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Research on State-owned Manufacturing Enterprises' Productivity

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Till now, the state-owned Enterprises (SOEs) still plays a vital role in Chinese economy. By using DEA model, this paper investigated the total factor productivity of listed manufacturing SOEs between 2011 and 2014.Authors' work revealed the fact that the overall stall of total factor productivity of SOEs can be explained by the declination of technological innovations. Total factor productivity of SOEs in East China is higher than those of the rest and the productivity of SOEs in Central China has the fastest growth. Furthermore, total factor productivity of high-tech SOEs maintains a slight improvement while the data in other industries decrease by various margins. At the end of this paper, it is suggested to prioritize R&D investment, industry upgrading, and layout and appraisal system optimization in the reform of SOEs to improve productivity.

1. Introduction

Chinese economy has thrived on the development of manufacturing enterprises, and thanks to the large proportion of State-Owned manufacturing Enterprises (SOEs), the effectiveness of those companies had become the bedrock for the performance of the whole economy. For many years, the concern of low productivity of SOEs had been marked in the theoretical cycle (Jeffersson, 1992; Zheng, 2003; Liu et al., 2002). Different proposals aiming to improve enterprise productivity were delivered both from the perspective of reform of state-owned equity and construction of modern enterprise system. Kornai (1986) and Justin Yifu Lin（2004）believed the soft budget constraint of SOEs is a major cause of low efficiency; Weiying Chang (1999) studied the efficiency problems of SOEs based on agency theory and concluded that the serious problems of the agent chain on the public sector leads to inefficient. Therefore, regulate the behavior of the business operator is a must to promote efficiency of SOEs. Mechanisms that discussed by scholars to regulate the behavior of business operators are developed from the perspective of rational corporate governance, such as, manager payment arrangements, independent director system, big shareholders, managers' characteristics, management shareholders and performance evaluation system, etc.(Stern, 2004; Richardson, 2006; Li, 2007; Qin, et al., 2010)

In 2010, the State-owned Assets Supervision and Administration Commission of the State Council (SASAC hereafter) took the lead to start implementing economic value added (EVA hereafter) performance evaluation system among SOEs. EVA is the net profit after tax earned by the firm less the total capital cost. This index is of great significance requiring that opportunity cost must be considered in all investments, cost benefit should be maximized and resource allocation should be optimized. SASAC expects to regularize SOEs' marketing behavior and improve their operating efficiency by reforming performance evaluation system. Liu Fengwei et al. (2013) constructed a multiple linear regression model to compare investments of SOEs before and after adopting EVA evaluation. They concluded that EVA evaluation could improve efficiency of investment. This shows that the scale efficiency of state-owned enterprises can be improved in the EVA evaluation system. However, compared the scale efficiency, We should pay more attention to the operational efficiency of enterprises. So far, paralleled with systematic construction of Chinese market and development of the reform in SOEs, institutional factors affecting enterprise efficiency have improved gradually. Remarkable enhancement could be seen in SOEs' profitability and economic contribution. However, whether the operational efficiency of SOEs is improved remains unstudied. Therefore, this article analyzed the operational efficiency of SOEs in recent years so as to supply microscopic evidences to the future reform of the SOEs.

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Battese and Coelli (1988) considered four methods to measure production efficiency: Solow Surplus Value Algorithm, index method, Data Envelopment Analysis (DEA) and stochastic frontier analysis (SFA). The first and fourth ones are parametric methods and the others are non-parametric methods. So far, DEA is widely applied in efficiency evaluation in industries of finance, education, health care, agriculture, transportation, etc. Of the first part of the article, this paper takes manufacturing-listed SOEs as samples and evaluates the efficiency of SOEs through DEA model. Section two describes theoretical analysis and research design; Section three provides empirical results and analysis; Final section is the conclusion and policy suggestion for the further reform of SOEs in China.

2. Theoretical analysis and research design

2.1 Brief introduction of DEA

Data Envelopment Analysis (DEA) is a linear programming method mostly used to measure productive efficiency of units of the same nature with large inputs and outputs. Charnes, Cooper and Rhodes (1978) proposed a DEA model under the constant-returns-to-scale condition; while Banker, Charnes, and Cooper modified the former model so it can deal with the variable-returns-to-scale. In DEA model, each unit is a decision-making unit (DMU). In this paper, each state owned enterprise is a DMU. Ratio between input and output is conducted taking weight of each input-output factor of DMU as variable to confirm the functional production frontier. At last evaluate the functionality of DEA for each DMU according to the distances between each DMU and the functional production frontier. This paper uses BCC model (a DEA model under the constant-returns-to-scale condition) to evaluate the efficiency of China's state-owned manufacturing enterprises. Before introducing the BCC model, we need to understand the CCR model firstly, because it is the basis of the BBC model. Suppose there are K SOEs, each as a decision-making unit j , containing l input factors x_{il}(l=1,…,L) and m output factors x_{jm}(m=1,…,M). The paper assumes that enterprise n(n=1,…,k) has the minimum sum of convexity, cone and unavailability. Then DEA model (CCR) in invariant scale can be expressed as

$$\min\left[\theta - \varepsilon\left(\ell_1^T + \ell_2^T s^+\right)\right] \tag{1}$$

$$\text{s.t.} \sum_{j=1}^{k} x_{jl}\lambda_j + s^- = \theta x_l^n \quad l = 1,2,\ldots,L \tag{2}$$

$$\sum_{j=1}^{k} y_{jm}\lambda_j - s^+ = y_m^n \quad m = 1,2,\ldots,M \quad n = 1,2,\ldots,K \tag{3}$$

$$\lambda \geqslant 0, s^- \geqslant 0, s^+ \geqslant 0 \tag{4}$$

In the equation (1), θ($0<\theta\leq 1$) refers to objective functional value. If θ=1, CCR is effective and the enterprise is at the optimal productive frontier. The greater value of θ indicates the higher overall efficiency level of enterprise. When adding a constraint condition $\sum_{j=1}^{k}\lambda_j = 1$ to equation (4), CCR model can be transformed into a BCC model. BCC model decomposes the overall efficiency into technical efficiency and scale efficiency. The overall efficiency is the product of the technical and scale efficiency. Efficiency index of BCC model(θ_b, $0<\theta_b \leq 1$, $\theta_b \geq \theta$) is pure technical efficiency index. Scale efficiency (SE) is calculated from the equation SE=θ/θ_b($0<SE\leq 1$). Value of θ_b and SE close to 1 indicate the higher level of pure technical and scale efficiencies. When θ_b and SE values are equal to 1, pure technical and scale efficiencies are at the optimal level.

2.2 Index selection and data sources

According to the framework of economic analysis, the production function of an enterprise can be expressed as:

$$y=f(x_1, x_2, x_3 \ldots) \tag{5}$$

In equation (5), y and x_i(i=1,2,3…) refer to outputs and inputs variables separately. Input factors include capital, labor, land and so on. On the basis of correlation of input and output, comparability and availability of data, the paper selects operating revenue representing enterprises' output; selects the net value of fixed assets, number of employees and operating cost as inputs of enterprises. Related indicators were shown in the table 1.

Table 1: Enterprise input-output factors summary

Type of factor	Name of factor	Explanation
Input factors	Net value of fixed assets	Net value of depreciated fixed assets at the end of(t-1)term, referring to capital input of term t
	Employees number	Number of employees at term(t-1), referring to labor force of term t
	Operating costs	Operating costs of enterprise at term t, referring to direct capital investment of term t (unit: 1 million RMB)
	Executive compensation	Total management reward at term t, referring to entrepreneurial ability input of term t
Output factors	operating revenue	Operating income of term t, referring to output level of enterprise

Data in this paper is derived from the annual reports of the enterprises and Wind Database. Selection standards for sampled enterprises are: 1), trading in Shanghai and Shenzhen stock markets, actually controlled by State-owned Assets Supervision and Administration Commission of the State Council (SASAC hereafter); 2), being in the manufacturing industry classified by China Securities Regulatory Commission (CSRC hereafter), without any changes during 2011 to 2014. There are 104 enterprises match the standards. Because the government carried out the new evaluation system for state-owned enterprises in 2010, the time span of this paper is from 2011 to 2014. In DEA model, input and output factors are required to positively correlated, which means output will usually increase along with input increase. Lang and Golden (1989) stated that selection of input factors and output factors must pass Pearson correlation test to assure correlation between input and output factors. This thesis conducts Pearson correlation analysis to the data above (Table 2) and the results demonstrate a high-positive correlation between input and output. Correlation coefficients are all higher than 0.7, meeting the requirement of DEA model.

Table 2: Pearson correlation coefficient of input-output factors

Output factor	Input factors			
	Fixed assets	Employees number	Operating costs	Executive compensation
Operating Income	0.756	0.927	0.946	0.704
P-value	0.002	0.004	0.012	0.023
N	416	416	416	416

Note: at 0.05 significance level (bilateral)

2.3 Descriptive statistics of samples

The summary statistics for input/output factors is given in Table 3. It is shown that average input/output factors are increasing during 2011 to 2014. Compared with the enterprises in private sector, state-owned enterprises have a lot of advantageous. The economic crisis in 2008 has provided some good opportunities for the expansion of state owned enterprises. The growths of fixed assets, human resources and other factors of investment have proved this view. Growths of these three indexes also showed that enterprises had optimistic expectations for economic situation. On the other hand, the variance of samples showed that changes of scales of state owned enterprise holding listed companies were big. Major companies and small-sized companies coexisted. That reflected that state owned enterprises had an important position in national economy.

Table 3: Statistical summary of input-output factors

variables/unit	Number	Mean	SD	Min	Max
operating income(million RMB)	416	12623.50	7645.81	219.60	191135.54
fixed assets (million RMB)	416	4177.27	3567.87	65.41	115371.36
number of employees (person)	416	6831.01	5432.90	402.00	64530.00
operating costs (million RMB)	416	10986.75	6933.24	201.82	176879.36
executive compensation (10,000 RMB)	416	533.98	524.66	40.45	3597.00

3. Production efficiency analysis of state-holding listed companies

3.1 Production efficiency of state owned manufacturing-listed companies

Using MAXDEA software, the efficiencies of sample enterprises in each year are calculated and seen in Table 4. Based on the data, following conclusions are drawn. The total factor productivity of state-owned listed companies was not high with average value across the 4 years being only 0.813. The pure technical efficiency was 0.867 and the scale efficiency was 0.939. The reason for the pure technical efficiency being lower than the scale efficiency was that the output scale of state-owned enterprise was better than its resource management. The pure technical efficiency grew faster than the scale efficiency. It was because the improvement of enterprise overall efficiency was driven by resource allocation efficiency. In 2010, SOEs implemented EVA evaluation. Liu Fengwei et al. (2013) considered that EVA evaluation system is able to improve the scale efficiency of enterprise by restraining over-investments of SOEs to a certain degree. But the empirical results of this paper are not supportive enough to verify this theory. The scale efficiency of sample enterprises had no obvious changes after 2010.

Table 4: Average efficiency of state-holding listed companies over 2011 and 2014

Year	overall efficiency	pure technical efficiency	scale efficiency	Proportion of enterprises with diminishing returns of scale
2011	0.779	0.84	0.931	60.7%
2012	0.821	0.873	0.943	53.7%
2013	0.813	0.875	0.931	56.7%
2014	0.838	0.881	0.951	46.6%
mean	0.8128	0.8673	0.9390	54.5%

Table 5: Efficiencies of state-holding listed companiesin different regions

Year	East China			Central China			West China		
	overall efficiency	pure technical efficiency	scale efficiency	overall efficiency	pure technical efficiency	scale efficiency	overall efficiency	pure technical efficiency	scale efficiency
2009	0.792	0.846	0.939	0.767	0.860	0.901	0.756	0.797	0.952
2010	0.823	0.876	0.941	0.835	0.888	0.943	0.798	0.843	0.949
2011	0.833	0.892	0.936	0.799	0.874	0.919	0.773	0.826	0.934
2012	0.842	0.886	0.952	0.852	0.887	0.961	0.801	0.860	0.935
average	0.823	0.875	0.942	0.814	0.873	0.931	0.791	0.837	0.946

3.2 Classification features of production efficiency of state-owned listed companies

(1) Comparative analysis of state-owned listed companies in different regions

The paper divides sample enterprises according to administrative regions and economic zones. In general, we can divide China into three regions: east region, central region and west region. The east region of China is the most developed area in China. The west region is relatively less developed. There are about 55% enterprises belong to east China, and that of Central China enterprises and West China enterprises are 26% and 19%. The enterprises in East China are more efficient and competitive. The pure technical efficiency of West China enterprises is 0.837, lower than that of East and Central China (approximately 0.87). It reveals that the resource management level of West China SOEs still needs to be improved. The scale efficiencies of SOEs in each region are similar with average value of approximately 0.94. This index is the highest among all indexes in this paper illustrating that most of the SOEs had realized economies of scale. One reason is that most of them are capital-intensive enterprises. From the perspective of development trend, the overall efficiency, pure technical efficiency and scale efficiency in each region during 2011 to 2014 had increased to various extents. Especially in 2014, the efficiency level had been greatly increased. It was possibly benefited by the Twelfth Five-year Plan.

(2) Comparative analysis of state-owned listed companies in different industries

Hsiao (2005) divided manufacturing industries into traditional manufacturing industry, basic manufacturing industry and high-tech manufacturing industry and further analyzed and compared their total factor productivities. Based on his concept, this paper also divides sample enterprises into three groups: high-tech manufacturing industry (modern emerging industries such as electronics and automobile industry), basic manufacturing industry (production of industrial materials such as metal and chemicals) and traditional industry (traditional handicraft production such as spinning and wine making).

Table 6 shows that the overall efficiency value of traditional sectors is 0.779, lower than that of high-tech sectors and basic sectors. The country should strive to develop high-tech manufacturing industry. Overall efficiency is decomposed into pure technical efficiency and scale efficiency. The efficiency of traditional industry is low because its pure technical efficiency is low. Hence, improvement of enterprise technological level helps improving the efficiency of resource allocation. The ranking of scale efficiencies is totally the opposite. The scale efficiency of traditional industry is the highest and that of high-tech industry is the lowest. High-tech industry's low scale efficiency is probably due to its high research input which might cause high sunk cost and lower the enterprise scale efficiency. On the whole, overall efficiency, pure technical efficiency and scale efficiency of each industry from 2011 to 2014 had all increased to various extents. Similarly, the improvement in 2014 was the greatest. It was related to the whole economic transition occurred in our country.

Table 6: Efficiencies comparison between state-holding listed companies in different industries

	high-tech manufacturing industry			basic manufacturing industry			traditional manufacturing industry		
Year	overall efficiency	pure technical efficiency	Scale efficiency	overall efficiency	pure technical efficiency	Scale efficiency	overall efficiency	Pure Technical Efficiency	scale efficiency
2009	0.779	0.855	0.912	0.791	0.821	0.961	0.732	0.766	0.957
2010	0.823	0.883	0.935	0.825	0.862	0.958	0.787	0.813	0.968
2011	0.835	0.882	0.925	0.817	0.871	0.939	0.779	0.809	0.963
2012	0.836	0.884	0.946	0.848	0.885	0.958	0.816	0.841	0.971
Average	0.823	0.876	0.931	0.820	0.860	0.954	0.779	0.807	0.965

4. Conclusions

This paper attempts to analyze production efficiency of SOEs holding manufacturing listed companies through DEA model and draws the following conclusions: 1), production efficiency of SOEs holding manufacturing listed companies is at a good statue. After decomposing companies' overall efficiency into pure technical efficiency and scale efficiency, the paper finds out that the former one is generally lower than the latter one. The fact illustrates that the output scale efficiency of the companies is better than their resource management efficiency. 2), production efficiency of East China SOEs was higher than that of Central China and West China ones. It was due to East SOEs' high pure technical efficiency and meanwhile scale efficiency of SOEs in West China was the highest. 3), production efficiency of companies in high-tech industry is higher than that of companies in traditional industry and basic industry. Pure technical efficiency in high-tech industry is the highest which means that resource management ability in this industry is the best. Scale efficiency in traditional industry is the highest. To sum up, the improvement of production efficiency in high-tech industry is the biggest.

Conclusions drawn above have important policy inspirations for SOEs management in the future: First, the main factor affecting the efficiency of state-owned enterprises is the management ability, therefore, it should improve the governance structure of state-owned enterprises. Second, R&D investment should be increased to upgrade the technical level of SOEs. At the same time, positive fiscal taxation policy system should be enacted to ensure technical improvement of SOEs. Policies like transfer payment from the exchequer, fund support and tax preference are beneficial to improve total factor productivity. And again, high-tech industry is of great importance in the process of upgrading industries. Industries should be transferred from East to central and west China for the strategic purpose of balancing regional economic development and upgrading production efficiency level of companies in all regions. At last, market-driven economic reform should be deepened, market mechanism should be improved and with help of these moves competitive level of each industry could be upgraded. State-owned monopolized industry ought to be opened and introduces civilian capitals and competitive mechanism. Only in this way can production efficiency of SOEs be truly improved.

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