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Changes in Production Efficiency in China

Identification and Measuring

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Abstract

Against the background of sustainable growth, the Chinese government has put forward both stimulating investment and accelerating healthy urbanization development as priority tasks in following 5 years in 2013. The initial investment and resource allocation philosophy in China is oriented with equity allocation, while the investment philosophy of foreign direct investment (FDI) emphasizes efficiency promotion. The absorbing of FDI will inevitably bring about changes in production efficiency with the transfer from equity pursuit to efficiency promotion. Therefore, the fast rise of the proportion of fixed asset investment to GDP and population agglomeration has naturally raised questions as follows. First, whether the investment and population agglomeration brought changes in production efficiency in the past China? Second, whether the promoting role of investment, especially foreign direct investment (FDI), on economic growth in Eastern China can be transferred to the growth in both Middle and Western China in future?

Synthesizing the perspectives of management science and statistics, the book aims to identify and measure how investment and population agglomeration changes in production efficiency in sustainable growth from aspects of allocation efficiency, scale efficiency, technical efficiency, and sustainable efficiency with innovative path-converged design techniques. The main results are presented as below.

Theoretically, using large sample theory from statistics achieves unique results and the ability to reproduce experiment in engineering; the technique of path converged design is innovative in two aspects. First, path identification presents an observable benchmark as the criterion of the production efficiency to replace the unobservable production frontier surface. Second, path-converged design is designed to select a controllable variable as a path of identification and to ignore uncontrollable natural variables.

- *Allocation efficiency with investment and population agglomeration*
  Reallocation of public expenditures in cities successfully reduces allocation inefficiency by up to 2 %, with reallocating 27.83 billion Yuan of public expenditure, which accounts for 2.020 % of the original total amount in overall China in 2006 (Chap. 2).

Reallocation shows that decision-making eliminates allocation inefficiency in urbanization development with population migration from lower urbanization levels to higher urbanization levels. The inefficiency of regional population patterns shrink to 5.800, 4.100, and 5.600 % for small, medium, and large cities, respectively (Chap. 3).

- *Scale efficiency with investment*
  Foreign direct investment (FDI) path exhibits a crowd-in effect on capital after 1996 in the Eastern region, while crowd-out effect on capital is presented in both Middle and Western regions during almost the entire period. Possible strategies are designed with environment FDI path identification to narrow regional discrepancy. Implementation of urbanization environments with the FDI path realizes the crowd-in effect on capital in Middle regions. However, the situation fails in Western regions in China (Chap. 4).
- *Technical efficiency with investment*
  Technical progress is significant with the FDI path because the declining trend of technical levels is reversed in Eastern regions after 1994. Unfortunately, this is not the case in both Middle and Western regions. The total factor productivity growth with the FDI path is attributed mainly to technical progress rather than efficiency improvements in both Eastern and Middle regions. However, neither technical progress nor efficiency improvement is found in Western regions (Chap. 5).
  Strategies are presented through transplantations of Eastern technical efficiency with the FDI path into Middle and Western regions, which not only succeed in raising technical efficiency, but also keep technical efficiency from decreasing (Chap. 6).
- *Sustainable efficiency with urbanization*
  Transplantation strategies with an interior migration of population by 30 % and a selected enhancement of investment by 30 % will be two promising strategies to reach balanced urbanization development between middle and eastern regions. Transplantation strategies with an additional 10 % rise in investment put into big cities with urbanization level than the overall average urbanization level and only changes 50 % of the original added value of investment in big cities to promote the overall urbanization level for sustainable efficiency (Chap. 7).

Contents

Chapter 1
Introduction

This book focuses on the identification and measuring of changes in production efficiency in China for sustainable growth. The introduction in this chapter is mainly presented to illustrate motivation, objectives and outline of the book.

1.1 Motivation

Economic growth is a perpetual topic, and only those who keep rapid and sustainable growth can survive fierce competitions in the world. As far as a miraculous economic growth is concerned, it shifts one country to another as a domino effect in the world.

- Japan embodied a miraculous growth in the 1960s;
- Brazil witnessed its highest growth in the 1970s;
- Korea, Singapore, Hong Kong and Taiwan, Asia's "four little dragons", experienced their rapid growth which drew worldwide attention in the 1980s;
- China's economy has been developing with surprising rapidity since the 1990s, averaging almost 10 % per year.

Table 1.1 presents the top 10 economies that witness highest economic growth speed in the world during 1978–2005, illustrating their GDP annual growth rates.

Figure 1.1 presents the GDP growth in china during 1978–2006, after two decades of two-digit economic growth, China has climbed to the fourth place in terms of its gross economy scale. The issue of sustainable development in China has been debated with worldwide interests. In 1997, Nobel Prize Laureate, Laurence R. Klein expressed his doubt on whether the fabulous growth trend in the past 19 years would continue for the following 20 or 30 years. Fogel (2006) has stated that China is expected to have done pretty well in achieving its growth despite of its various problems that stand in the way of China's economic improvement. Klein and Mak (2007) express their confidence in the sustainability of China's economic expansion. General Secretary of China Reform Foundation Gang Fan addressed at the 2007 Forum of Supply Chain Management in China that the fast growth in China

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Table 1.1 Top 10 economies with highest growth during 1978–2005 (%)

Country	China	Botswana	Singapore	Taiwan, China	Korea, Rep.
Annual growth	9.73	8.04	7.08	6.79	6.66
Country	Vietnam (1985–2005)	Malaysia	Thailand	Bhutan (1981–2005)	Belize
Annual growth	6.66	6.37	6.12	6.08	5.97

Data source World Development Indicators (various years)

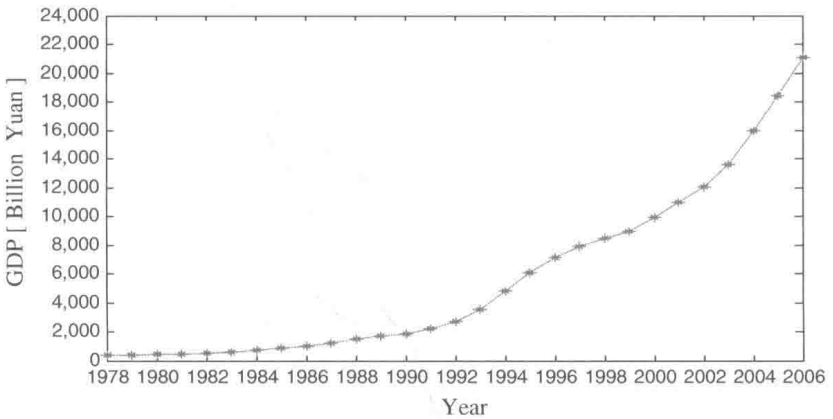

Fig. 1.1 Chinese GDP growth during 1978–2006

will continue without any sudden slowdown. The sustainable growth can be achieved with reliance on the reform effect, opening-up, education and technology, and urbanization process in China.

The history of China's growth reveals that the majority of growth is mostly attributed to large scale of investment. Specifically, the proportion of fixed asset investment to GDP has witnessed a fast rise of from 42 to 47 and even to 50 % during 2008–2009 and 2010–2011 in China. The fact naturally raised questions involving sustainable growth in China. In this sense, the key point to settle the debate lies in whether the behavior of investment, scale of investment, scale effect, allocation effect and technical transfer effect will be sustainable in production system in future. It is well accepted that both the investment behavior and investment scale will not last forever in any growth system.

Therefore, the questions remains to be explored are whether its resulting effects (scale effect, allocation effect and technical transfer effect) of investment will last for a long period. Specifically, first, whether the investment brought changes in production efficiency in the past China? Second, whether the promoting role of investment, especially foreign direct investment (FDI), on economic growth in Eastern China can be transferred into the growth in both Middle and Western China in future?

1.1.1 Present Framework

The production function provides the neoclassical model to investigate the growth,

$$Y_0 = F_0(A, K, L) \tag{1.1}$$

where Y_0 is the output, K and L are capital and labor, respectively, and A is the technical level.

The major interest of changes in production efficiency lies in identifying and measuring the efficiency change with a new factor P introducing into initial neoclassical production model (1.1). Specifically, the extended production function with the new factor is given by:

$$Y = F(A, K, L, P) \tag{1.2}$$

To identify and measure the changes of production efficiency due to new factor P, it is necessary to settle two questions.

The first one is how to identify the changes in production efficiency due to new factor P. The second one is how to make decision on optimal allocation in order to realize production efficiency of new factor P.

Take the total differential of model (1.2) with respect to P and it results in the following equation:

$$\frac{dY}{dP} = \frac{\partial F}{\partial P} + \frac{\partial F}{\partial K}\frac{dK}{dP} + \frac{\partial F}{\partial L}\frac{\partial L}{\partial P} + \frac{\partial F}{\partial A}\frac{dA}{dP} \tag{1.3}$$

Model (1.3) shows the output change due to new factor P can be split into three parts:

(a) Direct effect of factor P by $\partial F/\partial P$;
(b) Indirect effect of factor P via endogens variables K and L by $\partial F/\partial K$ and $\partial F/\partial L$;
(c) Indirect effect of factor P via exogenous technical variable by $\partial F/\partial A$.

The following analysis presents detail decomposition of the three parts.

1. Direct effect of factor P

It is unavailable to calculate $\partial F/\partial P$ directly since the underlying production function F is unknown. Take the first-order difference of Eq. (1.3) and it comes to the following linear model

$$\Delta Y = \frac{\partial F}{\partial P}\Delta P + \frac{\partial F}{\partial K}\Delta K + \frac{\partial F}{\partial L}\Delta L + \frac{\partial F}{\partial A}\Delta A + error \tag{1.4}$$

The technical level A is assumed to be exogenous and unknown. To replace technical level A, the existing research often uses a control factor C based on the endogenous growth theory, given by

$$\Delta Y = \frac{\partial F}{\partial P}\Delta P + \frac{\partial F}{\partial K}\Delta K + \frac{\partial F}{\partial L}\Delta L + \frac{\partial F}{\partial C}\Delta C + error \tag{1.5}$$

The empirical research on allocation efficiency of new factor P, i.e. $\partial\hat{F}/\partial P$, is often obtained by ordinary least square (OLS) regression after the unit root test and Granger causality test.

If $\partial\hat{F}/\partial P \geq 0$, the new factor P brings about positive production efficiency. Otherwise, if $\partial\hat{F}/\partial P < 0$, it is taken as the negative efficiency of factor P.

2. Indirect effect of factor P via endogenous capital and labor

The new factor P will indirectly impact production efficiencies of capital and labor by $\partial F/\partial K$ and $\partial F/\partial L$ via dK/dP and dL/dP in (1.3) respectively. Take the total differential of model (1.2) with respect to time t and get

$$\frac{dY}{dt} = \frac{\partial F}{\partial K}\frac{dK}{dt} + \frac{\partial F}{\partial L}\frac{dL}{dt} + \frac{\partial F}{\partial P}\frac{dP}{dt} + \frac{\partial F}{\partial A}\frac{dA}{dt} \tag{1.6}$$

Then

$$\begin{aligned}\frac{dY/dt}{Y} &= \frac{\partial F}{\partial K}\frac{K}{F}\frac{dK/dt}{K} + \frac{\partial F}{\partial L}\frac{L}{F}\frac{dL/dt}{L} + \frac{\partial F}{\partial P}\frac{P}{F}\frac{dP/dt}{P} + \frac{\partial F}{\partial A}\frac{A}{F}\frac{dA/dt}{A} \\ &\equiv \alpha\frac{dK/dt}{K} + \beta\frac{dL/dt}{L} + \lambda\frac{dP/dt}{P} + \frac{\partial F}{\partial A}\frac{A}{F}\frac{dA/dt}{A}\end{aligned} \tag{1.7}$$

where $\alpha = \dfrac{\partial F}{\partial K}\dfrac{K}{F} = \dfrac{\partial \ln F}{\partial \ln K}$ and $\beta = \dfrac{\partial F}{\partial K}\dfrac{L}{F} = \dfrac{\partial \ln F}{\partial \ln L}$ are the elasticity of capital and labor, respectively.

$\alpha + \beta$ is assumed to be the production scale. The estimation algorithm usually employs the logarithmic variable for analysis in order to obtain the stability of error item in model (1.5). Therefore,the $\partial F/\partial K$ and $\partial F/\partial L$ explain scale efficiency when taking the logarithm of original data.

The empirical investigation of scale efficiency is obtained by the OLS estimation $\hat{\alpha}$ and $\hat{\beta}$ by regression model (1.7) after replacing A by C, which indicate the values of α and β respectively.

3. Indirect effect of factor P via exogenous technical variable

The new factor P will indirectly impact production efficiency of technical variable A by $\partial F/\partial A$. The partial derivative $\partial F/\partial A$ is often obtained indirectly such as by "Solow Residual" or by decomposition of Malmquist Index (Kim and Park 2006) because A is exogenous and unavailable in observation data, given by

$$\frac{\partial F}{\partial A}\frac{A}{F}\frac{dA/dt}{A} \equiv \frac{dY/dt}{Y} - \alpha\frac{dK/dt}{K} + \beta\frac{dL/dt}{L} - \lambda\frac{dP/dt}{P} \tag{1.8}$$

Equation (1.8) presents the traditional empirical estimation of technical efficiency. More specifically, $(\partial F/\partial A)/(A/F)$ indicates the efficiency improvement and $(dA/dt)/A$ refers to the technical progress.

1.1.2 Questions

Given the research framework above, the empirical investigation provides us the following three questions due to uncontrolled factor C in (1.5), which is the second difficulty mentioned above. More specifically, the previous model framework brings about heated debate on whether factor input P changes production efficiency including allocation efficiency, scale efficiency and technical efficiency, which greatly impacts the decision-making of factor input strategy.

- **Changes in Allocation Efficiency of Resource**

The $\partial\hat{F}/\partial P$ in regression model (1.5), which is merely an average value, cannot express the dynamic efficiency of the changing P and would be either positive or negative. Another, because of different control factor C *in* (1.5), the analysis often brings about lots of contrary conclusions to the theoretical ones. For example, both positive and negative effects of public expenditure on economic growth are reported, and consequently raise the question on the allocation efficiency of public expenditure.

Question 1: Positive or negative effect of investment with the perspective of allocation efficiency?

The key to the question lies in the exploration of efficiency-oriented or equity-oriented allocation of investment strategy. Team (2004) points out the development of China's economy should emphasize more on the supply effect of fiscal policy. It is desirable to maintain high public capital expenditure in the economic primary take off period. Sun (2006) empirically illustrates that government spending shocks have *positive effects* on output, while tax revenues have negative effects. Similarly, Cao (2006) finds that the government expenditure scale has *positive* correlation with economic growth rate.

Conversely, Hansson and Henrekson (1994) hold that government transfers, consumption and total outlays have consistently *negative effects*, while educational expenditure has a positive effect, and government investment has *no effect* on private productivity growth. The impact is also found to work solely through total factor productivity and not via the marginal productivity of labor and capital. Chen and Yu (2006) point out that the raising proportion of public expenditure in GDP can *lower* the technological efficiency, but raising some parts, which to turn the public expenditure structure, of public expenditure in GDP can promote the technological efficiency. Ang (2008) finds that various public investment programs seem to have impacted *negatively* on economic development in Malaysia.

The debate of positive or negative effect on GDP results in different investment strategies under the framework of efficiency-oriented or equity-oriented allocation respectively.

- **Changes in Scale Efficiency of Factors**

The scale efficiency changes with *different control factor C* in regression model (1.5), which often puzzles the decision-making of investment strategy from the perspective of scale efficiency. For instance, the existing researches of FDI in China empirically confuse decision-makers with its investment strategy with contrary conclusions.

Question 2: Crowd-in or crowd-out effect of investment from the perspective of scale efficiency?

Wei (2002) holds that about 90 % of China's regional discrepancy in growth can be explained by the foreign direct investment (FDI) in Chinese authoritative *Economic Research Journal.* In the same Journal, Wu (2002) points out that less than 20 % of regional discrepancy is attributed to the regional differences of FDI.

Accordingly, Wei (2002) puts forward that energetic efforts should be made to actively absorb foreign capital into Middle and Western regions so as to push their developments; while Wu (2002) denies the possibility that the FDI regional distribution change could narrow the regional discrepancy in China. The indirect production efficiency of FDI depends on crowd-in and crowd-out effect on capital.

- **Changes in Technical Efficiency**

If the low production efficiency is attributed to little improvement in technical progress, the decision-making aiming to technical innovation is expected to be designed. If high rates of technical progress coexist with deteriorating technical efficiency, resulting in slow production efficiency, the decision-making aiming to bring improvements in learning-by-doing processes and in managerial practices (Kim and Han 2001) is expected to be adopted.

Question 3: Technical progress or efficiency improvement of technical variable from the perspective of technical efficiency?

Murakami (2007) demonstrates the entry of foreign-owned firms has a *positive* effect on the productivity of local firms in Japan as a result of *technology spillovers* in the long run. Fare et al. (2001) find that productivity growth is generally achieved through *technical progress*, and the efficiency change *negatively* contributes to productivity growth for Taiwanese manufacturing.

However, Cook and Uchida (2002) find that *efficiency improvement* dominates technical progress in developing countries. Lam and Shiu (2008) point the differences in efficiency scores are mainly due to the differences in the operating environments of different provinces, rather than the efficiency performance of telecommunications enterprises.

Kim and Park (2006) show both domestic and foreign R&D played an important role in increasing efficiency and technical progress in Korean manufacturing.

However, domestic R&D has more effect on *technical progress*, while foreign R&D has played a relatively stronger role in *efficiency improvement.*

Taken the perspective of technical transfer, whether the technical progress or efficiency improvement on economic growth in Eastern China can be transferred into the growth in both Middle and Western China is of great significance in order to narrow the regional discrepancy in China.

1.2 Objective

The objective of this book is to provide unique identification technique with empirical data during 1985–2006 to identify and measure the changes in production efficiency due to investment in cities or regions in China from the perspectives of allocation orientation, scale crowd-in effect and technical transfer. The innovative identification is established with application to implement optimal strategy of investment and migration for decision-making in urban planning through Path-Converged Design by means of production function.

First, it presents an observable benchmark as the criterion of the production efficiency to replace the production frontier surface with efficiency-oriented framework rather than output-oriented or input-oriented one. Second, the path-converged design is designed to select a controllable variable as a path of identification and to avoid uncontrollable natural variables.

The book launches specific researches from three parts:

1. Allocation efficiency orientation with investment and migration
   - Provides identification on allocation efficiency of investment and migration in cities, and on positive or negative effect on GDP growth in regions.
   - Implements simulation of optimal strategy on allocation efficiency of investment, and on migration allocation from inefficient cities to efficient ones and from regions with negative effect to regions with positive effect.
2. Crowd-in scale efficiency with foreign direct investment
   - Provides identification of crowd-out or crowd-in effect on scale efficiency in region using path identification of time-varying elasticity of production factors.
   - Implements simulation of alternative strategy on scale efficiency from regions with crowd-out effect to regions with crowd-in effect.
3. Technical efficiency transfer with investment
   - Provides evidence on whether technical efficiency realizes technical progress or efficiency improvement in regions.
   - Implements simulation of technical efficiency to change production efficiency in regions.