經營學碩士　學位論文

A DEA-based Productivity Analysis of the Chinese Regional Economies

中國地域經濟의 DEA에 基礎한 生產性分析

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<LIST OF TABLES>

<LIST OF FIGURES>

국 문 요 약

中國地域經濟의 DEA에 基礎한 生産性分析

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본 論文은 1978년부터 2003년 사이의 中國의 地域開發에 대하여 調査하고 DEA方法(Data Envelopment Analysis: 資料包洛分析法)을 適用하여 中國地域들의 生産性의 變化를 分析하고, 未來의 發展戰略들에 대하여 論議한다. 이러한 過程을 통하여 政策立案者들을 위한 適切한 結論이 導出될 수 있을 것이다. 總要素生産性(TFP)增加를 技術變化와 效率性變化要素로 分割함으로써, 우리는 TFP增加를 技術變化 寄與와 技術效率性 改善으로 區分할 수 있다.

본 研究에서 우리는 中國 經濟가 1978년과 2003년 사이에 매우 높은 TFP成長率을 보여 왔고 이러한 TFP成長은 技術效率性의 改善 보다는 技術進步를 통하여 成就된 것처럼 보인다는 것을 確認하였다. 이 研究는 中國의 地域經濟가 地域間에 특히 海岸地域과 內陸地域간에 다른 TFP增加率을 보여주고 있음을 發見하였다. 이러한 發見들은 經濟的, 地域的 그리고 歷史的 要因들이 內陸보다는 海岸地域에 더 有利한 立地를 提供하여왔다는 것을 보여준다. 그리고 地域的 發展 戰略과 政策 그리고 生産要素市場의 歪曲들은 相互 密接하게 聯關되어서 地域間 效率性 隔差에 중요한 役割을 해 온 것이다.

이러한 地域間 隔差를 상당히 줄이는 것은 長期的인 課業이 될 것이다. 中國中央政府는 地域間에 비슷한 정도의 開放과 經濟的 自由를 賦與할 必要가 있다. 그리고 生産要素의 移動에 대한 障壁을 除去하기 위한 詳細한 節次들을 作動시키고, 産業發展戰略의 指針들을 提供하고, 內陸地域 특히 西部地域의 더 나은 社會的인 下部構造의 確立을 促進하고 比較優位에 基礎한 資源配分을 督勵할 必要가 있다.

ABSTRACT

A DEA-based Productivity Analysis of the Chinese Regional Economies

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This paper investigates the regional development in China over the period 1978-2003, analyzes the productivity change of Chinese regions using the DEA method, and discusses future development strategies, which can lead to relevant conclusions for policymakers. By decomposing TFP growth into technical change and efficiency change components, we can separate TFP growth into technical progress contribution and the improvement in technical efficiency.

In this paper we find that Chinese economy has shown very high TFP growth rates during the year 1978-2003, and this TFP growth seems to have been accomplished through “technical progress” rather than improvement in technical efficiency. The study finds that the Chinese regional economies show different TFP growth rates among regions, especially the coastal and inland area. This finding shows that economic, geographical and historical factors put the coast area in a better position than the inland area. Regional development strategies and policies, and factor market distortions, which are closely linked with each other, have played important roles in regional productivity disparity.

It will be a long-term task to significantly reduce this regional disparity. The Chinese central government needs to allow a similar degree of openness and economic liberalization across regions; work out detailed procedures to remove barriers to the movement of factors of production; provide industrial development guidelines; promote the establishment of better infrastructure in the inland areas; and encourage optimal resource allocations based on comparative advantages.

Chapter 1
Introduction

1-1 The Background and Purpose

China’s dynamic economy has one of the highest sustained growth rates in the 20th century. It has also gone through profound institutional and structural changes. It has been in a long, gradual transition from rigid central planning toward a more decentralized, market-based economy since initiating economic reforms in 1978. Gross Domestic Product (GDP) growth averaged more than 8 percent per year from 1978 to 2003. In 2004, China’s GDP grew 9.1 percent and many sectors grew in excess of 10 percent. This growth is unprecedented in world history. Economic reform was the key to the Chinese success. The reforms can boost productivity growth in two conceptually different ways. One way is by increasing the efficiency with which the existing resources are utilized in production. Due to well-known systemic reasons, centrally planned economies like the Chinese economy produce well below their best practice outputs. Economic reform aims to raise production close to the frontier (i.e. improvement in technical efficiency). Another way to boost productivity growth is by stimulating innovation, i.e. technological progress. Centrally planned economies have recorded low levels of technological progress according to international standards. Most analysts feel that the current pace of growth is unsustainable. Even the Chinese government is trying to rein in growth. It is unprecedented for a large country to sustain such a high rate of growth over two decades.

Changes that took decades to achieve in other countries are occurring in China over the course of just a few years. However, opinions differ as to the future of China's growth. Some scholars made a less exciting prediction, due to their finding of a decline in TFP growth in the 1990s China. To evaluate the truth of such studies, in this paper, we make an empirical analysis of the roles of TFP and technical efficiency of Chinese regions using the DEA method that calculate the Malmquist index, with the consideration of a structural change and other changes due to reform in 1978. In paper we use a comparison of the roles of TFP, technical efficiency, capital and labor in China's growth in order to illustrate the unique pattern of China's reform growth and the regional differences in economic development. For China, technology adoption leads to a higher TFP growth in the post-reform period, and the problem is an inefficient allocation of capital, due to the official control of credit.

1-2 The Plan of The Paper

In the remainder of this paper, firstly we review the previous studies and in Chapter 2 we conduct a brief survey of the regional current economic situation about the three regions with historical policies. In Chapter 3 explain our methodology of the Malmquist TFP Index. In Chapter 4 we will designate three regions in China and then analyze the data to get the empirical results. The results from table 5 to table 12 are calculated by the DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program. According the tables, we present our empirical results and their implications in Chapter 4. In the final section Chapter 5 we will summary the problem in

China and present the suggestion.

1-3 Previous Studies

Recent interest in productivity studies was largely triggered by the desire of economists and the general public to explain productivity slow-down in the United States over the past decades. Empirical studies such as Baumol (1986), Nguyen (1989) and Wolff (1991, 1996) focused on investigating the long-run trend of productivity growth. Especially, it is argued that the relative productivity slow-down in the US and European countries may be due to the natural process of convergence, as countries with a low level of productivity catch up to those with a high level of productivity. While the convergence view is being questioned, there remains empirical evidence supporting the convergence in productivity, per capita income and economic growth.

The convergence debate has recently been extended to studies of the high performing economies in East Asia. In particular, empirical studies of East Asian economies have focused on examining the contribution of total factor productivity to economic growth. On the one hand, it is argued that the rate of productivity growth in the East Asian is not high even though the growth of output and manufacturing exports in these countries is unprecedented. On the other hand, the World Bank (1993) and other authors have shown empirical evidence of rapid productivity growth in the high performing Asian economies (HPAEs). [1] The existing literature covers both

[1] Other authors include Kawai (1994), Oshima (1995) and Sarel (1995).

cross-country and industry studies. Several authors also presented empirical analyses of regional economies within countries.[2]

Empirical studies of productivity performance in the Chinese economy are more sectors oriented. There is an abundant literature on China's agricultural and industrial productivity.[3] It is now widely accepted that agricultural productivity increased considerably after the initiative of economic reform in 1979, in particular in the first half of the 1980s. However, researchers are still uncertain about whether industrial productivity has increased since the reform. Early studies such as the World Bank (1985), argued that industrial TFP declined in the initial years of the reform. However, more recent studies including Chen et al. (1988), Jefferson presented evidence of significant TFP growth during the reform period. This study attempts to extend previous work and shed some light on the issues associated with productivity convergence, catch-up and growth using China's regional economies as the setting.

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[2] Such as Holtz-Eakin (1993) and Paul and Karras (1994)

[3] See Wu (1993) and Wu and Yang (1998) for comprehensive reviews of the literature.

Chapter 2
The Regional Current Economic Situation in China

2-1 The Regional Current Economic Situation

The coastal region: Productivity on coastal provinces is in general higher than in the inner provinces. This is because coastal provinces pursued economic reform earlier and faster than did the inner provinces. Coastal provinces have attracted more foreign direct investment than have the inner provinces, which remain highly reliant on state funding support. Government policy favors the coast in terms of higher investment and the concessions granted for foreign capital. Chinese leadership opened up for foreign investment and trade a few Special Economic Zones on the south coast in 1980, granting them special development incentives and privileges, which were later extended to the fourteen port cities and then to the entire Coastal Region.[4] These policies, combined with the coast's historical advanced economic position, insured that the Coastal Region would prosper with reform.

The central region: In China most of the state-owned enterprises (SOEs) concentrate in this area, especially the heavy industries and it also is the main agricultural area. So the central region supports the coastal regional

[4] The four Special Economic Zones are Shenzhen, Zhuhai, Xiamen, and Shantou. Fourteen port cities are Qinhuangdao, Tianjin, Dalian, Yantai, Qingdao, Lianyungang, Nantong, Shanghai, Ningbo, Wenzhou, Fuz hou, Guangzhou, Zhanjiang, and Beihai. For development of the southeastern coastal provinces, see Lyons and Nee (1994).

economic development in industrial products and energy resources. After the 1978 reform, the central region developed with the costal region, and the government wants to increase the levels of industrialization and urbanization, and then strengthen their superior position in agriculture, and industrialize the agricultural sector.

The western region: Before 2000 the western regional economy developed very slower than the other two regions. Development of the western region is vital to the balanced growth of China. The Chinese government's regional development strategy in the tenth FYP (2001-2005) is to "put into effect the development of the west, accelerate the regional development of the central and the western regions, rationally adjust regional economic distribution, and promote coordinated regional development". As for the development of the west, the government wants to see significant progress in infrastructure construction and ecological environment protection. There should also be a substantial advance in science, technology and education. The west has been open to the outside world and the rest of the economy. The western regions use both foreign and domestic capital for growth now.

We can see from Table 1 that most provinces experienced tremendous real GDP growth over the 25-year period, with a national average growth rate of 8.91%. And generally, the provinces in the East performed best, whereas provinces in the West had the poorest performance.

Table 1 Average Growth Rates of GDP, capital and labor, 1978 to 2003

Growth Rates	GDP	Capital	Labor
East	9.79%	10.92%	2.23%
Central	8.82%	7.78%	2.53%
West	8.13%	6.98%	2.61%
National	8.91%	8.56%	2.46%

Source: China Statistical Yearbook (various editions). The data of Chongqing are included in Sichuan for better coherence. We do not include Hainan, which is an island without direct road/railway connection with the continent, and Xizang because of their special characteristics.

2-2 The Historical Effective Policy Reforms in Regions of China

The Chinese government's regional development strategies and the corresponding policies are the most often mentioned factor leading to regional economic development. During 1973-1978, China adjusted its strategy and the priority began to be shifted from the inland to the east. Immediately after the adoption of economic reforms and the open-door policy, the Sixth Five-Year Plan (FYP) (1981-1985) outlined that regional development should be based on comparative advantages. While the coast should upgrade their industrial structure, tackle the infrastructure bottleneck and engage in foreign trade and investment, the inland should develop energy, transportation and raw material industries to support the coast. This shows that the government still meant to have balanced regional development in the early 1980s.

The Seventh FYP marked a significant shift in China's regional strategy. It was based on the so-called "step ladder development", i.e. the Chinese version of 'trickledown' development. Its theory was that economic development should be gradually carried forward from the coast to inland. Following this, the "coastal development strategy" was formulated in 1988, and the coast was allowed to establish 5 special economic zones, 14 coastal open cities, 13 economic and technical development districts, 3 economic development areas and Shanghai Pudong New District. Foreign trade and investment were highly encouraged to help the development of high-tech and outward oriented industries and service sectors in the coast. State-owned enterprises (SOEs) and fiscal and financial reforms and the development of town and village enterprises (TVEs) in the coast were also allowed to go ahead of the inland.

The development strategies in both the Eighth (1991-1995) and Ninth (1996-2000) FYPs clearly focused on the coordinated development and the reduction in regional disparity. A number of measures were taken to promote the development of the inland, including increasing investment in infrastructure, education and training, facilitating the inflow of foreign capital, making more anti-poverty efforts in the inland and promoting cooperation between the coast and inland. The western development strategy was formulated in September 1999 to improve infrastructure and the business environment and attract foreign direct investment (FDI) in the west.

In summary, it seems that regional strategies during most of the reform period have meant to stimulate balanced or coordinated regional growth. Strictly speaking, only the coastal development strategy in the second half of the 1980s was designed to widen the regional gap in the short run. For various reasons, the effect of the balanced or coordinated regional development has not been felt yet since 1990s. Empirically, some professors suggest that the government's favorable policies for the coast were an important reason for the increase in regional disparities. Because of these policies, the coast has attracted more FDI and experienced quicker economic development. However, the concentration of FDI in the coast can be explained by their inherent local comparative advantages. Government policies help the realization of these advantages.

So we can say the apparent logic behind the open door policy was that the coast would establish links to both foreign markets and interior provinces. The benefits were to be many, such as the development of low-wage, labor-intensive exports to pay for needed imports; industrial concentration to generate technological advances; and perhaps most important, the eventual trickle-down of prosperity to the less developed areas of the interior. Interior development, then, would be only a question of time.

Chapter 3
Methodology

3-1 The Background of the Methodology

The theoretical framework concerning our study is the neo-classical growth theory. Growth in this framework stems from two sources: factor accumulation and productivity (TFP) growth. The theoretical foundation of this approach is the production theory according to which an economy can grow by (1) deploying more inputs, labor and capital, to production and/or by (2) becoming more efficient, i.e. producing more output per unit of input.

Input-driven growth is not sustainable because of the law of diminishing returns to capital. This leaves productivity as the sole viable engine of long-term economic growth (Liu, 2000). Therefore, the key point of the productivity debate on Asia as well as on China is the relative importance of each of these two components. In comparison with factor accumulation, the problems inherent in the estimation of TFP are not a simple issue, and hence most of the debate has focused on TFP (Felipe, 1999).

Usually aggregate TFP growths on China are studied with two mythologies, growth accounting and the aggregate time series production function estimation. The former has been used by the World Bank (1997), Hu and Khan (1997), Maddison (1998), Liu (2000), Wang and Yao (2003), Young (2003), while the latter by Chow (1988, 1993, 2002a, 2002b), Heytens and Zebregs (2003), Wang and Meng (2001). However, the two methodologies suffer from three major drawbacks. First, in the case of growth accounting fairly strong behavioral and institutional assumptions have to be maintained in order to calculate the rate of TFP growth. Second, none of the two approaches distinguish between the part of productivity growth due to technical progress and the part due to an increase in technical efficiency. Third, aggregate time series were used in most of the studies. With just about two score of observations, it is very difficult to include more than a few explanatory variables in the analyses.

3-2 The Malmquist TFP Index and DEA Method

There are a number of different methods that could be used to measure the distance functions, which make up the Malmquist TFP index. To date, the most popular method has been the DEA linear programming methods suggested by Färe et al (1994).

3-2-1 The Malmquist TFP Index

The Malmquist productivity indexes were first suggested by Caves, Christensen and Diewert (1982), and furthered developed by Fare et al. (1989). This index is defined using the Shephard (1953)'s distance functions that describe multi-input and multi-output production technology without the requirement to specify a behavioral objective (such as cost minimization or profit maximization). The distance functions can be defined using an output-oriented approach or input-oriented approach. An output distance function is defined as the maximal proportional expansion of the output vector, given an input vector, whereas an input distance function looks at a minimal proportional contraction of the input vector, given an output vector.

In this study we use the Malmquist Index (Färe et al. 1994), which belongs to the category of frontier production function estimations. It is free of the strong assumptions involved in the Divisia index approach of growth accounting. Another major advantage of this approach is that it allows decomposing the change in TFP into technical progress and technical efficiency change; the former is associated with changes in the best-practice production frontier, and the latter with other productivity changes, such as learning by doing, improved managerial practices, and change in the efficiency with which a known technology is applied. This distinction is fundamental for policy actions, especially in developing countries, where identifying TFP growth with technical progress can miss the fact that technical efficiency change seems to be the most relevant component of the total change in TFP, and therefore, the introduction of new technologies without having realized the full potential of the existing ones might not be meaningful (Felipe, 1999). A third advantage of our study involves the panel data nature of the provincial sample. It provides extra degrees of freedom (more than 600 observations for the reform period) in analyzing the determinants of productivity growth, of technical progress, and of efficiency improvement.

This paper applies the method of Data Envelopment Analysis (DEA) and computes the Malmquist index to measure the productivity in China. To start with, suppose that we have an output possibility set:

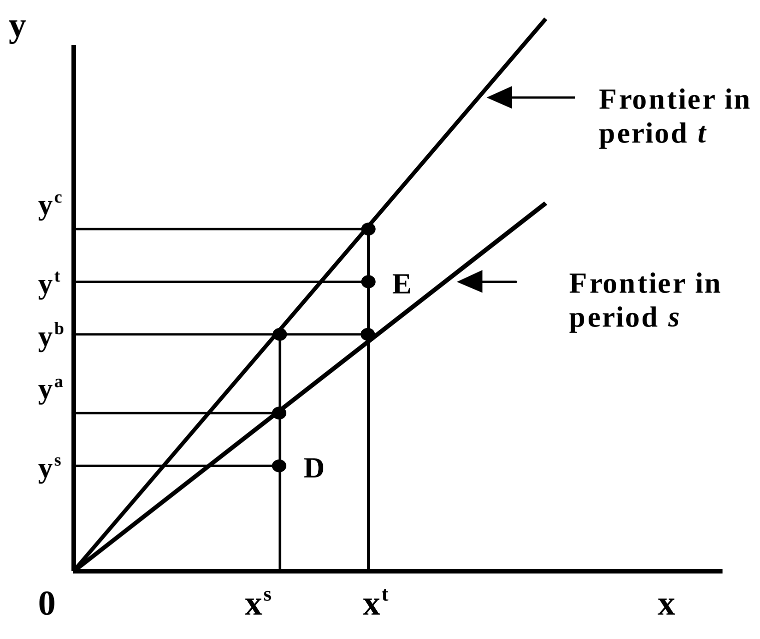
(1) P(x) = {y: x can produce y}.

The output distance function with technology at time s, the initial period, can be defined as:

(2) $$d^s(x,y) = \min\{\theta : \frac{y}{\theta} \in P(x)\}$$

Note that when θ is minimized, y/θ is maximized. Thus this distance function measures the maximum possible output that a given amount of inputs can produce. It is a measure of technical efficiency. Similarly, we can define a distance function in relation to the technology in time t, the final period, as $d^t(x,y)$.

Figure 1 Decomposition of the Malmquist Productivity Index



The idea can be shown graphically by a simplified (one-input and one-output with constant returns to scale (CRS) technology) case. Points D and E in Figure 1 represent the input-output combinations of a production unit in periods s and t respectively. In both cases, it is operating below the production possibility frontier. In period s (correspondingly, period t), with input xs (xt), it should be able to produce ya (yc) if it has full technical efficiency. Then the technical efficiency is measured by ys/ya (yt/yc).

Productivity change can be measured by the part of output growth that is not contributed by input growth. In Figure 1, we can calculate a productivity index by $(y^t/y^s)/(y^b/y^a)$, where (y^t/y^s) is the output growth and (y^b/y^a) represents a movement along the production frontier in periods. This can be rewritten as $(y^t/y^b)/(y^s/y^a)$, where the numerator is a distance function for output in period t (y^t) with reference to the technology of period s and the de numerator is the distance function representing technical efficiency in period s. This is precisely the Malmquist Productivity Index defined by Caves, Christensen and Diewert (1982a and 1982b; hereafter CCD), with reference to the technology of the initial period:

(3) $$m^s_{CCD} = \frac{d^s(x^t, y^t)}{d^s(x^s, y^s)}$$

However, we can also choose the technology in period t as the reference in defining a productivity index. The Malmquist Productivity Index in relation to the technology of the final period can be defined as:

$$m_{CCD}^{t} = \frac{d^{t}(x^{t}, y^{t})}{d^{t}(x^{s}, y^{s})} \tag{4}$$

The two indexes appear to be identical in the simple case represented by Figure 1. However, they may or may not be the same in the cases of multiple inputs and varying returns to scale (VRS) technology. To avoid the arbitrariness in choosing the benchmark, Färe et al. (1992 and 1994) specify the Malmquist Productivity Index as the geometric mean of the above two indexes:

$$m\ (x^{t}, y^{t}, x^{s}, y^{s}) = \left[\frac{d^{s}(x^{t}, y^{t})}{d^{s}(x^{s}, y^{s})} \times \frac{d^{t}(x^{t}, y^{t})}{d^{t}(x^{s}, y^{s})} \right]^{1/2} . \tag{5}$$

Färe et al. (1992) shows that this index is equivalent to:

$$m\ (x^{t}, y^{t}, x^{s}, y^{s}) = \frac{d^{t}(x^{t}, y^{t})}{d^{s}(x^{s}, y^{s})} \times \left[\frac{d^{s}(x^{t}, y^{t})}{d^{t}(x^{t}, y^{t})} \times \frac{d^{t}(x^{s}, y^{s})}{d^{t}(x^{s}, y^{s})} \right]^{1/2} , \tag{6}$$

where the ratio outside the brackets measures the change in technical efficiency between the years s and t. The geometric mean of the two ratios inside the square brackets captures the shift in technology between the two periods evaluated at xs and xt. In Figure 1, the two components of the Malmquist Index as in Equation (6) is represented by:

(7) Efficiency change = $\dfrac{y^t / y^c}{y^s / y^a}$; and

(8) Technical change = $\left[\dfrac{y^t / y^b}{y^t / y^c} \times \dfrac{y^s / y^a}{y^s / y^b}\right]^{1/2}$.

All the distance functions can be estimated by Data Envelopment Analysis (DEA). Ali and Seiford (1994), Grosskopf (1994) and Rao and Coelli (1998) explain clearly how the estimation can be done. Suppose we there are K regions (indexed by k) using N inputs (indexed by n) to produce M products (indexed by m). x_n^{ki} and y_m^{ki} denote the nth input and mth output in the kth region at time period i (i=s, t). We have to solve a linear programming problem to evaluate each of the distance functions in equation (6). Assuming a constant returns-to-scale technology, we have

(9) $$\left[D^i(x^{k'i'}, y^{k'i'})\right]^{-1} = \max_{z,\theta} \theta^{k'}$$

s.t. $\theta^{k'i'} y_m^{k'i'} \leq \sum_{k=1}^{K} z^{ki} y_m^{ki}$, m = 1,…,M,

$\sum_{k=1}^{K} z^{ki} x_n^{ki} \leq x_n^{k'i'}$, n = 1,…,N,

$z^{ki} \geq 0$, k = 1,…,K,

where z^{ki} is a variable indicating the intensity at which a particular activity is employed in constructing the frontier of the production set. Note that when i=i'=s (correspondingly, i=i'=t), solving the above linear programming yields the technical efficiency in period s (t).

This linear programming problem is the basis for DEA and the distance function estimates are referred to as DEA efficiency estimates.

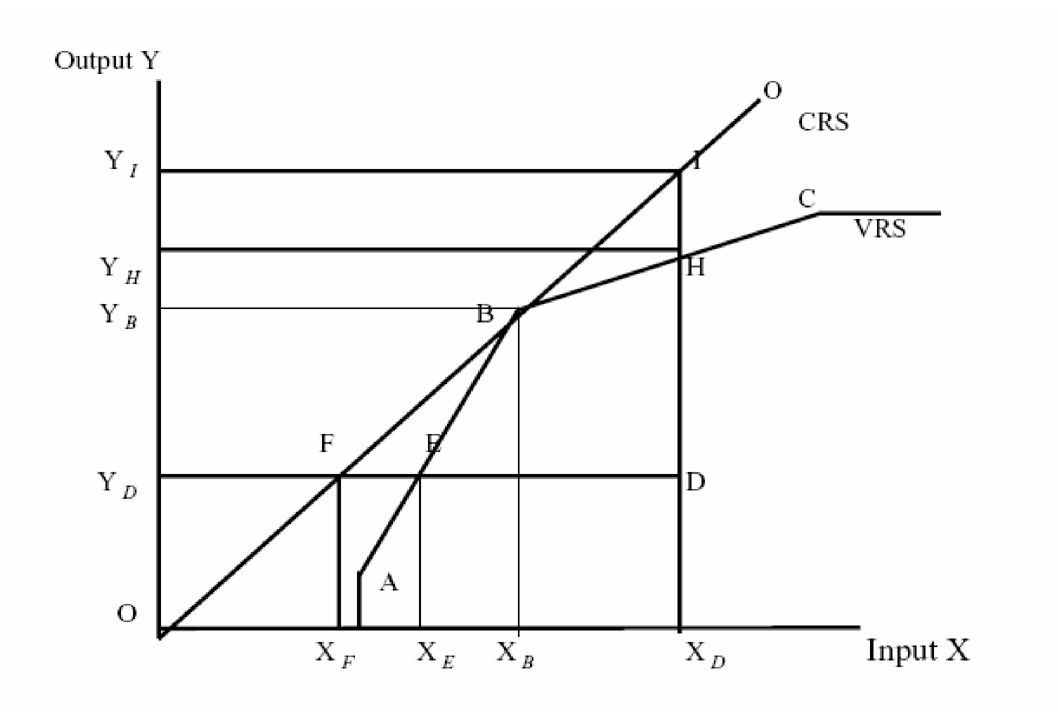
3-2-2 The DEA Method

Data Envelopment Analysis (DEA), our non-parametric linear programming method of measuring efficiency is fundamentally based on the work by Farrell (1957) which was further elaborated by Charnes et al. (1978) and Banker et al. (1984). This approach (see e.g. Färe et al.1985) has been widely used in empirical efficiency (or productivity) analysis especially in cases where the units (DMUs) use multiple inputs to produce multiple outputs, and there are problems in defining weights and/or specifying functional forms to be employed in analysis. As DEA does not require input or output prices in determining empirical efficiency frontiers based on best practice technology and related measures of inefficiency, it has become especially popular in the study.

Four decision-making units are described in Figure 2 below; these are the points A, B, C and D. The DMUs use one input X to produce one output Y. Either constant returns to scale (CRS) or variable returns to scale (VRS) can be assumed for the production possibility frontier. In practical research several inputs and possibly more than one output are used, creating a multidimensional situation.

Under CRS, the most efficient unit is B, for which the tangent of the angle measured from the origin (output/input) is greatest (Y_B / X_B). Accordingly, the efficiency frontier under CRS is the line OO. Compared with B, points A, C and D are clearly inefficient. Point D for example uses more of the input (X_D) to produce less of the output (Y_D) than point B. In order to be efficient, only X_F should be used to produce Y_D, or alternatively Y_I should be produced with input use X_D. From this we get X_F / X_D as the relative efficiency of D in the input direction; in the output direction the efficiency score is Y_D / Y_I. Under CRS these two ratios are equal, or $(X_F / X_D) = (Y_D / Y_I)$.

Figure 2 Efficiency of decision-making units in DEA, basic case



Under VRS the efficiency frontier passes through the points A, B and C. Consequently the relative efficiency of D is X *E* /X *D* in the input direction and Y *D* /Y *H* in the output direction, these ratios being generally unequal. In VRS efficiency can be further decomposed into scale efficiency and technical efficiency. Scale efficiency relates the size of the DMU to optimal size; in the input direction it is given by the ratio (efficient input use under CRS)/(efficient input use under VRS), or X *F* /X *E* in Figure 2. Similarly, scale efficiency in the output direction is Y *H* /Y *I*. This efficiency loss is due to the not optimal size of the DMU. The rest of the inefficiency of D is technical inefficiency, measured by X *E* /X *D* in the input direction, or Y *D* /Y *H* in the output direction.

Data envelopment analysis (DEA) involves the use of linear programming methods to construct a non-parametric piece-wise surface (or frontier) over the data. In this study, the DEA method is used to compute the Malmquist index, which measures the total factor productivity (TFP) and technological and technical efficiency changes in China. The use of the DEA does not require any specification of the functional form of the production relationship. Given inputs used and output produced, prior weighting of the relative importance of outputs and inputs is not required.

Chapter 4
Analyses of Empirical Results

4-1 The Description of Three Regions in China

For the purpose of comparison, interpretation of the results is presented in light of the regional economies.[5] In the following sessions, a brief description of the regional economies is presented first. This is followed by comparisons of productivity and efficiency performance among the regions.

In the Figure 3 designate three regions in China because the government designates the 27 provinces of China geographically into three macro-regions: the Coastal (East), Central, and Western Region.

The Coastal (Eastern) Region encompasses nine provinces Hebei, Liaoning, Shandong, Zhejiang, Jiangsu, Fujian, Guangdong Hainan and Guangxi (including three municipalities): Shanghai, Beijing, Tianjin municipalities which is the most developed and industrialized area with the highest industry shares in total national income and with the highest ratios of national average of industrial output per capita. State-owned, large and middlesized enterprises dominate in this region and all Special Economic Zones & most of the Open Cities and priority development areas[6] are

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[5] More detailed analysis is documented in Wu (1998).

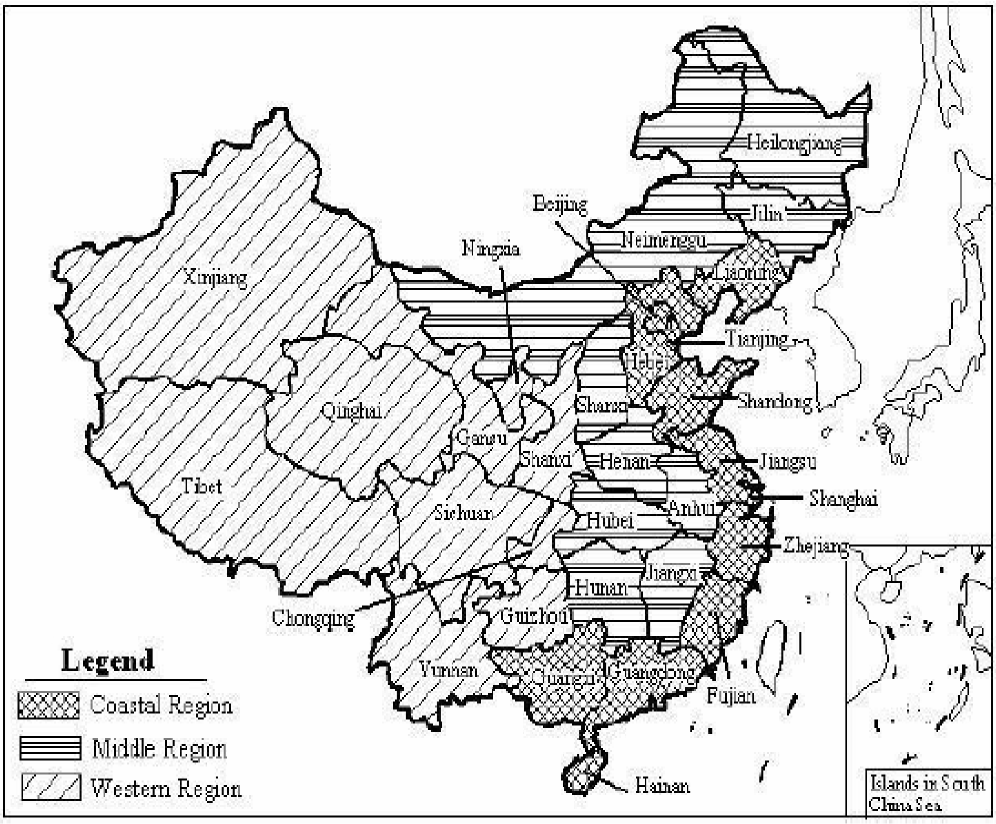
[6] The four Special Economic Zones are Shenzhen, Zhuhai, Xiamen, and Shantou. Fourteen port cities are Qinhuangdao, Tianjin, Dalian, Yantai, Qingdao, Lianyungang, Nantong, Shanghai, Ningbo, Wenzhou, Fuz hou, Guangzhou, Zhanjiang, and Beihai.

located in this region.

The Central Region includes nine provinces: Heilongjiang, Jilin, Hubei, Shanxi, Hunan, Anhui, Jiangxi, Henan, and Inner Mongolia[7].

The Western Region includes nine provinces: Xinjiang, Qinghai, Ningxia, Gansu, Shaanxi, Yunnan, Quizhou, Sichuan and Tibet. Their ratios of national average of industrial output per capita and shares of national industrial output are quite low relative to all other provinces.

Figure 3 China's Three Economic Regions



[7] Inner Mongolia is the least developed area. Because the data of Inner Mongolia is difficult to get so we will not calculate the TFP of Inner Mongolia.

4-2 The Data Description

In this paper, panel data for China's real GDP for 1978-2003, nominal gross capital and labor for 1978-2003 are taken from China Statistical Yearbook (CSY), China Provincial Statistical Yearbook China Labor Statistical Yearbook to calculate China's TFP growth rate and regional efficiency. Specifically, the data for output and input variables are from the China Industrial Economy Statistical Yearbook and I also adopt the capital data from the paper--China's Capital and Productivity Measurement Using Financial Resources by Professor Kui-Wai Li who works at City University of Hong Kong. All price indices are from the China Price Statistical Yearbook.

4-3 The Analysis of Economic Growth in China

The purpose of the analysis here is to determine the trends and nature of productivity growth of China during economic reform. The nature of the productivity growth is discussed through examination of the components of the TFP growth, i.e., technical progress and efficiency change.

Table 2 shows that the country average technical efficiency did not increase highly during the 24 years between 1979 and 2003. It was 82.61% in 1979 and 83.12% in 2003. The technical efficiency decreased and the scale efficiency increased. In Table 3 the productivity growth increased mainly because the technical progress increased but not due to the efficiency change. Especially from 1979-1984, the productivity growth was very high. By decomposing TFP growth into technical and efficiency change components, we can separate the part of TFP growth due to technical progress from the part due to an improvement in technical efficiency. We can see in Table 3 that productivity growth seem to have been accomplished through “technical progress” rather than improvement in technical efficiency. The accumulated “technical progress” during 1979-2003 is am impressive of 203.12%, while the change in technical efficiency is minus. So Table 2 and Table 3 shows that the economic growth in China was accomplished through technical progress.

Table 2 Technical Efficiency（Country Average，1979-2003）

Year	Technical Efficiency (CRS)	Technical Efficiency (VRS)	Scale Efficiency
1979	0.8261	0.8613	1.0384
1980	0.8167	0.8382	1.0512
1981	0.7763	0.8316	1.0335
1982	0.7613	0.8433	1.0542
1983	0.8089	0.8612	1.0612
1984	0.7898	0.8289	1.0601
1985	0.7602	0.8108	1.0633
1986	0.7611	0.8212	1.0816
1987	0.7762	0.8253	1.0813
1988	0.7936	0.8431	1.0694
1989	0.8262	0.8623	1.0511
1990	0.8289	0.8664	1.0467
1991	0.7922	0.8376	1.0656
1992	0.7889	0.8336	1.0721
1993	0.7923	0.8425	1.0771
1994	0.8062	0.8477	1.0662
1995	0.8121	0.8553	1.0701
1996	0.8179	0.8629	1.0707
1997	0.8176	0.8622	1.0709
1998	0.8238	0.8648	1.0671
1999	0.8239	0.8638	1.0641
2000	0.8241	0.8632	1.0640
2001	0.8223	0.8501	1.0412
2002	0.8276	0.8678	1.0652
2003	0.8312	0.8711	1.0701

Table 3 The Components of Malmquist Productivity Index

Year	Productivity Growth	Technical Progress	Efficiency Change (CRS)	Efficiency Change (VRS)	Scale Efficiency Change
1980/1979	1.0856	1.1251	0.9671	0.9687	0.9993
1981/1980	1.0601	1.0767	0.9753	0.9683	1.0083
1982/1981	1.0771	1.0733	1.0044	1.0143	0.9842
1983/1982	1.0721	1.0471	1.0242	1.0262	0.9969
1984/1983	1.1089	1.1292	0.9731	0.9811	1.0041
1985/1984	1.0652	1.1132	0.9681	0.9651	0.9931
1986/1985	1.0059	1.0221	0.9829	0.9862	1.0011
1987/1986	1.0349	1.0112	1.0166	1.0121	1.0051
1988/1987	1.0451	1.0211	1.0243	1.0109	1.0133
1989/1988	1.0055	1.0012	1.0056	1.0013	1.0024
1990/1989	1.0144	1.0213	0.9945	0.9939	1.0016
1991/1990	1.0299	1.0832	0.9533	0.9589	0.9932
1992/1991	1.0639	1.0723	0.9942	0.9944	0.9989
1993/1992	1.0378	1.0330	1.0067	1.0061	1.0011
1994/1993	1.0290	1.0199	1.0093	1.0031	1.0078
1995/1994	1.0189	1.0211	0.9989	0.9972	1.0032
1996/1995	1.0209	1.0154	1.0067	1.0033	1.0042
1997/1996	1.0128	1.0169	0.9948	0.9942	1.0031
1998/1997	0.9898	1.0076	0.9931	0.9894	1.0043
1999/1998	1.0056	1.0161	0.9889	0.9861	1.0052
2000/1999	1.0014	1.0113	0.9891	0.9879	1.0024
2001/2000	0.9971	1.0069	0.9890	0.9851	1.0046
2002/2001	1.0561	1.0102	0.9996	0.9901	1.0089
2003/2002	1.0768	1.0198	1.0051	1.0049	1.0103
2003/1979	1.9986	2.0312	0.9901	0.9671	1.0169

4-4 The Analysis of Different Regions and Periods

Table 4 The Eastern Region (1978-1990)

Regions Provinces	Efficiency Change (CRS)	Efficiency Change (VRS)	Tech Progress (CRS)	Scale Efficiency Change	TFP Growth
Beijing	0.9913	0.9911	1.0411	1.0004	1.0331
Shanghai	1.0000	1.0000	1.0501	1.0000	1.0500
Tianjin	0.9829	0.9831	1.0426	0.9999	1.0249
Jiangsu	1.0009	1.0043	1.0625	0.9968	1.0629
Zhejiang	0.9951	0.9953	1.0659	0.9997	1.0608
Shandong	0.9956	0.9950	1.0659	1.0004	1.0611
Guangdong	1.0123	1.0097	1.0647	1.0026	1.0774
Hainan	0.9919	0.9904	1.0668	1.0025	1.0575
Liaoning	0.9916	0.9921	1.0519	0.9996	1.0430
Fujian	1.0061	1.0057	1.0669	1.0004	1.0729
Hebei	0.9892	0.9875	1.0637	1.0019	1.0512
Guangxi	0.9983	0.9993	1.0601	0.9996	1.0577
Average	0.9963	0.9961	1.0585	1.0003	1.0544

Table 5 The Central Region (1978-1990)

Regions Provinces	Efficiency Change (CRS)	Efficiency Change (VRS)	Tech Progress (CRS)	Scale Efficiency Change	TFP Growth
Heilongjiang	0.9856	0.9856	1.0518	0.9998	1.0361
Jilin	0.9894	0.9899	1.0599	1.0004	1.0479
Hubei	0.9956	0.9934	1.0641	1.0021	1.0591
Shanxi	0.9743	0.9747	1.0618	0.9998	1.0341
Anhui	0.9868	0.9851	1.0603	1.0013	1.0451
Jiangxi	0.9934	0.9939	1.0633	0.9998	1.0545
Henan	0.9956	0.9944	1.0608	1.0009	1.0552
Hunan	0.9911	0.9887	1.0626	1.0024	1.0521
Average	0.9890	0.9882	1.0606	1.0008	1.0364

Table 6 The Western Region (1978-1990)

Regions Provinces	Efficiency Change (CRS)	Efficiency Change (VRS)	Tech Progress (CRS)	Scale Efficiency Change	TFP Growth
Sichuan	0.9906	0.9877	1.0601	1.0033	1.0483
Guizhou	0.9971	0.9974	1.0603	0.9974	1.0560
Yunnan	1.0043	1.0051	1.0605	0.9999	1.0635
Xizang	0.9721	0.9804	1.0672	0.9914	1.0381
Shaanxi	0.9867	0.9866	1.0658	1.0004	1.0511
Guansu	0.9813	0.9818	1.0636	1.0003	1.0432
Qinghai	0.9856	0.9594	1.0583	1.0006	1.0145
Ninxia	0.9704	0.9694	1.0629	1.0023	1.0311
Xingjiang	0.9898	0.9899	1.0631	1.0006	1.0520
Average	0.9864	0.9842	1.0624	0.9996	1.0442

According to Table 4, Table 5, and Table 6, we can see that in 1978-1990 TFP growth rate in China didn't mainly depend on the efficiency change, but mainly depend on the technical progress. In this period the technical improve rate is faster than the efficiency slow down rate and TFP improved very fast. The technical improvement in eastern region and central region were faster than the western region. These regions had the high growth rates in economies, because the earlier open reform policy gave more help and support to the provinces in these regions, especially the eastern region. The western provinces in this period had a very slow increasing speed in economy.

According to Table 4, Table 5, and Table 6 we can see clearly that in the early reform period the economy in China developed healthily. Although the efficiency change had met some difficulties, the reform policy improved the economy. So we call this period the pre-reform period. The pre-reform in China in 1978 beginned from the agricultural reforms, and then according to national aggregate data, total factor productivity (TFP) in China's agriculture increased by 55 percent in 1980s. This was unprecedented in the developing world, and most of the rapid change was attributed to the Household Responsibility System (HRS), which was a one-off institutional change.8

[8] Stone indicates that several technological improvements were made prior to 1979. These included the adoption of new varieties of wheat, rice, and corn. For wheat and rice it was new short-straw varieties and for corn it was hybrid varieties. In addition, Stone documents the significant improvement in irrigation facilities prior to institutional reform, and the accelerated growth of fertilizer supplies. Stone notes that: "For staple crops, the increased supply of fertilizer nutrients was more significant than labour incentives fostered by the responsibility system reforms, which on balance led labour away from the previous over-concentration on staples. Food grain yields had been constrained not by inadequate labour application, but by insufficient

Because of the reform policy to agriculture, the labor in rural improve the technique of agricultural production. And rural labor went to the city to work give the industry more and more labors needed at that time. It helped the economy in China increased so quickly in this period where the agricultural sector was an important contributor to growth. Comprehensive liberalization of the primary sector was initiated at the end of 1978 by expanding the use of agricultural markets. Some production incentives (notably, profit-retention and bonus) were introduced for some classes of secondary and tertiary activities during the first phase of reform. The average annual growth rate for the period was very high. Agriculture and industry made almost equal contribution to the output expansion.

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soil nutrients." See Bruce Stone, "Basic Agricultural Technology under Reform." in Y.Y. Kueh and R.F. Ash, eds., *Economic Trends in Chinese Agriculture: The Impact of Post-Mao Reforms*, chap. 9, New York: Oxford University Press, 1993, p.352.

Table 7 The Eastern Region (1991-2003)

Regions Provinces	Efficiency Change (CRS)	Efficiency Change (VRS)	Tech Progress (CRS)	Scale Efficiency Change	TFP Growth
Beijing	0.9825	0.9799	1.0271	1.0029	1.0096
Shanghai	1.0000	1.0000	1.0797	1.0000	1.0795
Tianjing	1.01633	1.0119	1.0322	1.0042	1.0489
Jiangsu	1.0145	1.0001	1.0395	1.0143	1.0544
Zhejiang	0.9871	0.9856	1.0253	1.0012	1.0116
Shandong	1.0081	1.0139	1.0154	0.9951	1.0242
Guangdong	0.9912	0.9938	1.0365	0.9972	1.0266
Hainan	0.9832	0.9755	1.0334	1.0077	1.0161
Liaoning	1.0039	1.0041	1.0384	1.0001	1.0423
Fujian	1.0096	1.0083	1.0159	1.0012	1.0256
Hebei	0.9986	1.0022	1.0156	0.9963	1.0142
Guangxi	0.9961	0.9902	1.0066	1.0053	1.0023
Average	0.9993	0.9971	1.0305	1.0021	1.0296

Table 8 The Central Region (1991-2003)

Regions Provinces	Efficiency Change (CRS)	Efficiency Change (VRS)	Tech Progress (CRS)	Scale Efficiency Change	TFP Growth
Heilongjiang	1.0087	1.0065	1.0296	1.0015	1.0377
Jilin	1.0089	1.0082	1.0241	1.0012	1.0332
Hubei	1.0063	1.0036	1.0184	1.0023	1.0247
Shanxi	1.0062	1.0031	1.0223	1.0032	1.0286
Anhui	1.0177	1.0201	1.0068	0.9981	1.0241
Jiangxi	1.0033	1.0002	1.0065	1.0033	1.0096
Henan	1.0065	1.0083	1.0066	0.9984	1.0126
Hunan	1.0103	1.0123	1.0062	0.9981	1.0164
Average	1.0085	1.0078	1.0151	1.0008	1.0234

Table 9 The Western Region (1991-2003)

Regions Provinces	Efficiency Change (CRS)	Efficiency Change (VRS)	Tech Progress (CRS)	Scale Efficiency Change	TFP Growth
Sichuan	1.0002	1.0006	1.0067	0.9991	0.9993
Guizhou	0.9866	0.9893	1.0068	1.0082	0.9932
Yunnan	0.9833	0.9885	1.0065	1.0055	0.9998
Xizang	1.0001	1.0003	1.0251	1.0019	1.0189
Shaanxi	1.0013	1.0016	1.0100	1.0025	1.0112
Guansu	0.9934	0.9978	1.0062	1.0053	0.9996
Qinghai	0.9998	1.0001	1.0251	1.0124	1.0177
Ninxia	0.9899	0.9984	1.0276	1.0113	1.0063
Xingjiang	0.9983	0.9991	1.0315	1.0026	1.0086
Average	0.9948	0.9973	1.0162	1.0054	1.0061

According to Table 7, Table 8, Table 9,we find that the period of 1992-2003 was the golden age for China's economic development. We call it post-reform period. This period registered the GDP growth rate from 9% to 12%, and TFP growth is 1.0197. There was an obvious positive correlation between TFP growth and GDP growth.

In the 1990s, China’s TFP had grown significantly, due to technology adoption (copying existing technology from the advanced economies), which leads to a technological progress, because of China’s technology gaps. However, there is a limitation in this upgrading of technology, which is shown by the gradual slowdown of China’s TFP growth in the 1990s. This trend reflects the fact that China’s “late development advantage” in technology adoption is wearing out, due to an increasing level of difficulty in copying technology from the advanced economies.

In the post-reform period, labor is the major source of China’s growth, due to human capital accumulation and labor market development. Rural industrialization, which happens with the transfer of surplus labor out of the agricultural sector, substantially increases the labor participation rate of the township and village enterprises (TVEs), and speeds up the proliferation of small firms in the non-state sector.

According to the Tables, there is an East-West coordinated development. In this period three regions continue the development in economy, especially the Central and West regions had a rapid improvement. The reason for this is that the government gave the new policy to develop the Central and West region.

Practical Plan for Developing West China

(1) The Chinese government is promoting fiscal transfer as a major financial support to accelerate development of the West.

(2) China has promised to grant favorable policies to projects in the west whose foreign investment takes up more than 25 percent of the total. Foreign investors, who invest in industries encouraged and supported by the country, will get another three years of tax cuts, following five years of tax exemptions or reductions.

Closely related to the globalization and economic liberalization policies, a number of authors (especially within China) are in favor of the so-called 'east-west coordinated action' strategy. Based on regional comparative advantage analysis, some professors argue that the eastern and western economies are strongly complementary to each other. The east should not only open to the outside world, but also link its own development to that of the west. The east should focus on new and high technological industries and transfer traditional industries to the west. During this transfer process, the east should help raise the technological standards of these traditional industries. Given that the west is bounded by many foreign countries, the east can establish production bases in the west for Asian and European markets. The west should improve its investment environment to attract capital and technology from both the east and foreign countries. Only when both areas develop together, can the overall efficiency and competitiveness be raised. In this coordinated process, the central government promotes the marketisation, science, technology and education, and speed up the development of infrastructure and regional trade centers and growth poles in the west to support the simultaneous development of the eastern and western regions. Because of the suggestions above, the government can give more help and investment to the Central and West regions. So in this period, the result clearly shows that the government policy is an important role in regional development.

But if we compare TFP in 1979-1990 period to that in 1991-2003 period, we can find that the TFP in China slowed down clearly. And all the other provinces had slowed down in technical progress than before. The production in almost all the industries experienced the efficiency slower than before seriously. The reasons for that maybe as following:

(1). Since the late 1980s, there has been a decline in the marginal returns to capital in China's case. Basically, China's inefficient utilization of capital is caused by the existing financial distortions, such as the official control of credit. In contrast, labor has contributed in a significant way to China's growth, especially in the post-reform period, as the result human capital accumulation and labor market development. So for China, further financial reforms are needed to enhance the efficiency of capital inputs.

(2). In this period the rural labor's contribution to the economy had been to the limitation, because there was no more new policy came out. After the effects of the Household Responsibility System (HRS) petered out, a policy issue that surfaced in the late 1980s and early 1990s was a slowdown in the growth of investment in agriculture.[9]

4-5 The Summary of The Empirical Results

This study shows that technical efficiency performance in China's regional economies has converged rapidly since the early 1980s. This indicates the success of economic reform, which helped stimulate the Chinese regional economies to catch up with the best practice producers. However, the growth potential in efficiency was almost exhausted by the middle of the 1990s. Further growth in the regions will rely largely on improvement in innovation, i.e. technological progress, as has been argued by the World Bank and other China watchers. The record of technological progress among the regions is poor, especially in the 1980s. However, the rate of change of technological progress has been positive. Due to this upward trend, most regions have shown a positive rate of technological progress in the 1990s. As a result, the rate of TFP changes across the region has become positive in the 1990s.

In the post-reform period, China's TFP growth has been driven by both technical efficiency and technology adoption. In the 1990s, when there were fewer institutional innovations, and no further reforms in capital allocation, the marginal returns to capital declined as a result. Technical efficiency estimates show that, as expected, Shanghai, Beijing and Tianjin the three city

9 Total investment in agriculture slowed down between 1985 and 1990, and actually fell in real terms over this period. It then resumed growth at the beginning of 1990s, but fell again in 1993 and 1994, in real terms. Investment in agriculture then increased significantly in 1996 (*Statistical Yearbook of China*, 1997).

economies have been the most efficient. According to the data, China's economic reform has brought about significant improvement in efficiency. The above estimates also show the tendency of catching-up among the regional economies. However, the potential in efficiency improvement has been almost exhausted in the 1990s. It clearly shows the rate of efficiency changes over time. The rate of efficiency improvement has declined significantly over time. It seems that economic growth in the future will mainly rely on innovation, i.e. technological progress which in contrast, may continue indefinitely.

Chapter 5
Conclusions

TFP growth estimates become more informative when the strong behavioral and institutional assumptions are relaxed by switching from the factor share based traditional growth accounting methodology to a production function based approach. TFP growth was found to be significantly slower during 1991-2003 than the previous period of 1978-1990, raising serious questions about the nature of China's growth patterns in recent years. The decomposition of TFP growth into technical progress and efficiency improvement components has important policy implications, because the distinction is fundamental for policy actions, especially in developing countries. As far as China is concerned, where identifying TFP growth with technical progress can miss the fact that technical efficiency change seems to be the most relevant component of the total change in TFP, and therefore, the introduction of new technologies without having realized the full potential of the existing ones might not be meaningful. As we have seen from our empirical findings that although considerable productivity growth was found for most of the data period, it was accomplished mainly through technical progress rather than through efficiency improvement

5-1 The Problems That I Found from The Empirical Results

Efficiency problems: The issue of technical efficiency improvement at provincial level is particularly interesting for policy actions due to the need for further reforms, i.e., the reform of the SOE sector, of the financial system, and of the governance structure of the political system. So in the foreseeable future, China will still have to face efficiency problems derived from the gradual nature of its economic reform started more than twenty years ago.

Technology problems: Technological progress in China are mainly the results of transferring foreign technologies into domestic use, there are little innovation of its own. In other words, during the past 20 years, China took the advantage of the foreign technologies and had the advantages of backwardness, but during the 1990s its provincial production frontier moved slowly, indicating a slow down in technical progress.

Short-term problems: It must be pointed out that the above estimation reflects a potential long-term economic trend. Considering the reality of the radical reforms of the state-owned economic sectors and the fact that the factors that have resulted in economic decline are likely to have much impact in the coming years, actual economic growth may be slower than potential.

5-2 The Suggestions

Technology: China's future productivity growth depends ultimately on its ability to innovate in science and technology, which, in turn, depends on government policies towards entrepreneurial activity and research and development, and on the establishment of market-based institutions.

Strategy: China has achieved rapid economic growth in the past 20 years, and still has the potential to maintain a high economic growth rate in the next 20 years. China should continue to stick to its reform and opening-up policies. It can be expected that the fast growth in productivity can be sustained in the coming 20 years through establishing and perfecting the socialist market economic system, expanding and deepening the opening up efforts and implementing the strategy to invigorate the country with science and education.

Labor: The total labor force will increase fairly fast in this decade. The accelerated process of industrialization and urbanization, and the continued movement of large numbers of surplus agricultural laborers to the secondary and tertiary industries will provide sufficient labor for their development. The massive agricultural force and the low capital/labor ratio gives the potential for further capital deepening in the coming 20 years, while the people's high savings rate will guarantee speedy capital accumulation.

Capital market: Restructuring of industrial sectors and the reforms of state-owned enterprises will force inefficient enterprises to withdraw from the market gradually, leading to decreased demand for labor, reduced stock and enterprise investment. Reform has increased the independent character of banks and their awareness of risks and reduced loans to inefficient investment projects. Success in the reform of the banking system and the gradual establishment of the capital market will lead to greater efficiency in capital use.

5-3 The Summary and Conclusion

All these factors will give the economy the potential for maintaining fast growth in the next 20 years. These institutional transformations, and the changes in enterprise behavior are beneficial in a long-term perspective and will improve economic efficiency. In the short term, however, these factors will lead to reduced demand and depressed economic growth. When analyzing long-term growth potential, we assume that productive factors such as capital and labor are fully utilized. But, at the transitional stage, during which structural adjustments take place, there will be a certain amount of inevitable idleness of some productive factors such as labor. Therefore, in a mid-term period of two or three years, economic growth will, to a certain extent, be lower than its potential level. If we can reduce the transactional costs, accelerate enterprise reform and promote technological transfer to domestic firms and the development of non-state sectors, it is possible to achieve a future productivity growth faster than that in the last two decades. And it is possible that, after a short period of decline, the economic growth rate will go up again. However, if the financial reform cannot not succeed in adapting to the challenge of opening up to the outside world, growth will be depressed.

In the next 20 years, China has to grasp the opportunity of high economic growth in the first 10 years to keep forging ahead by stepping up the reform of enterprises, banking system, social security system and other micro-economic fields. China should speed up the process of industrialization and urbanization, promote the development of science, technology and education and improve the population quality. China must bring into 2010 a Chinese economy characterized by a sound socialist market economic system, a fine economic and social infrastructure, a labor force with relatively high quality, a consolidated and highly efficient banking system and an effective but not enormous social security system. Only by doing so China can meet greater challenges in the future and bring about sustained rapid growth to better prepare for the next 20 years.

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