The Industrial Development of Western China in the First 5 years of Western Development Program

Ke Zhang
School of Public Policy & Management, Tsinghua University

1. Introduction

Since 1999, China launched the program of western development and began to implement a series of development plans in 2000. As the economic base, industrial sectors are one of the development focuses of the program. An important policy measure in the program is to increase investment. As we know, investment, especially government investment, has been the main source maintaining China's high speed growth for a long time. Investment growth causes fast capital accumulation and then scale expansion of industries. However, capital productivity decides the impact of investment on promoting economic growth. Investing in low productivity sectors will not only waste capital, but also accumulate economic risk. Recently, China has realized that high inputs and relative low income are not a recipe for a sustainable growth mode. It's important to improve industries' productivity to grow more efficiently.

Productivity is a measure of the efficiency of production: the quantity or value of output in relation to a quantity or cost of input. Productivity is the economic measure of the level of technology and management and is the source of long-term competitive advantages. Any competition or industrial policy tries to promote productivity and the policy effect of the program is partially reflected in the growth and efficiency changes of local sectors. In order to keep sustainable development, western China should try to improve local industries' productivity.

This paper sheds light on the growth and productivity changes of the industry mix in the western region in order to assess the policy effect of the western development program. According to neoclassical economic growth theory, input factors, such as capital, labor, etc. and Total Factor Productivity (TFP) are the direct resources of growth. This paper applied the basic analytical framework in industrial sector level. Capital growth is used to show scale expanding. TFP is looked at as a measure of potential competitiveness. High and low TFP distinguish two different growth modes. In order to find the change of western industrial

Ke Zhang is a PhD Candidate in the School of Public Policy & Management, Tsinghua University, Beijing. The author wishes to acknowledge the help of reviewer.

sectors, shift-share analysis is employed, which tells the difference between growth rate of local sectors and national ones. Based on data envelopment analysis, the productivity change of each sector is analyzed and compared. This reflects the basic competitiveness of sectors and can predict the development potential. This paper also discusses the technological efficiency of local sectors and tries to explain the growth mode. The general finding is that most industrial sectors of western regions show productivity growth but the efficiency improvement is relatively slower than the technical frontier's progress.

2. Methodology and data

2.1 Shift-share analysis basics

Shift-share analysis is one of the widely used techniques for examining regional growth and comparisons. The shift-share model decomposes economic change in a region into three additive components: the reference area component, the industry mix and the regional share. The decomposed variable may be income, capital stock, employment, value added, or a variety of other measurements.

The reference area component generally refers to the national economy and is so called the national share (NS), which measures the regional target variable change if it grew at the same rate as the nation. Capital stock is used as the target variable in this paper. The industrial mix (IM) is the industry composition of the region and refers to the capital stock change due to the difference between the growth rate of a particular sector and that of the whole national industry. Thus it reflects the degree to which the region specializes in sectors that are fast or slow growing nationally. The regional share (RS) reflects the regional impact on a particular sector, which is measured by the capital stock change due to the difference between the regional growth rate and the national growth rate of the industry. The total shift (TS) is the sum of the three components, reflecting the changing economic position of the region relative to the nation. These components are formulated as:

$$NS \equiv K_{ir} g_n \quad (1)$$

$$IM \equiv K_{ir}(g_{in} - g_n) \quad (2)$$

$$RS \equiv K_{ir}(g_{ir} - g_{in}) \quad (3)$$

$$TS \equiv NS + IM + RS \quad (4)$$

where the subscript i refers to industry i, r refers to region r, and n refers to the nation. K_{ir} is the capital stock, and g_{ir},g_{in}, g_n are the change rate of capital stock. This paper identifies the sectors which grow faster at western regional level than at national level through calculating local industries' RS to see if RS>0 or not. These fast growing sectors are the main growth sources of the western region, whose level of productivity reflects the growth mode of such region. Total productivity increase generates efficient growth. However productivity decrease generates inefficient growth.

2.2 Data envelopment analysis (DEA) basics

The term of efficiency is about the utility of resources. It expresses the degree to which units best utilize their available resources to obtain maximum potential output. The modern efficiency measurement begins with Farrell (1957) who defined a simple measure of firm efficiency which could account for multiple inputs. The basic idea of the measure is to identify the production or cost frontier and quantify the difference between the unit to be examined and the frontier. The production or cost frontier reflects the maximum output given input or minimum input given output. Generally, data envelopment analysis (DEA) is a principal method to estimate frontiers which involves mathematical programming without assumed frontier function form. Fare, Grosskopf and Lovell (1994) discussed details of DEA methods.

A relatively simple presentation of the DEA model is[1]:

$$\text{Max.} \quad h_k = \sum_{r=1}^{s} u_r y_{rk} \Big/ \sum_{i=1}^{m} v_i x_{ik} \qquad (5)$$

$$\text{s.t.} \quad \sum_{r=1}^{s} u_r y_{rj} \Big/ \sum_{i=1}^{m} v_i x_{ij} \le 1 \qquad \textit{for} \quad j = 1 \ldots n$$

$$v_i \ge 0 \quad \textit{for} \quad i = 1 \ldots m, \quad \textit{and} \quad u_r \ge 0 \quad \textit{for} \quad r = 1 \ldots s$$

where x_{ik} and y_{rk} are the i-th input and r-th output of the k-th decision making unit (DMU) respectively. u and v are the weights that DEA will optimally assign to each input and output (Dinc and Haynes 1999). This paper employs DEA and Malmquist index approach to measure the locally fast growing sector's total factors productivity (TFP) changes.

[1] Mustafa Dinc, Kingsley Haynes. "Sources of Regional Inefficiency, An Integrated Shift-Share, Data Envelopment Analysis and Input-output Approach". *The Annals of Regional Science*. Vol. 33, issue 4 (1999), 473.

2.3 Data

This paper deals with inter-provincial sectors' data, including all twelve western provinces: Ningxia, Shannxi, Gansu, Qinghai, Xinjiang, Inner Mongolia, Tibet, Sichuan, Chongqing, Yunnan, Guangxi, and Guizhou. Because of the accessibility and consistency of data, the analysis covers the change of selected sectors from 1999, the beginning of the western development strategy, to 2003. Twenty-three sectors (GB/T4754-2002 two digital classification code)[2] are analyzed, including part of manufacturing, energy, mining, metallurgy and chemical engineering industry, etc.

The data are from *Yearbook of Industrial Economy Statistics* edited by National Bureau of Statistics of China. Output is measured by sector's value added. Inputs include capital stock measured by the sum of the average annual balance of capital and current assets and labor measured by each sector's annual average employment.

Table 1: List of 23 sectors

Code of sectors	Name of sectors
06	coal mining & preparation
07	petroleum & natural gas extraction
08	ferrous metals mining & preparation
09	nonferrous metals mining & preparation
13	food processing
14	food manufacturing
15	beverage manufacturing
17	textile manufacturing
22	paper making & manufactured goods
25	petroleum processing & coking
26	chemical materials & products manufacturing
27	medical & pharmaceutical products
28	chemical fibers
31	non-metal mineral products
32	smelting & processing of ferrous metals
33	smelting & processing of nonferrous metals
34	metal products
35	universal machine manufacturing
36	special purpose equipment & machinery manufacturing
37	transportation equipment manufacturing
39	electric equipment and machinery manufacturing
40	computer, electronic & telecommunications equipment manufacturing
44	power generation, steam and hot water production and supply

[2] The code and name of all twenty-three sectors are listed in table 1.

3. Analysis

3.1 fast growing sectors

Because investment is one of the main development measures, we use capital stock as the measure of each sector's scale. Based on equation 3, we calculated RS of every sector in all twelve western provinces. The outcome is reported in table 2 where each column represents a province and each row represents a sector. Table 2 shows that since 1999, every western province has several sectors expanding faster at provincial level than at national level. And, relatively, northwest provinces have more fast growing sectors than southwest provinces. It seems that the western region grows rapidly during the implementing of a western development strategy. On average, a western province has eight fast growing sectors, covering one third of the twenty-three sectors.

3.2 productivity changes

We have identified the fast growing sectors of each western province. The province with most of its fast growing sectors experiencing productivity increase is growing efficiently. Following Fare et al (1994), DEA is employed to measure TFP of each fast growing local sector, and output-based Malmquist index is employed to measure annual TFP changes of each fast growing local sector. Here we take capital stock and labor both into account as inputs because quantity of employees is an important input factor affecting productivity and traditionally Chinese enterprises employ more labor than the efficient level. Controlling the quantity of employees at an efficient level is a goal of economic reform of Chinese enterprises. When measuring scale of a sector, labor can be ignored because it doesn't reflect the real level. But when measuring productivity or efficiency of a sector, labor must be considered.

Table 2: fast growing sectors in western provinces

code	province abbreviation											
	Northwest provinces						Southwest provinces					
	IM	XJ	QH	GS	NX	SX	TB	SC	CQ	YN	GX	GZ
06				★		★						★
07	★			★		★			★			
08	★	★	★	★		★	★		★			
09			★	★		★						★
13	★		★	★		★		★				
14	★	★					★	★		★		
15		★	★	★	★	★		★		★		
17	★				★							
22	★				★					★	★	
25	★	★		★	★	★		★		★		
26		★	★					★		★		
27	★		★		★	★	★			★	★	★
28				★				★				
31	★	★	★	★	★	★		★	★			★
32	★	★	★							★	★	
33	★				★	★		★		★		★
34									★			★
35					★							
36	★			★		★		★	★		★	
37								★	★			
39				★	★				★			
40												
44		★		★	★						★	★

Note: The following abbreviations means, IM-Inner Mongolia; XJ-Xinjiang; QH-Qinghai; GS-Gansu; NX-Ningxia; SX-Shannxi; TB-Tibet; SC-Sichuan; CQ-Chongqing; YN-Yunnan; GX-Guangxi; GZ-Guizhou

We calculated the means of annual TFP changes and reported the outcome in table 3. If TFP stays unchanged, the index equals 1. If TFP increased, the Malmquist index is more than 1, otherwise less than 1. Table 3 shows that about 90% fast growing sectors have indices more than 1, experiencing TFP increase. This is significant for the western region because it reflects that its growth is efficient.

Table 3: Means of annual TFP change index of fast growing sectors in western provinces

code	province abbreviation											
	Northwest provinces						Southwest provinces					
	IM	XJ	QH	GS	NX	SX	TB	SC	CQ	YN	GX	GZ
06				1.013		1.118						1.083
07	1.104			1.066		1.268			1.103			
08	1.174	1.043	1.314	0.808		1.26	1.113		1.14			
09			0.988	1.004		1.183						1.145
13	1.237		1.215	1.091		1.205		1.229				
14	1.206	1.345					1.332	1.161				
15		0.899	0.843	0.935	0.995	1.148		1.022		1.071		
17	1.16				2.279							
22	1.075				1.16					1.135	1.052	
25	1.155	1.455		1.32	0.985	1.327		1.262		1.132		
26		1.169	1.028					1.122		1.079		
27	1.213		1.139		1.132	1.029	0.85			1.075	1.057	1.007
28				1.27				1.183				
31	1.172	1.082	1.103	0.991	1.116	1.054		1.084	1.163			0.997
32	1.166	1.379	1.08							1.199	1.223	
33	1.254				1.073	1.239		1.165		1.179		1.19
34									1.088			1.114
35					0.979							
36				1.116		1.142		1.236	1.032		1.27	
37								1.66	1.44			
39				0.986	1.2				1.185			
40												
44		0.938		0.815	1.076						1.011	1.093

Note: The following abbreviations means, IM-Inner Mongolia; XJ-Xinjiang; QH-Qinghai; GS-Gansu; NX-Ningxia; SX-Shannxi; TB-Tibet; SC-Sichuan; CQ-Chongqing; YN-Yunnan; GX-Guangxi; GZ-Guizhou

Following Fare et al (1994), we divided the TFP change index into both an efficiency change index and a technology change index. This will indicate that a local sector's TFP change comes from two factors. One is the most advanced local sector's technical progress, which represents the technical frontier's movement. Another is the local sector's technical efficiency improvement, which represents the achievement of such a sector in "catching up" to the most advanced one. Figures 1 and 2 reflect that local sectors' TFP changes show different modes. Forty-four percent of the local sectors with TFP increases experienced technical efficiency decreases in the circumstance of technical frontier progress. We can conclude, therefore, that these sectors' efficiency improvements are relatively slower than their most advanced peer's technical progress. They still have the potential to make their management and technical learning or innovation more efficient, even though their TFP has increased. But such a lag in progress is a potential threat to their long-term TFP increase and, thus, sustainable growth. Among local sectors with TFP decrease, 80% show an efficiency decrease while their most advanced peers improved technology. Inefficient management or technical progress is the main reason for the TFP decrease.

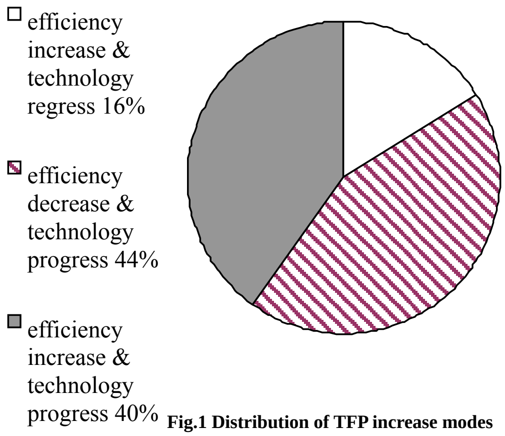

Fig.1 Distribution of TFP increase modes

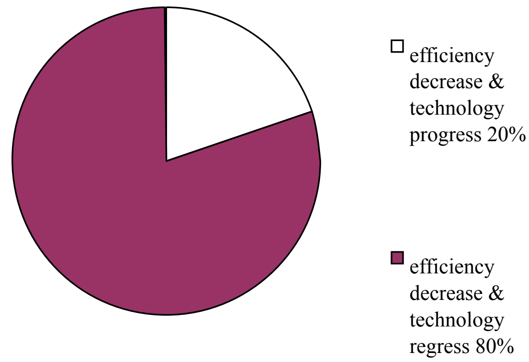

Fig.2 Distribution of TFP decrease modes

We also compared the referenced regions with an index of the national mean level and of the relatively developed province level, including Beijing, Shanghai, Jiangsu, Zhejiang, Guangdong, Fujian, and Shandong. Table 4 reported the outcome, from which we can find that the TFP change index of western provinces' sectors is almost the national mean level. Also, it's clear that Beijing, Shanghai and Guangdong have few advantages among these twenty-three sectors, which shows the difference of industrial structure between western provinces and Beijing, Shanghai, and Guangdong. But Shandong, Fujian, Jiangsu and Zhejiang have more fast growing sectors respectively than western provinces, although the TFP change index is similar. It seems that western provinces still develop a little more slowly than Shandong, Fujian, Jiangsu and Zhejiang.

Table 4: Means of annual TFP change index of reference provinces

code	Provinces abbreviation							
	BJ	SH	JS	ZJ	GD	FJ	SD	NM
06						1.124	1.147	1.15
07			0.923		1.313		1.119	1.116
08			1.337					1.16
09					1.224	1.145	1.154	1.11
13						1.043	1.144	1.185
14						1.067	1.11	1.168
15				1.071			1.06	1.062
17			1.122	1.119	1.054	1.09	1.154	1.161
22			1.299	1.102	1.081	1.083	1.201	1.13
25		1.304	1.218	1.146				1.206
26		1.116	1.145	1.071	1.213	1.236	1.21	1.162
27	1.124		1.175	1.118		1.082	1.137	1.08
28			1.108	1.183		1.046	1.169	1.125
31				1.147		1.165	1.138	1.142
32	1.193		1.251	1.267	1.254		1.228	1.253
33						1.154	1.247	1.206
34			1.141	1.144		1.132	1.12	1.134
35		1.127	1.147	1.12	1.133	1.242	1.199	1.195
36				1.149	1.146	1.214		1.185
37			1.116	1.092		1.409	1.236	1.201
39			1.125	1.101		1.156	1.217	1.174
40		1.032	1.158	1.077		1.03	1.212	1.218
44		0.984				1.001	0.932	1.008

Note: The following abbreviations means, BJ-Beijing; SH-Shanghai; JS-Jiangsu; ZJ-Zhejiang; GD-Guangdong; FJ-Fujian; SD-Shandong; NM-National mean

4. Conclusion

Twenty-three industrial sectors in 12 western provinces constitute a total of 276 local sectors, among which 101 local sectors developed faster than the national level in terms of capital stock. Or, in other words, 37% of the total local sectors in 12 western provinces evidenced rapid development in investment growth. Through DEA, we find that in 90% of the 101 fast growing local sectors' TFP has increased from 1999 to 2003. And 40% of these sectors with TFP increases showed efficiency improvements when their most advanced peers realized technical innovation. This is critical for western provinces since these sectors showed strong evidence in improving efficiency and, thus, narrowing the gap between them and their advanced peers. But, at the same time, the western region must realize that about 50% of 101 fast growing local sectors experienced efficiency decreases, which is the main reason for TFP decrease and the main weakness of 44% of sectors with TFP increases. Such sectors should pay more attention in improving management level and building their ability in technical innovation while sustaining their growth.

Reference

Coelli, Tim, Perelman Sergio. "A Comparison of Parametric and Non-parametric Distance Functions: With Application to European Railways". CREPP Discussion Paper. 1996.

Fare, Rolf, Shawna Grosskopf, Mary Norris and Zhongyang Zhang. "Productivity Growth, Technical Progress and Efficiency Change in Industrialized Countries". *American Economic Review*. Vol. 84, No.1 (March 1994), 66-83.

Fare, Rolf, Shawna Grosskopf and C.A.Knox Lovell. *Production Frontiers*. Cambridge University Press, 1994.

Farrel, Michael. "The Measurement of Productivity Efficiency". *Journal of the Royal Statistical Society*. Series A (General), Vol. 120, No. 3 (1957), 253-290.

Haynes, Kingsley, Mustafa Dinc. "Productivity Change in Manufacturing Regions: A Multifactor/Shift-share Approach". *Growth and Change*. Vol. 28 (Spring 1997), 201-222.

Dinc, Mustafa, Kingsley Haynes. "Sources of Regional Inefficiency, An Integrated Shift-Share, Data Envelopment Analysis and Input-output Approach". *The Annals of Regional Science*. Vol. 33, issue 4 (1999), 469-489.

Rigby, D. L. and W.P. Anderson. "Employment Change, Growth and Productivity in Canadian Manufacturing: An Extension and Application of Shift-share Analysis". *Canadian Journal of Regional Science* XVI:1 (1993)

Stimson, Robert, Roger Stough and Brian Roberts. *Regional economic development : analysis and planning strategy.* New York : Springer, 2002.

National Bureau of Statistics of China. *Yearbook of industrial economy statistics. 1998- 2004.* Beijing: China Statistic Press.

Appendix

Malmquist productivity index,

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\left(\frac{D_0^t\left(x^{t+1}, y^{t+1}\right)}{D_0^t\left(x^t, y^t\right)}\right)\left(\frac{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^{t+1}\left(x^t, y^t\right)}\right)\right]^{1/2} \quad (1)$$

Decomposition of Malmquist index,

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)}\left[\left(\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1})}\right)\left(\frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)}\right)\right]^{\frac{1}{2}} \quad (2)$$

The first term of right side of equation 2 is efficiency changes and the second term is technical changes.

To calculate equation 1 we must calculate the four component distance functions, which will involve four LP problems. Here we begin with assuming CRS technology and the output-orientated LP used to calculate $D_0^t\left(x^t, y^t\right)$ is as following,

$$\left[D_0^t\left(x^t, y^t\right)\right]^{-1} = \max \omega \qquad \text{subject to}$$

$$\begin{aligned} &\sum_{j=1}^{n} \lambda_j x_{ij}^t \le x_{ij_0}^t, i = 1, \cdots, \ m \\ &\sum_{j=1}^{n} \lambda_j y_{kj}^t \ge y_{kj_0}^t, i = 1, \cdots, \ s \\ &\lambda_j \ge 0, \omega \ge 0, \ j = 1, \cdots, \ n \end{aligned} \quad (3)$$

The remaining three LP problems are simple variants of this one,

$$\left[D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)\right]^{-1} = \max \omega \qquad \text{subject to}$$

$$\begin{aligned} &\sum_{j=1}^{n} \lambda_j x_{ij}^{t+1} \le x_{ij_0}^{t+1}, i = 1, \cdots, \ m \\ &\sum_{j=1}^{n} \lambda_j y_{kj}^{t+1} \ge y_{kj_0}^{t+1}, i = 1, \cdots, \ s \\ &\lambda_j \ge 0, \omega \ge 0, \ j = 1, \cdots, \ n \end{aligned} \quad (4)$$

and

$$\left[D_0^t\left(x^{t+1}, y^{t+1}\right)\right]^{-1} = \max \omega \ \text{ subject to}$$

$$\sum_{j=1}^{n} \lambda_j x_{ij}^{t+1} \le x_{ij_0}^{t}, i = 1, \cdots, \ m$$

$$\sum_{j=1}^{n} \lambda_j y_{kj}^{t+1} \ge y_{kj_0}^{t}, i = 1, \cdots, \ s \qquad (5)$$

$$\lambda_j \ge 0, \omega \ge 0, \ j = 1, \cdots, \ n$$

The above approach can be extended by decomposing the (CRS) technical efficiency change into scale efficiency and pure (VRS) technical efficiency components. This will involve calculating two additional LP problems, which are repeating LP's (2) and (3) with the convexity restriction ($\sum_{j=1}^{n} \lambda_j = 1$) added to each. Then we can use the CRS and VRS values to calculate the scale efficiency residually.