real per capita income of the rural population more than doubled within 6 years (Yao, 2000).

Decentralisation in the Industrial Sector

The resulting jump in agricultural production in 1979-1983 convinced China's leadership to extend the contract responsibility system to the industrial sector in 1984.

In the industrial sector, management responsibilities of SOEs were shifted from the state to enterprises. The enterprises acquired decision-making power in production as well as in investment, while it must guarantee to pay to the state an agreed amount of the after-tax profit. The decentralized production-investment decisions are supposed to give the enterprises the incentive to maximize their financial surplus. However, the SOEs were subject to a soft-budget constraint, being absolved from the responsibility of paying the contracted amount of profit if the financial outcome was poor.

Before 1993, the general reform direction has been the steady expansion of the operational autonomy of the SOEs with almost no serious discussion of privatization as a reform option. A fundamental change in the official philosophy about SOEs reform occurred at the end of 1993 when the Central Committee of CCP identified the ambiguity of property rights to be an important cause of the unsatisfactory performance of SOEs, and decided that:

> Large and medium-sized State-owned enterprises are the mainstay of the national economy; … (for them) it is useful to experiment with the corporate system. As for the small State-owned enterprises, the management of some can be contracted out or leased; others can be shifted to the partnership system in the form of stock sharing, or sold to collectives and individuals. (China Daily, 1993)[65]

[65] "Decision of the CCP Central Committee on Issues concerning the Establishment of a Socialist Market Economic Structure", China Daily (Supplement), November(17), 1993.

A consequence of decentralisation in the industrial sector is that the industrial sector has experienced a structural change in ownership during the reform period. Many new policies and institutions have been established to facilitate the entry of new domestic producers with a view to create market competition. There have been some establishment of private enterprises and privatisations of existing (mostly small) SOEs, but this has not been a major force behind this structural change in ownership. Township and village enterprises (TVEs) and foreign-invested enterprises (FIEs) formed the backbones of the non-state industrial sector.

The TVEs represent a unique Chinese institutional form, in that rural industry is owned - at least formally - by the local government or collectively by members of a village. The TVEs are non-state enterprises in the sense that they operate entirely outside of the state plan, and with rather hard budget constraints (receiving almost no subsidies from the state budget, or state banks, and only rarely from the local government). At least formally, they are not private enterprises, however, since they lack clear private owners.

As Naughton (1996) pointed out, the changes in rural policy were an essential preliminary to creating the conditions for growth of TVEs. The Chinese government began to encourage non-agricultural activities such as industrial enterprises in rural areas to absorb the surplus labour supply and the rise in agricultural income resulting from agricultural reforms. The steady relaxation of regulations governing the registration and supervision of non-state enterprises since 1984 has caused TVEs in the rural areas to grow explosively.

Along with the extension of opening-up and further implementation of domestic reforms, other forms of organization also emerged in urban areas, such as private or foreign-invested enterprises, stock companies, etc. As a result, the SOEs lost dominance in the industrial sector. The non-state industrial sector’s share of manufacturing output rose from 13 per cent in 1978 to 72 per cent in 2001 (See Table 1.2).

Decentralisation in the Investment System

During the pre-reform period, overall, China’s investment system was highly centralized through centralized planning, centralized administration and state-controlled banks. The central government attempted to control the size, structure, and location of fixed investment, and gave little consideration to investment efficiency and local autonomy. During this period, the state budgetary investment often accounted for 80% of capital construction investment in SOEs. Bank loans, enterprise funds and foreign capital played little role in the capital construction. In terms of sector allocation, investment was concentrated in heavy industry and SOEs, reflecting the heavy involvement of the state and the influence of the Soviet-model of socialist industrialization, which emphasized the development of heavy industry.

This centralized investment system partially enabled the government to mobilize resources among sectors and regions for the consideration of industrialization, national defense, and balanced development. This system, however, had several problems, most of which are typical to Soviet-type command economies: (1) over centralized investment planning and management that gave little incentive to local governments, enterprises, and individuals; (2) over concentration of investment in heavy industry and the defense sector, and little investment in infrastructure and services; (3) low investment efficiency. These problems and the changing international and domestic conditions prompted post-Mao reforms of the investment and financial system.

In the late 1970s, the Chinese government introduced financial and investment reforms to solve problems in investment allocation and management. Policies of adjustment were implemented in the following years to adjust size, structure, and spatial distribution of fixed investment. With the focus of reforms shifting to urban reforms in the mid-1980s, more investment policies were introduced, focusing on investment decentralization and investment structural adjustment. A significant change was decreed from a system consisting of profit remittances from the enterprises to the government and targeted budgetary investments from the government to the enterprises, to a system which involves profit retention, enterprise taxes, and the financing of investment through bank loans. Deeper reforms were implemented in the 1990s to stimulate the development of market mechanisms to improve investment allocation and management.

Consequently, the structure of fixed investment has changed dramatically over time. The control of the state over investment has declined during the reform period, and the influence of local factors and foreign investments in capital formation has risen.

Specifically, investment financing beyond state budget and state-controlled banks increased rapidly, especially in using enterprise funds and foreign capital. As economic reforms allow enterprises to keep some of their profits and fixed capital depreciation funds, more profitable enterprises (often non-state enterprises), most of which are located in more developed coastal provinces, are able to accumulate more capital for investment. This has directly contributed to a rapid increase of investment from enterprise funds. Since the end of the 70s when China started its efforts to attract foreign investment, foreign investment has played an important role in capital formation as well.

During Mao's era, budgetary investment often accounted for more than 80% of capital construction investment in the SOEs. During the reform period, with the introduction of market mechanisms and the declining role of budgeting, however, the importance of budgetary investment has decreased dramatically. Budgetary financing of SOEs' investment declined from 73.2% in 1978, to 29% in 1988 and 5% in 1995 (Wei, 2000). From 1981 to 1995, total fixed investment financed through budgetary investment declined from 28.1% to 3.1% (Wei, 2000). This change shows that the state and state budget are no longer dominative in the investment process.

6.1.2 Attraction of Foreign Direct Investment (FDI)

Attracting foreign capital is an integral part of China's overall economic reform strategy. China started its efforts to attract foreign investment at the end of the 1970s by setting up four SEZs in two provinces in the coastal region.[66] In these SEZs, foreign investors, particularly those who could offer "advanced technology", were encouraged with preferential policies to set up branches or joint ventures with domestic enterprises.[67] At the same time, many laws and regulations were put into effect successively to set the legal framework for FDI.[68]

[66] Specifically, three SEZs were set up in the Guangdong province (Shenzhen, Zhuhai and Shantou) and one in the Fujian province (Xiamen).

[67] To be noticed, domestic private investors in these SEZs were also provided with the same preferential policies to establish firms, which produce exclusively for export.

The preferential policies applicable to FIEs include:

- The right to engage directly in foreign trade;
- Duty-free import of raw materials and components for export production;
- Duty-free import of investment goods.[69]
- Concessionary income tax rates.[70]
- Significant tax holidays.[71]
- Moreover, the FIEs enjoy other advantageous financing, special flexibility of employment, and so on.

As the FDI could not only expand the volume of production with capital accumulation and trade expansion but also improve the efficiency of production through technological transfer, economic development in the SEZs was so successful that the government decided to open another 14 cities in the coastal region in 1984[72], Hainan Island in 1988 and Shanghai Pudong Development Zone in 1989. Hereafter we refer to these coastal cities and development zones, which enjoy the similar preferential policies as the SEZs in Guangdong and Fujian, as well as the SEZs. Until now, all main cities in China have been opened to foreign investors. The growth of FDI flows into China is astonishing. From an almost isolated economy in the late 1970s, China has become the largest recipient of FDI in the developing world and globally the second only to the USA since 1993 (Zhang and Song, 2000).

6.1.3 International Trade Liberalization

As we described in Chapter 1, China has had a highly centralized and monopolistic foreign trade regime during the pre-reform period. Since 1978, the government has

[68] For example: The Law on Sina-Foreign Equity Joint Venture (1979), The Law on Foreign Wholly Owned Enterprises (1986), The Law on Sina-Foreign Contractual Enterprises (1988), ect.

[69] This used to be an across the board exemption for all FIEs. Automobiles were excluded after December 1994, and all tariff exemptions for investment goods ware phased out by the end of 1997.

[70] The statutory corporate income tax rate in China is 33 percent (that is, 30 percent national plus 3 percent local income tax), but FIEs qualify for a variety of reduced rates on the basis of location (for example, a rate of 15 percent in the SEZs and 15 to 18 percent in approved development zones, 24 percent in open coastal cities)

[71] Taxes are regularly remitted in the first two years of the profit-making operation, and levied at 50 percent of the full rate in years three to five. Losses incurred during start-up can be credited against profits to delay the onset of the first profit-making year.

[72] 14 coastal cities include Dalian, Qinhuangdao, Tianjin, Yantai, Qingdao, Lianyungang, Nantong, Shanghai, Ningbo, Wenzhou, Fuzhou, Guangzhou, Zhanjiang, Beihai.

gradually dismantled the tight administrative controls over trade and many efforts have been made to boost export. The main elements of trade reform to date have included:

- De-monopolizing the foreign trade regime. From twelve national monopoly FTCs, the number of FTCs had grown substantially.[73] Besides the establishment of new FTCs, direct export and import rights were also granted to some manufacturing enterprises in the SEZs.
- Devaluation. By 1987, the real exchange rate was below 50 percent of its 1980 level.
- Relaxing restrictions on convertibility. Starting from inconvertibility, important steps have been taken toward making the Chinese currency fully convertible.[74]
- Reducing tariff and non-tariff barriers.

These steps have established the essential conditions for China's successful trade performance. Between 1978 and 2001, the nominal value of exports grew 15% annually while manufactured exports grew 21% per year. While China accounted for only 0.75% of world exports in 1978, the share rose to 4.3% in 2001. By 2003, China was the fourth largest exporter in the world.[75]

6.2 Impacts of State Policies on Uneven Regional Development

6.2.1 State Policies and Geographical Distribution of FDI

FDI has been playing an increasingly important role in China's economic development in the last two decades. It is evident from Table 6.1 that FDI contributed significantly to China's employment, export expansion and total fixed capital investment. The share of foreign affiliates' exports in total China's exports increased from negligible in the early

[73] There were already 5,075 FTCs by 1988. (Naughton, 1996)

[74] Initially, exporters were allowed to retain small but increasing percentages of their export earnings. In 1986 a dual exchange regime was instituted: selected enterprises (including most FIEs) were given access to a "swap market", in which Chinese domestic currency was traded for foreign exchange, usually at a significant discount relative to the official rate. At the end of 1996, full current account convertibility is realized.

[75] By 2003, China became the fourth largest exporter in the world only to the USA, Germany and Japan.

1980s (0.04% in 1980 and 0.27% in 1984) to 20% in 1992.[76] In 2001 Exports by foreign affiliates in China comprised 50% of China's total exports. The FIEs' shares in total urban employment, total investment on fixed assets and total gross industrial output have increased a lot during the reform period.

Table 6.1: **FDI Inflow and Its Contributions to the Chinese Economy**

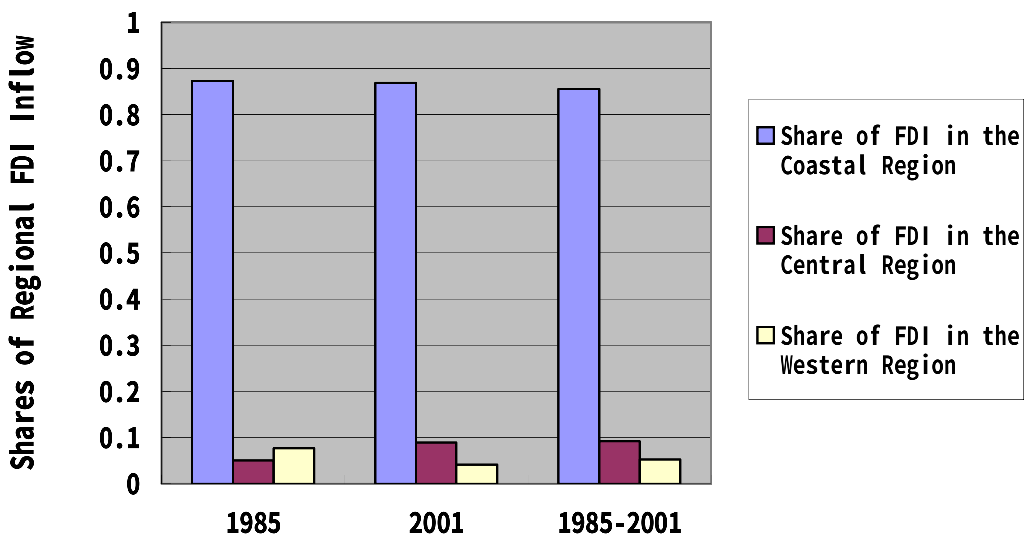
Year	FDI Inflow (millions of US$)	FIEs' Share in Total Export (%)	FIEs' Share in Total Urban Employment (%)	FDI's Share in Total Investment on Fixed Assets (%)	FIEs's Share in Total Gross Industrial Output (%)
1983	636	1.48	#	0.87	#
1984	1258	0.26	#	1.54	#
1985	1661	1.08	0.05	1.94	#
1986	1874	1.88	0.10	2.09	#
1987	2314	3.06	0.15	2.28	#
1988	3194	5.16	0.22	2.49	0.01
1989	3392	9.35	0.33	2.86	#
1990	3487	12.58	0.45	3.72	#
1991	4366	16.76	1.08	4.16	#
1992	11007	20.43	1.41	7.51	#
1993	27515	27.51	1.80	12.12	11.1
1994	33767	28.67	2.41	17.06	#
1995	37521	31.51	2.69	15.68	#
1996	41725	40.72	2.73	15.16	16.7
1997	45257	41.97	#	15.04	#
1998	45463	44.07	#	13.27	18.2
1999	40319	45.46	#	11.21	#
2000	40715	47.93	#	10.24	#
2001	46878	50.05	#	10.42	#

Sources: The data in the second, third and fifth column are from the Almanac of China' s Foreign Economic Relations and Trade (SSB, various years) and China Foreign Economic Statistical Yearbook (SSB, various years); the data in the fourth and sixth column are from Zhang and Song (2000).

However, the gradual geographical extension of the open-up policy brought about a highly unequal regional distribution of foreign capital flows throughout the period. Figure 6.1 shows the breakdown of FDI inflow in 1985 and 2001, and the total inflow of FDI during the period 1985-2001 by regions. As shown in Figure 6.1, in 1985, nearly 87 percent of FDI went to the coastal provinces. This imbalance changed little over time. 86 percent of FDI still went to the coastal region in 2001. During the period 1985-2001, the share of total FDI inflow in the coastal region was 85 percent, in contrast to 9 percent and 6 percent in the central and western regions.

[76] The contributions of FDI to China's exports have been widely recognized. A lot of literature has studied the link between FDI and export performance in China theoretically and empirically, such as, Branstetter and Feenstra, 1999; Chan, Tracy and Zhu, 1999.

Figure 6.1: Regional Shares of FDI Inflow in 1985 and 2001, and during the Period 1985-2001



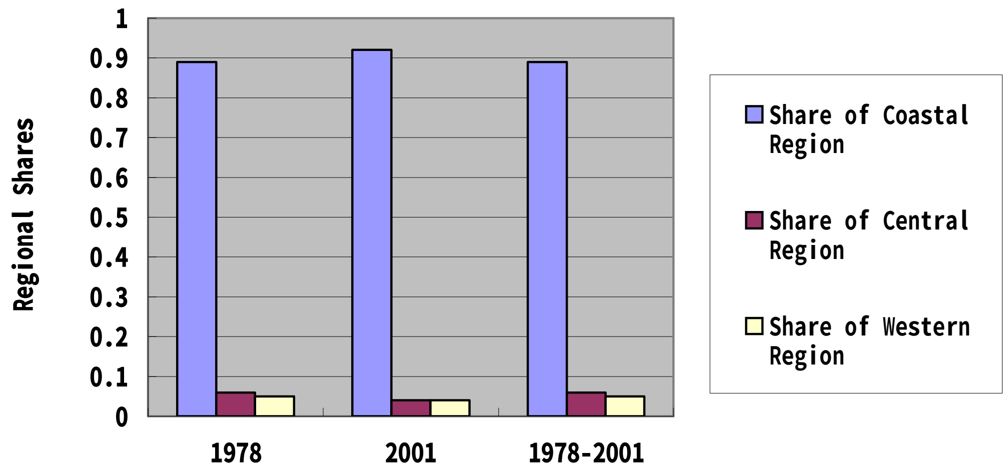
Sources: The Almanac of China's Foreign Economic Relations and Trade (SSB, various years) and author's calculations.

Besides the impacts of gradual geographical extension of open-up policy, the mutual causal relationship between FDI inflow and productivity increase contribute further the uneven distribution of FDI inflow by regions. Rapid economic growth in the coastal provinces induced partly by the inflow of FDI will build confidence of overseas investors on the expected profit rate. Additionally, economic growth, accompanied by an increased higher per capita income, will create huge opportunities for both industrial and consumer goods in the host market. All of these factors will further stimulate the inward FDI in the coastal region.

6.2.2 State Policies and Geographical Distribution of Trade Volume

In spite of the quantitative growth of international trade at the national level, the breakdown of trade volume by regions imply that China's domestic market is significantly less open to foreign trade than it initially appears. Figure 6.2 shows the breakdown of trade volume in 1985 and 2001, and during the period 1978-2001 by regions. It is evident that the trade activities were concentrated in the coastal region.

Figure 6.2: Regional Shares of Trade Volume in 1978 and 2001, and during the Period 1978-2001



Sources: see Figure 6.1

Naughton (1996) has proposed that there is a dualistic trade regime in China, that is, the co-existence of an Export Promotion (EP) regime and an Ordinary Trade (OT) regime. In the EP regime, many concessionary institutions and regulations are provided to enterprises to engage in trade activities. The most important of these institutions is the duty-free processing of imported materials and components into exports. But this regime is accessible primarily to enterprises with foreign investment or export-oriented domestic enterprises in the SEZs. However, in the OT regime, even domestic producers and traders have the authority to export directly; their ability to import is more restricted by different tariff and non-tariff barriers compared with the enterprises in the EP regime. The restriction on import indirectly hampers the efforts of domestic enterprises to export, since it limits a domestic firms' ability to respond quickly to changing market conditions or fashions and restricts its range of growth and cost-minimization strategies.

Since most SEZs are located in the coastal region, it is implied that most enterprises in the inland region still have severely restricted access to the world market. The existence of a dualistic trade regime in favour of FIEs and enterprises in the coastal region may be the most fundamental factor that explains the concentration of foreign trade activity in the coastal region.

6.2.3 State Policies and Geographical Distribution of Domestic Investment

As shown in Table 5.1, there have been large disparities in the rates of capital accumulation by provinces and regions during the reform period. More developed and fast growing coastal provinces have recorded more rapid growth in fixed investment than inland provinces.

Obviously, the concentration of FDI in the coastal region has contributed to the gap of investment between the coastal and inland regions. Because of the gradual geographical extension of open-door policy and the mutual causation between FDI inflow and productivity increase, coastal provinces have absorbed much of the foreign investment in China.

However, the distribution of domestic investment is also uneven between regions. The coastal region has a higher ratio of domestic investment to GDP than the inland region on average (see Table 5.1). Except for the mutual causal relationship between the productivity increase and capital accumulation, we argue that the coastal provinces have benefited more from the investment reform due to their favorable structures of ownership and sector.

We can distinguish three groups of economic agents in the Chinese economy roughly, i.e. economic agents (enterprises and individuals) in the agricultural sector, SOEs industrial enterprises and non-state industrial enterprises (mostly, FIEs and TVEs). As shown in Table 1.2 and 1.3, most of the inland provinces are dominated by the agricultural sector and state-owned industrial sector. On average, the provinces in the coastal region have more non-state enterprises than those in the inland region. For some historical reasons, the provinces in the coastal region had a well-developed base of non-state industries. But the main reason for the dominance of non-state sectors in the coastal region compared with the inland region is that, at the beginning of economic reform, non-state enterprises are given a favourable environment for their developments in the coastal region[77].

[77] To break away from ideological barriers and to demonstrate that state ownership was not the only form of ownership in socialist China, the non-state enterprises were only encouraged in the SEZs in the Guangdong and Fujian provinces initially. Non-state enterprises in the SEZs have been provided with the same preferential policies as the FIEs during the reform period.

China's investment reform has decentralized considerable investment decision-making power to economic agents. As the economic agents are allowed to keep some of their profits and make their own investment decisions, more profitable agents are able to accumulate more capital for re-investment. The coastal provinces, with more profitable non-state enterprises located there, are capable of generating more enterprise funds for investment. Many inland provinces dominated by the agricultural sectors and SOEs have been less effective in creating new sources of investment beyond the state. Because of the low economic efficiency in the agricultural sectors and SOEs, the economic structure in the inland provinces has hindered the economic growth of these provinces. In the rest of this subsection, we will give some reasons for better efficiency and higher profitability of non-state enterprises (especially, TVEs) than the SOEs and the agricultural sectors.

As put in Sachs and Woo (1997), there has been a steady increase in SOEs' losses since additional decision-making powers were given to SOEs' managers in the mid-1980s. The situation stabilized in the 1990-1991 period when the state attempted to recover some of the decision-making power devolved to the SOEs. In 1992, decentralizing efforts accelerated at the initiative of local leaders after Deng Xiaoping called for faster economic reforms in order to avoid the fate of the Soviet Union. The unexpected event was that the faster economic growth was accompanied by larger SOEs' losses. About two-thirds of Chinese SOEs ran losses in 1992 when output growth in that year was 13 percent. SOEs' losses have continued to accelerate since then. In the first quarter of 1996, the SOEs sector slid into the red for the first time since the establishment of China in 1949, it reported a net deficit of 3.4 billion yuan. This financial situation has worsened over time. A national audit of 100 SOEs in 1999 found that eighty-one falsified their books, and sixty-nine reported profits that did not exist; and an audit of the Industrial and Commercial Bank of China and the China Construction Bank found that accounting abuses involving 400 billion yuan, of which 200 billion yuan was an overstatement of assets (Financial Times, 1999)[78].

The literature has identified two possible factors for being responsible for the disappearing SOEs' profits. The first factor is the emergence of competition from the

[78] "China: Finance Ministry Reveals Widespread Accounting Fraud", Financial Times, December(24), 1999.

non-state enterprises[79]. The problem with the competition explanation is that the profit rates of SOEs in the industry sectors that experienced little entry by non-SOEs showed the same dramatic drop as the profit rates of SOEs in sectors with heavy penetration by non-SOEs (see Fan and Woo, 1996). Profits in SOEs fell regardless of whether they faced competition from non-SOEs or not.

The second factor is the increasing ability of SOEs' insiders to appropriate the income and assets of the SOEs, and hence, the continued inefficiency of the SOEs despite the new profit incentives from the decentralizing reforms. It is emphasized by scholars such as, Fan and Woo (1996), Woo (1996), that asset-stripping and "spontaneous appropriation" of firm profits by managers and workers were the most important cause for the general decline in SOEs' profits. With the end of the central plan and the devolution of financial decision-making power to the SOEs, the key source of information to the industrial bureaus regarding the SOEs were reports submitted by the SOEs themselves. Reduction in the monitoring ability of the state in a situation of continued soft-budget constraints meant that there were rooms and incentives for state-enterprise managers to private the profits and to socialize the losses. One result of this principal-agent problem is the tendency of SOEs to over-consume through various book-keeping subterfuges. Fan and Woo (1996) used various samples and national data to show that the sum of direct income (wages and bonuses) and indirect income (e.g., subsidies, and in kind distributions) increased more than labor productivity growth.[80]

The better performance of FIEs is not difficult to be understood. Except for the preferential conditions provided to them by the Chinese government for the attraction of FDI, most of FIEs possess much better productive and managerial technologies than domestic enterprises.

There are three reasons why TVEs have been more efficient than SOEs. The first is that TVEs face harder budget constraints because their owners can not turn to state banks for bailouts. In the 1990 economic downtown, the number of industrial TVEs fell from 7.7 million in 1988 to 7.2 million in 1990 while the number of industrial SOEs increased from 99 thousand to 104 thousand (Sachs and Woo, 1997). The second reason is that

[79] For example: Naughton (1995) and Jefferson and Rawski (1994).
[80] Another reason is the heavy social burdens.

TVEs have much more operational flexibility and fewer social welfare functions to distract the managers. TVEs can hire and fire freely, and they do not need to provide extensive social services like housing and pension to their workers. The third reason is that TVEs can implement institutional innovations without approval of the central government. The recent locally-initiated transformation of TVEs into “share-holding cooperatives” shows this feature very well, and this feature has enabled the TVEs to move closer to the best international practices in corporate governance.

The inefficiency of the agriculture sector has further hindered the ability in creating sources of investment in the inland region, since most inland provinces are dominated by agricultural activities. Many authors have found that the impressive agricultural growth in the early years of the agricultural reform are a one-shot improvement in productivity that followed the liberalization of the agricultural sector and the introduction of the household responsibility system for land tenue (Lin, 1992). Three factors have contributed importantly to the agricultural slowdown after 1985. The first factor is that farmers’ uncertainty about future land use rights has reduced their incentives to improve the productive conditions (for example, the construction of irrigation works). The second important factor for agricultural stagnation is that state procurement prices after the early 1980s have not been raised in line with the increases of input prices. A third factor contributing to the post-1985 slowdown in agricultural productivity growth has been the insufficient state investment in agricultural infrastructure during the reform period.

6.3 Concluding Remarks

As introduced in Section 1.1.3, an important distinctive feature of the economic reform in China is the adoption of a gradual or incremental strategy. According to this gradual strategy, a new policy would be experimentally introduced only in a specific sector or geographically in some provinces. Once the experiment is proved to be successful, the new policy will then be extended to other sectors or provinces. The above analyses indicate that, the uneven distribution of domestic investment, FDI and international trade, which are main factors accounting for the regional growth difference in China, should be not only ascribed to the mutual cumulative causation between productivity increase and these economic factors but also to the gradual implemented state policies of decentralisation and opening-up, since these state policies were not applied to all the provinces at the same pace and to the same extent.

The analysis of the impacts of state policies in this chapter have also provided explanations for why the provinces with lower levels of economic development in the coastal region have successfully caught up with the three municipalities of Beijing, Tianjin, and Shanghai during the reform period, whereas the gap of economic development between the coastal and inland region has widened. According to the theory of cumulative causation, the mutual causal relationships between economic factors will lead to a circular and cumulative process in an economic system and hence, to a widening of inequality between advanced and backward regions. But there are some forces that could reverse such a circular and cumulative process. State policy is one of them. The analysis in this Chapter has verified this proposal in the Chinese economic context. If there were not any interference of state policies, the five coastal provinces with lower levels of economic development at the outset of economic reform compared with the three municipalities would have lagged behind further. However, the preferential state policies favouring these coastal provinces have led to income convergence within the coastal region in reality.

Chapter 7 Conclusions and Policy Recommendations

Since the initiation of economic reform at the end of 70s, the Chinese economy has recorded a remarkably high level of economic growth. However, the unequal regional development raises the question concerning the sustainability of this development process in China, since the increased growth difference and income disparity between the coastal and inland regions tend to create economic, political and social tensions that might hold back the growth of the Chinese economy in the long term. Motivated by this acute situation of regional inequality, this dissertation is aimed at finding the sources of regional growth difference and income disparity in the Chinese economic context.

The stylised facts presented in Chapter 1 show clearly that there has been a complex regional growth pattern in China since the start of the reform period. Specifically, the coastal region has experienced higher growth rates of per capita income and labour productivity than the inland region during the reform period, which has enlarged income disparity between these two regions. However, a relationship of income and productivity convergence exists within the coastal region significantly.

From the above-mentioned stylized facts arise two crucial questions on the regional growth pattern in China. The first question is related to the sources of growth difference. Namely, what explains the difference in growth rates across provinces? What are the major factors that drive high economic growth in the coastal region, and what causes the inland region to lag behind? The second question is related to the driving forces of income convergence. Namely, why do the poorer inland provinces fail to catch up to the richer coastal provinces while, within the coastal region, provinces with lower income levels at the outset of economic reform have caught up with the three rich municipalities successfully?

The review of previous empirical studies in Chapter 3 suggests to us that these two questions have not been correctly answered by previous empirical studies in growth literature. Therefore, in Chapter 4 we have constructed a new analytical framework based on the growth theory of cumulative causation to investigate sources of growth difference and income disparity. In Chapter 5 and 6, with the help of econometric techniques including the Granger-causality and multiple-regression tests, the extent to which such a framework is able to explain the regional growth pattern in China has been verified empirically to Chinese statistical data.

In the first section of this concluding chapter, we will summarize our answers to the above-mentioned questions on the sources of growth difference and driving forces of income convergence. Then, policy recommendations for the reduction of inequality between coastal and inland regions in China are given in Section 7.2. Two directions of further research will be proposed at the end of this chapter.

7.1 Main Findings

Sources of Growth Difference

Based on our empirical analyses, we are able to conclude that the main factors accounting for the regional growth difference in China include not only different rates of factor accumulation but also different rates of technological progress. The higher rate of capital accumulation and technological progress in the coastal region should be ascribed partly to the cumulative relationships between productivity increase and its underlying economic factors, and partly to the state preferential policies favouring the coastal provinces.

With respect to capital accumulation, the coastal provinces with higher levels of income and productivity at the outset of economic reform have attracted more investment during the reform period. Since investment is mainly driven by the profit rate and productivity increase has positive influences on the profit rate, such a cumulative relationship between capital accumulation and productivity increase has led to the self-sustained economic growth in the coastal region. The positive effect of higher productivity on the profit rate is very marked in the Chinese economic context since the surplus of labour in China tends to weaken the bargaining power of workers, so that higher productivity is translated into lower costs rather than higher wages. In addition to this cumulative relationship, the preferential open-up policies aimed at attracting FDI have further contributed to the higher rate of capital accumulation in the coastal region.

In our analytical framework, we have proposed that technological progress may come from experience (or, learning-by-doing) represented by the cumulative production of capital goods, intentional innovative activities, and technological adoption from outside economies. Measures of R&D expenditure and human capital are used as surrogates for all activities which help to promote new and improved products and processes. Inward FDI and international (or, interregional) trade are treated as two effective channels of technological transfer. Stock of human capital is taken as a proxy for the capability of technological adoption in the host economy. Results of the Granger-causality and multiple-regression tests indicate that these factors, i.e. the growth of capital stock, human capital, FDI inflows and international trade, do affect the rate of economic growth positively. Moreover, there are the same mutual causal relationships between economic growth and these economic factors. Therefore, during the reform period, the coastal provinces have improved their abilities to innovate and adopt advanced technology, which have further contributed to their growth performance.

Driving Forces of Income Convergence

As presented by the stylised facts in Chapter 1, at the outset of economic reform, the provincial disparity in economic development was mainly reflected between the three municipalities (Beijing, Tianjin, and Shanghai) and other backward provinces. According to the theory of cumulative causation, the mutual causal relationships between economic growth and its underlying factors will lead to a circular and cumulative process in the economic system and hence, to a widening of inequality between advanced and backward regions. This seems to contradict with the fact that there has been income convergence within the coastal region during the reform period.

The analysis of the impacts of state policies in Chapter 6 has provided explanations for why the five coastal provinces with lower levels of economic development have successfully caught up with the three municipalities of Beijing, Tianjin, and Shanghai during the reform period, whereas the gap of economic development between the coastal and inland regions has widened. The reason why state policies of economic reform have had great impacts on the regional growth pattern in China lies in the fact that many state policies were not applied to all the provinces at the same pace and to the same extent.

We can use two provinces of Fujian and Ningxia to illustrate how geographical location affects the response to economic reform and its impacts on economic growth and income distribution. As depicted in Figure 1.4, in 1978, the coastal Fujian province ranked 19th in income level, which was almost the same as the 17^{th} rank of the inland Ningxia province. In a closed economy during the pre-reform period, Fujian did not enjoy any obvious better resource endowments than inland provinces. However, after China opened its door to the world, Fujian has become the most favoured place for FDI and international trade, in large due to the early establishment of SEZs. As depicted in Figure 1.5, Fujian ranked 7^{th} in income level in 2001. Meanwhile, the ranking of income level in Ningxia has declined from 17^{th} in 1978 to 22th in 2001. Clearly, the relative comparative advantages between these two provinces have changed significantly associated with economic decentralisation and opening up to the outside. The above story of Fujian and Ningxia is reflected nationwide in the behaviour of the components of inequality.

The analysis of "direct growth contagion" among provinces in Chapter 5 has complemented our understanding on the formation of regional growth pattern in China. "Direct growth contagion" may be compared to the physical phenomenon of wave propagation: the buoyancy of the coastal provinces tends to engender a pacesetting effect, a geographical dynamic that promotes faster growth in the coastal provinces and is disseminated to other provinces. However, this propagation phenomenon, in which the coastal region fuels the overall dynamism of the Chinese economy, is attenuated by the gradually decreasing dynamism of the provinces as the "wave" moves from the coast to the inland. Existing barriers of inter-regional economic connection have further weakened the effects of growth contagion among regions. This contagion effect thus affords at least a partial explanation for the complexity of China's regional development: both the convergence observed within the coastal region and the persistent disparities between coastal and inland provinces.

7.2 Policy Recommendations

The results of empirical analyses carried out in this dissertation lead us to suggest several lines of policy with the aim to reduce the gap between the coastal and inland regions.

Firstly, it is necessary to extend the open door policy to the inland region, especially by introducing preferential measures to attract FDI and promote international trade, as was done before in the coastal region.

Secondly, except for the diffusion effect of FDI and international trade, it is essential to implement supporting policies to abandon the inter-regional barriers of economic connection and allow the inland provinces to benefit also from the advanced provinces in the coastal area. Therefore, preferential policies should be provided not only to foreign investors but also to domestic investors from the prosperous coastal region.

Thirdly, productivity gains from the transfer of technology will certainly decrease in China's economic development over the longer run. Therefore, the country needs to build up its own capacity for technological innovation through R&D. Actually the inland region has strength in basic science and defence-related technologies. Efforts should be made to explore these potentials for industrial applications.

Governments have various fundamental and non-replicable roles in the process of promoting technical change which can take various forms: firstly, the direct pursuit of scientific and technological activities, as in the case of universities and other publicly funded research institutions; secondly, the financial support of innovation carried out in the business sector; and thirdly, the supply of necessary productive infrastructures, including education and training, standards and norms, and a legal system of intellectual property rights to allow individuals and firms to innovate.

Lastly, it is urgent to increase the economic efficiency of the agricultural sectors and SOEs. This will increase consequently investment abilities of these economic agents and improve the economic performance of the inland region, which is dominated by these inefficient sectors.

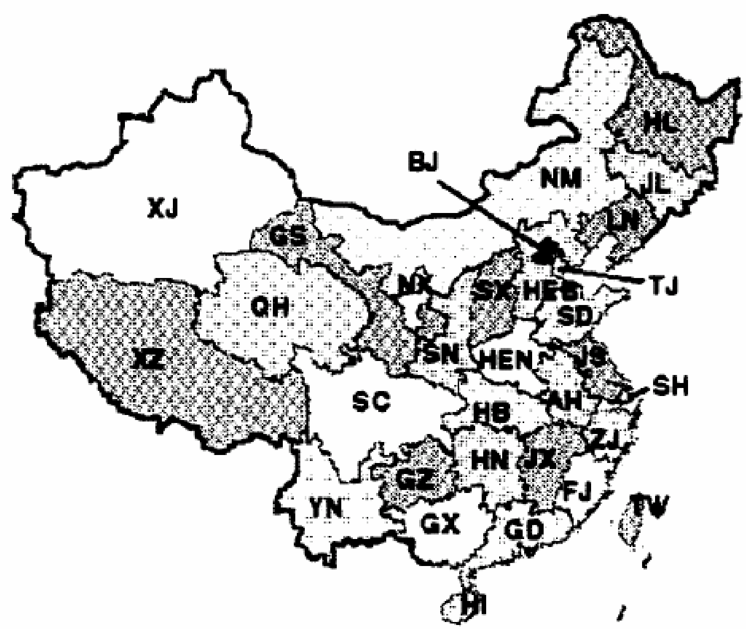
There can be little doubt that Chinese leadership recognizes the increasingly serious economic problems created by the sluggish development in the agricultural sector and the agency problem innate in the decentralizing reforms of SOEs. Since the end of the 90s, the national program of "Rural Area, Agricultural, and Peasants", labelled also as the "Three Agriculture Program", has been promoted at the national level. The main goals of this program are to decrease agricultural taxes and fees and to increase agricultural investment by the state. The acceleration in SOEs' conversion to joint-stock companies reflects the leadership's opinion that partial privatization through public offering in the stock markets and through joint ventures with foreign companies would be an improvement over the contract responsibility system. The important point about partial privatization is that the movement of the stock price of the firm is a publicly available indicator of the firm's relative performance. The existence of this objective indicator limits the supervising agency's ability to impose non-economic objectives on the firm, and places more pressure on the supervising agency to monitor the returns to state assets.

7.3 Directions of Further Research

As many other growth models do, we describe how GDP grows as a result of the expansion of production and omit possible demand constraints in this dissertation. The shortage of natural resources, infrastructure and funds has imposed restrictions on Chinese economic development for a long time since the economic reform. Therefore, most of China's econometric models are supply-oriented. After the mid-1990s, however, as the supply capacities of most sectors grew faster than demands, some new problems arose in the economy. The Chinese economy has been suffering from insufficient demand (especially insufficient demand in the domestic market), deflation and rising unemployment since the mid-1990s. Therefore, we can not easily say that China's GDP is determined only by productive capacity. Economic growth can be related to both the supply-side and the demand-side factors of production in later researches.

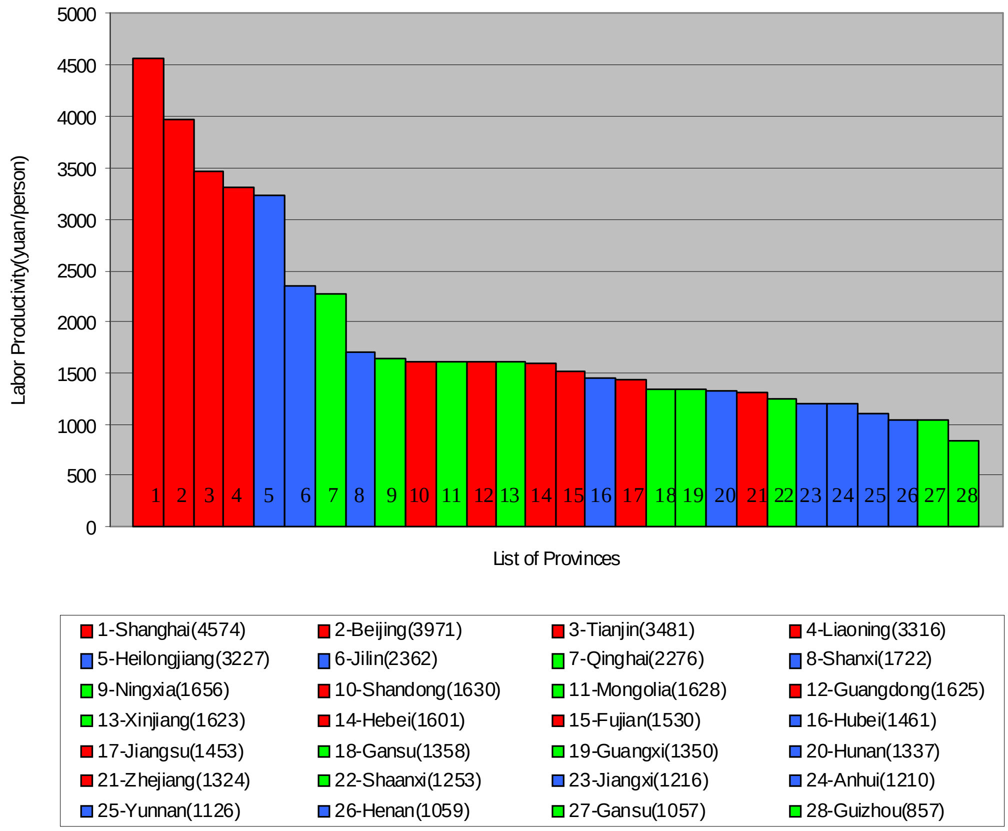
Moreover, it is suggested in some studies that two nested inequalities exist in China. One is the coastal-inland inequality, while the other is the rural-urban inequality. To fully understand patterns of income distribution in China, the sources of income disparity between the rural and urban areas can also be considered in later researches.

Appendix 1: Map of China



Appendix 2: Provincial Labor Productivity in 1978

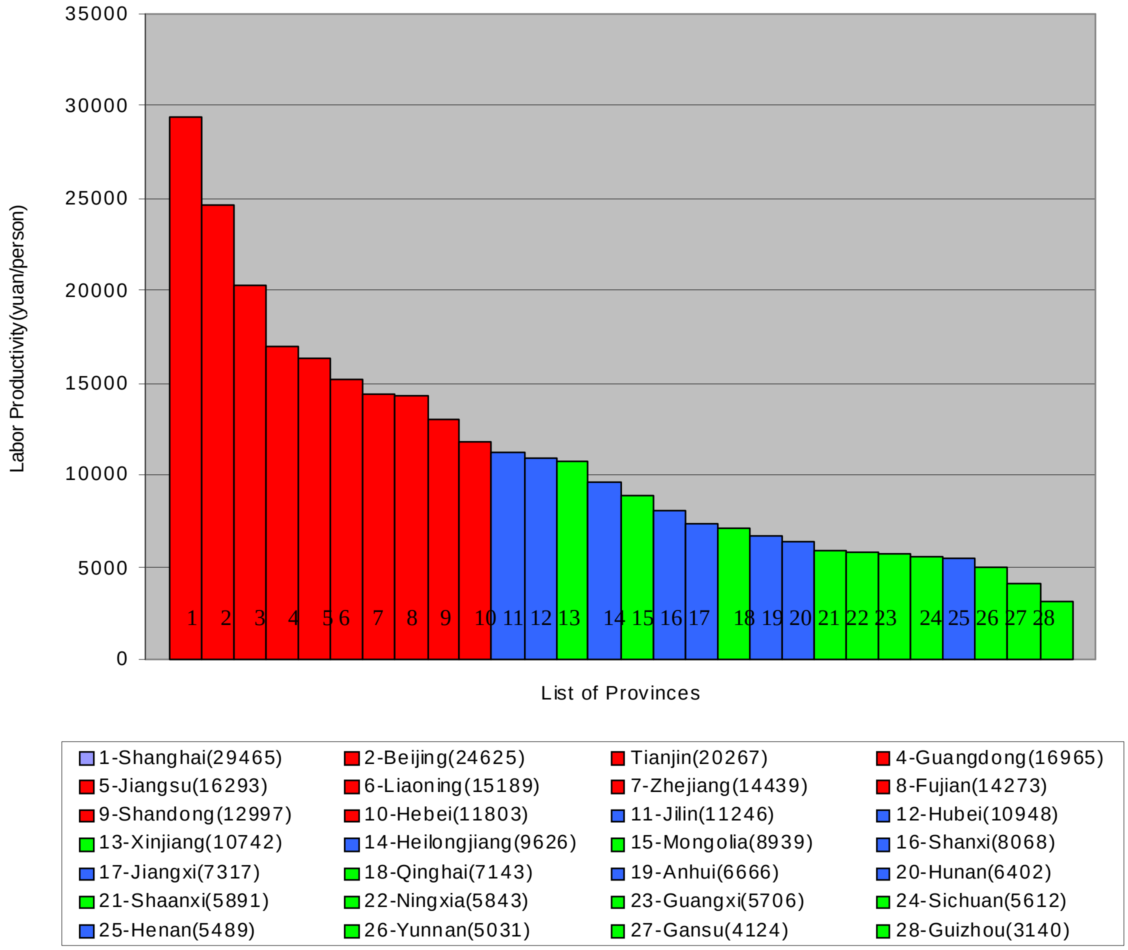
(at 1990 constant price)



Note: the number in the parenthesis is the provincial labor productivity in 1978(yuan/person)
Sources: see Figure 1.2

Appendix 3: Provincial Labor Productivity in 2001

(at 1990 constant price)



Note: the number in the parenthesis is the provincial labor productivity in 2001 (yuan/person)

Sources: see Figure 1.2

Appendix 4: Theil's T Index of per capita GDP and its Regional Decomposition

	GE_1 (nation)	GE_1 (coast)	GE_1 (centre)	GE_1 (west)	GE_1^W	GE_1^B
1978	0.075153	0.076913	0.01685	0.013354	0.04782	0.027334
1979	0.074198	0.075791	0.013793	0.00893	0.045664	0.028533
1980	0.075245	0.072433	0.014657	0.010921	0.044907	0.030338
1981	0.072374	0.067889	0.012494	0.010985	0.041976	0.030398
1982	0.067447	0.064114	0.012335	0.013634	0.040092	0.027356
1983	0.06726	0.063545	0.011502	0.010571	0.038953	0.028306
1984	0.0666	0.060767	0.011144	0.009872	0.037373	0.029227
1985	0.064889	0.056936	0.008904	0.010313	0.035041	0.029848
1986	0.063398	0.054367	0.008293	0.01072	0.033631	0.029767
1987	0.061943	0.049244	0.008704	0.009961	0.030933	0.03101
1988	0.061957	0.046359	0.009678	0.009417	0.029614	0.032343
1989	0.06073	0.045516	0.009104	0.009114	0.028907	0.031823
1990	0.060679	0.04559	0.009706	0.009763	0.029207	0.031471
1991	0.062797	0.042744	0.010399	0.009734	0.028123	0.034674
1992	0.064825	0.039437	0.008547	0.009783	0.026237	0.038587
1993	0.066631	0.035322	0.006712	0.008977	0.023658	0.042973
1994	0.069641	0.033666	0.005627	0.009081	0.022744	0.046897
1995	0.073403	0.033785	0.004331	0.00945	0.022846	0.050557
1996	0.074823	0.033718	0.00405	0.008646	0.022655	0.052168
1997	0.076882	0.034131	0.003918	0.00914	0.023062	0.05382
1998	0.079665	0.034784	0.004148	0.009121	0.023634	0.056031
1999	0.079118	0.034877	0.004868	0.008913	0.023739	0.055379
2000	0.081417	0.035906	0.005096	0.008991	0.024522	0.056895
2001	0.083148	0.037178	0.005488	0.008712	0.025374	0.057774

Notes: GE_1 (nation) is the Theil's T Index at the national level; GE_1 (coast) is the Theil's T Index within the coastal region; GE_1 (centre) is the Theil's T Index within the central region; GE_1 (west) is the Theil's T Index within the western region; GE_1^W is the within-region component of the Theil's T Index; GE_1^B is the between-region component of the Theil's T Index.

Sources: see Figure 1.2

Appendix 5: Theil's L Index of per capita GDP and its Regional Decomposition

	GE_0 (nation)	GE_0 (coast)	GE_0 (centre)	GE_0 (west)	GE_0^W	GE_0^B
1978	0.062378	0.073714	0.016152	0.013081	0.035613	0.026766
1979	0.061119	0.072671	0.013507	0.0091	0.033063	0.028056
1980	0.062467	0.069385	0.013994	0.010926	0.032681	0.029787
1981	0.060194	0.064161	0.011816	0.011163	0.030277	0.029917
1982	0.056519	0.060094	0.01195	0.013553	0.029717	0.026802
1983	0.056216	0.059961	0.011168	0.010439	0.028334	0.027882
1984	0.056061	0.057859	0.011016	0.009658	0.027261	0.0288
1985	0.054831	0.054028	0.008858	0.010249	0.025487	0.029344
1986	0.054051	0.052111	0.008366	0.010734	0.024835	0.029216
1987	0.053457	0.047426	0.008718	0.009967	0.022988	0.030469
1988	0.053806	0.044464	0.009615	0.00956	0.022041	0.031765
1989	0.052614	0.043392	0.009018	0.009289	0.021391	0.031223
1990	0.0527	0.043621	0.009578	0.009956	0.021871	0.030829
1991	0.054981	0.040901	0.010207	0.009801	0.021024	0.033957
1992	0.057287	0.037735	0.008464	0.009788	0.019391	0.037897
1993	0.059569	0.033757	0.00667	0.009111	0.017215	0.042353
1994	0.06286	0.032278	0.005589	0.009279	0.016439	0.046421
1995	0.066488	0.032365	0.004303	0.009707	0.016255	0.050233
1996	0.067899	0.032108	0.004023	0.009061	0.015852	0.052047
1997	0.06987	0.032253	0.003899	0.009527	0.016035	0.053835
1998	0.072471	0.032865	0.004127	0.009559	0.01633	0.05614
1999	0.071985	0.032655	0.004826	0.009515	0.01644	0.055545
2000	0.073959	0.033558	0.005043	0.009606	0.016857	0.057103
2001	0.075333	0.034753	0.005422	0.009356	0.017303	0.058031

Notes: GE_0 (nation) is the Theil's L Index at the national level; GE_0 (coast) is the Theil's L Index within the coastal region; GE_0 (centre) is the Theil's L Index within the central region; GE_0 (west) is the Theil's L Index within the western region; GE_0^W is the within-region component of the Theil's L Index; GE_0^B is the between-region component of the Theil's L Index.

Sources: see Figure 1.2

Appendix 6: Chinese Provinces and Their Neighbours

Code	Province	Neighbours
Coastal Region:		
BJ	Beijing	Tianjin, Hebei
TJ	Tianjin	Beijing, Hebei
SH	Shanghai	Jiangsu, Zhejiang
HEB	Hebei	Liaoning, Inner Mongolia, Shanxi, Henan, Shandong, Beijing, Tianjin
LN	Liaoning	Jilin, InnerMongolia, Hebei
JS	Jiangsu	Shanghai, Zhejiang, Anhui, Shandong
ZJ	Zhejiang	Shanghai, Jiangsu, Anhui, Jiangxi, Fujian
FJ	Fujian	Zhejiang, jiangxi, Guangdong
SD	Shandong	Hebei, Henan, Jiangsu, Anhui
GD	Guangdong	Fujian, Jiangxi, Hunan, Guangxi, ***Hainan***
HN	***Hainan***	Guangdong, Guangxi
Central Regional:		
SX	Shanxi	Hebei, Inner Mongolia, Shaanxi, Henan
JL	Jilin	Heilongjiang, Inner Mongolia, Liaoning
HL	Heilongjiang	Inner Mongolia, Jilin
AH	Anhui	Jiangsu, Zhejiang, Jiangxi, Hubei, Henan, Shandong
JX	Jiangxi	Fujian, Guangdong, Hunan, Hubei, Anhui, Zhejiang
HEN	Henan	Hebei, Shandong, Anhui, Hubei, Shaanxi, Shanxi
HB	Hubei	Henan, Anhui, Jiangxi, Hunan, Sichuan, Shaanxi
HN	Hunan	Hubei, Jiangxi, Guangdong, Guangxi, Guizhou, Sichuan
Western Region:		
GX	Guangxi	Yunnan, Guizhou, Hunan, Guangdong, ***Hainan***
NM	Inner Mongolia	Heilongjiang, Jinlin, Liaoning, Hebei, Shanxi, Shaanxi, Ningxia, Gansu
SC	Sichuan	Yunnan, Guizhou, Hunan, Hubei, Shaanxi, Gansu, Qinghai, ***Tibet***
GZ	Guizhou	Yunnan, Guangxi, Hunan, Sichuan
YN	Yunnan	Sichuan, Guizhou, Guangxi, ***Tibet***
SN	Shaanxi	Inner Mongolia, Shanxi, Henan, Hubei, Sichuan, Gansu, Ningxia
GS	Gansu	Inner Mongolia, Ningxia, Shaanxi, Sichuan, Qinghai, Xinjiang,
QH	Qinghai	Sichuan, Gansu, Xinjiang, ***Tibet***
NX	Ningxia	Inner Mongolia, Shaanxi, Gansu
XJ	Xinjiang	Gansu, Qinghai, ***Tibet***
XZ	***Tibet***	Xinjiang, Qinghai, Sichuan, Yunnan

Note: Provinces in italics are those excluded from the empirical analyses in this dissertation.

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Erklärung

Die vorliegende Dissertation mit dem Titel

Sources of Regional Growth Difference and Income Disparity during
the Reform Period in China: An Empirical Analysis

ist von mir ohne fremde Hilfe angefertigt worden. Es sind keine anderen als die angegebenen Quellen und Hilfsmittel verwendet worden. Alle Stellen, die wörtlich oder sinngemäß aus Veröffentlichungen entnommen wurden, sind als solche kenntlich gemacht.

Oldenburg, den 25. November 2004

Xiujuan Yu