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No. 28, 2006

The Development of 23 Industrial Sectors in Western China: Scale and Productivity

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This paper was presented at the 5th East-West Center International Graduate Student Conference, February 16-18, 2006 in Honolulu, Hawaii USA.

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The Development of 23 Industrial Sectors in Western China with Implementing of Strategy of Western Development: Scale & Productivity

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Abstract

Since 1999, China has been implementing strategy of western development for more than six years. As the economic base, western industrial sectors are one of main development object of the strategy. The growth and efficiency changes of local sectors partially reflect the policy effect of the strategy. This paper is trying to shed light on the growth and productivity changes of industry mix in western region to assess policy effect of strategy of western development. According to neoclassical economic growth theory, input factors, such as capital, labor, etc. and TFP are direct resources of growth. This paper applied the basic analysis framework to industrial sector level. Capital growth is used to show scale expanding. Total factor productivity is looked as the basic potential competitiveness. High and low TFP distinguish two different growth modes. In order to find the change of western industrial sectors, shift-share analysis is employed, which tells the difference between growth rate of local sectors and national ones. Based on DEA the productivity change of each sector is analyzed and compared with each other, which reflect the basic competitiveness of sectors and predict the developing potentiality. 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 technical frontier's progress.

1. Introduction

In 1999, China announced the strategy of western development and began to implement series of development plans in 2000. An important kind of policy measure in those plans is to increase investment. As we know, investment, especially government investment is 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 sustainable growth mode. It's important to improve industries' productivity to grow more efficiently.

Productivity is the efficiency of production, which is to produce more quantity or value of output using less quantity or cost of input. Productivity is the economic measure of level of technology and management and is the source of long-term competitive advantages. Any competition or industry policy tries to promote productivity. So does the industry policy of western development strategy. In order to keep sustainable development, western China should try to improve local industries' productivity.

This paper is engaged in trying to find the growth mode of western China. From 1999 to 2003, the industrial scale expansion is calculated. We employ shift-share method to find the sectors which locally grow faster than nationally. Then use data envelopment analysis (DEA) to measure the productivity changes of those fast growing sectors in western China.

2. Methodology and data

2.1 Shift-share analysis basics

Shift-share analysis is one of the widely used technique 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 refer to national economy and is so called 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 particular sector and that of 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 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 western region, whose level of productivity reflect the growth mode of such region. Totally productivity increase generates efficient growth. However productivity decrease generates inefficient growth.

2.2 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 drew upon the work of Debreu (1951) and Koopmans (1951) to define 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 DEA model is:

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

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

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

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 (Dink and Haynes, 1999). This paper employs DEA and Malmquist index approach to measure the locally fast growing sectors' total factors productivity (TFP) changes.

2.3 Data

This paper deals with inter-provincial sectors's data including all twelve western provinces, Ningxia, Shannxi, Gansu, Qinghai, Xinjiang, Inner Mongolia, Tibet, Sichuan, Chongqing, Yunnan, Guangxi, Guizhou. Because of the accessibility and consistency of data, the analysis covers the change of selected sectors from 1999, the beginning of western development strategy, to 2003. Total twenty-three sectors (GB/T4754-2002 two digital classification code)[①] 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 average annual balance of capital and current assets and labor measured by sector's annually 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

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

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

3. Analysis

3.1 Fast growing sectors

Because investment is one of the main development measures, we use capital stock as the measure of sectors' 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 western region grows rapidly during the implementing of western development strategy. Averagely a western province has eight fast growing sectors, covering one third of the twenty-three sectors.

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

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 employs more labor than the efficient level. To Control the quantity of employees on an efficient level is an object 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.

We calculated the means of annual TFP changes and reported the outcome in table 3. If TFP keeps unchanged, the index equals to 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. It’s good news for western region because their 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 TFP change index into efficiency change index and technology change index. It means 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 sector in “catching up” the most advanced one. Figure 1 and 2 report that local sectors’ TFP changes show different modes. 44% local sectors with TFP increase experienced technical efficiency decrease in the circumstance of technical frontier progress. So these sectors’ efficiency improvements are relatively slower than most advanced peer’s technical progress. They still have potential to make their management and technical learning or innovation more efficient, although their TFP have increased. Such progress lag is the potential threat to their long-term TFP increase and then sustainable growth. Among local sectors with TFP decrease, 80% show efficiency decrease while their most advanced peers improved technology. Inefficient management or technical progress is the main reason for TFP decrease.

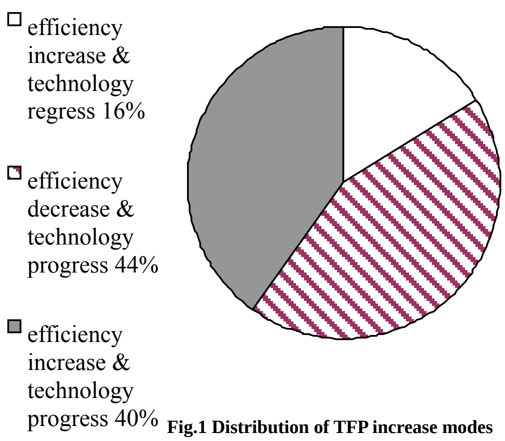

Fig.1 Distribution of TFP increase modes

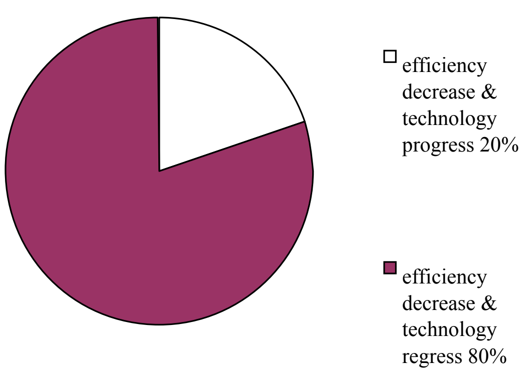

Fig.2 Distribution of TFP decrease modes

In order to compare with reference regions, we also calculated the index of national mean level and relative developed provinces level, including Beijing, Shanghai, Jiangsu, Zhejiang, Guangdong, Fujian, 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 clearly 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, 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

5. Conclusion

Twenty-three industrial sectors in 12 western provinces constitute totally 276 local sectors, among which 101 local sectors developed faster than its national level in term of capital stock. The ration is 37%, showing a relative rapid developing speed for the western development strategy promoting fast investment growth. Through DEA, we find that 90% of the 101 fast growing local sectors' TFP has increased from 1999 to 2003. And 40% of these sectors with TFP increase showing efficiency improvement when their most advanced peers realized technical innovation. It's a good view for western provinces since these sectors showing strong ability to improve efficiency narrowing gap between them and the advanced peers. But western region must realize that about 50% of 101 fast growing local sectors experienced efficiency decrease, which is the main reason for TFP decrease and the main weakness of 44% of sectors with TFP increase. Such sectors should pay more attention to improve management level and build ability of technical innovation while keeping suitable growing speed.

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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,

$$\begin{aligned}
&\left[D_0^t\left(x^t, y^t\right)\right]^{-1} = \max \omega \qquad \text{subject to} \\
&\sum_{j=1}^{n} \lambda_j x_{ij}^t \le x_{ij_0}^t, i = 1, \cdots, \ m \\
&\sum_{j=1}^{n} \lambda_j y_{kj}^t \ge y_{kj_0}^t, i = 1, \cdots, \ s \\
&\lambda_j \ge 0, \omega \ge 0, \ j = 1, \cdots, \ n
\end{aligned} \quad (3)$$

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

$$\begin{aligned}
&\left[D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)\right]^{-1} = \max \omega \qquad \text{subject to} \\
&\sum_{j=1}^{n} \lambda_j x_{ij}^{t+1} \le x_{ij_0}^{t+1}, i = 1, \cdots, \ m \\
&\sum_{j=1}^{n} \lambda_j y_{kj}^{t+1} \ge y_{kj_0}^{t+1}, i = 1, \cdots, \ s \\
&\lambda_j \ge 0, \omega \ge 0, \ j = 1, \cdots, \ n
\end{aligned} \quad (4)$$

and

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

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

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

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

and

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

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

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

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

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 problem, 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.