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Productivity and efficiency of state-owned enterprises in China

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Abstract The purpose of this paper is to evaluate the variations in SOE efficiency and productivity from the perspectives of macroeconomic fluctuations and systematic reform in China during 1986–2003. We use Data Envelopment Analysis to measure SOE efficiency. Subsequently, we use the Malmquist Index of Productivity change to measure productivity growth. The empirical results show that SOE efficiency and productivity exhibited obvious improvements during periods of strong systematic reform and a prosperous economy. The systematic reform after 1998 had a clear-cut impact on SOE performance.

Keywords SOE efficiency · SOE performance · Malmquist index of productivity · Productivity growth

JEL Classifications O4 · P2

1 Introduction

Since the implementation of China's economic reform in 1979, there have been all kinds of reform suggestions and policies concerning the State-Owned Enterprises (SOEs). SOE reform has been one of the primary components of China's economic policy. The importance of and need for the reform is clear from the change in the industrial structure in China: the percentage of SOEs' output in total industrial output dropped from 80% in 1978 to 28% in 2003.

The primary focus of SOE reform in the early 1980s was "deregulation." This deregulation allowed SOEs to operate with self-ownership and self-management, bearing their own operating losses or profits. However, after obtaining partial ownership, some SOEs experienced various kinds of corruption, which led to calls for other avenues of reform. Thus, in the second half of the 1980s, ownership-oriented reform attracted much attention. It was believed that SOE problems might be resolved by means of clear property ownership under a modern corporate system (Tian 1994; Zhang 1997; Li and Wu 2002). However, another school, which originated from an evaluation of the SOE policy mission and their privileged protection, recommended that SOE reform should aim for a fair and competitive market environment. These market reformers believed that SOE problems originated from the lack of a competitive environment, rather than from the absence of property ownership. Thus, SOE reform should start with resolving the burdens of SOEs, tightening their budget constraint, and introducing them into a competitive market. Eventually the profit rate of SOEs should be the signal that reflects operational efficiency (Lin et al 1997; Steinfeld 1999).

Theoretical approaches to the study of SOEs vary as well and are closely related to the type of empirical research found in the literature. In the early years, some scholars used a single factor productivity indicator, such as output per unit of working capital, taxable profit rate and the rate of operating profit/loss, to measure SOE

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productivity or efficiency. Since most indicators showed a downward trend, these researchers concluded that SOE productivity had declined. Though these single factor productivity indicators could reflect the operating conditions of SOEs, they conveyed limited information. In addition, due to the progress of the systematic economic reform, SOEs faced stronger market competition: product prices declined steadily, and the profit rate dropped. Rawski (1993) pointed out that the decline in various accounting indicators did not necessarily imply that SOE efficiency had decreased. Cheng and Lo (2002) analyzed SOE performance from a microeconomic industrial organization perspective. Their results supported the same view. Furthermore, the decline in profits rates was not limited to SOEs. In the 1990s, various non-state-related industries also showed declines in profit rates (Lo 1999).

In the early 1980s, some American scholars started to use total factor productivity (TFP) to evaluate SOEs' productivity efficiency. They did not find a sharp increase in TFP (Chow 1985; World Bank 1985), though Perkins (1988) did find evidence of a slight rise in TFP prior to the mid 1980s. As for the period after the mid 1980s, Jefferson and Rawski, together with others,[1] found that SOEs' TFP improvement was, though lower than the industry as a whole, quite obvious. Their results were consistent with the findings of Dollar (1990).[2] Even so, some researchers had doubts about the appropriateness of using TFP to reflect SOEs' productivity efficiency.

In China's economic system, the technical relationship in TFP was sometimes distorted by all kinds of government-imposed standards and objectives. For example, in the early years, under the objective of maximizing total output, some of the SOE products were of poor quality and therefore not marketable. Bai et al. (1997) pointed out that when profit maximization is not the objective of an enterprise, higher productivity is usually accompanied by a greater distortion in resource allocation, a lower profit rate and economic inefficiency. In addition, SOEs had played a special role in the Chinese economy. In the beginning of the 1980s, the amount of total profits was an important indicator for SOE managers. But with the lack of an appropriate profit-sharing system and the failure of the central government to provide the right for the residual claim, SOE managers tended to increase wages and fringe benefits to gain workers' support. The increase in costs implied a decline in profits. Given that the social security system had not developed, SOEs implicitly took up part of the social responsibility for quite a while. Bai et al. (2000) used a multitask model and showed that SOEs' tasks of maintaining a stable employment and providing retirement benefits were crucial for a stable economic development in a transitional economy.

Since the mid 1990s, some scholars started to use Data Envelopment Analysis (DEA) to evaluate the productivity and efficiency of various industries in China. Färe et al. (1996) used the Malmquist Index to calculate the change in productivity and efficiency in the 1980–1984 and 1984–1985 periods. Zheng et al. (1998) used DEA to compare the degree of efficiency between SOEs and township enterprises. Shiu (2002) used 1995 industrial survey data in a DEA model to investigate the efficiency variations between different types of ownership in different locations. Zheng et al. (2003) used 600 SOEs to evaluate the dissimilarity of SOE efficiency in five different stages of the economy in 1980–1994. Zhang et al. (2001, 2002) used the Malmquist Index method to calculate the productivity change of firms with different forms of ownership in the industrial sector in Shanghai.

The purpose of this article is to evaluate the variations of SOE productivity and efficiency from the perspectives of macroeconomic fluctuations and systematic reform in China. The data cover the period of 1986–2003 and the measurement unit is the province. We use DEA to evaluate SOE performance. Subsequently, we use the Malmquist Index of Productivity change, referred to as MPI, to measure productivity growth. This index allows us to decompose productivity growth into technological change and efficiency change. The plan of this paper is the following. Section 2 introduces the model. Variables and data selection are described in Sect. 3. Section 4 provides empirical results. A concluding section follows.

2 Model setup

A proper unit of measurement for the evaluation of SOEs' efficiency is a firm. However, firm-unit data are difficult to obtain. Published provincial aggregate data will be used to represent each province's average firm data. We refer to

[1] The research results of Jefferson and Rawski were published in (starting from 1987) the Journal of Comparative Economics, Economic Development and Cultural Change, China Quarterly, and some native Chinese journals. These articles were collected in Zheng and Rawski (1993), Jefferson and Rawski (1996), and Jefferson et al. (1996).

[2] Nevertheless, some scholars suspected that these results were affected by measurement error in the data. For instance, intermediate input deflators over-deflated inputs, which resulted in an understatement of the quantity of intermediate inputs. At the same time, actual total output was overstated. Altogether these problems caused an over-statement of TFP. In addition, the deflator index of the industrial value added had a declining tendency in several years, which was also against the norm (Woo et al. 1993, 1994). In response to these criticisms, Jefferson et al. (1996) explained that the deflator index caused minor measurement error. The deflator index had a small impact on the SOE TFP even though its impact on township enterprises was relatively large. Thus the conclusion about the SOE's TFP should be valid.

the average firm of each province as a Decision-Making Unit (DMU). We thus have DMU_1, DMU_2, ..., DMU_n, where n is the number of provinces. Each DMU has m inputs and s outputs. Let $x^t = (x_1^t, x_2^t, \ldots, x_m^t)$ be inputs and $y^t = (y_1^t, y_2^t, \ldots, y_s^t)$ be outputs at time t where $x^t \in R_+^m, y^t \in R_+^s$ and $t = 1, 2, \ldots, T$

To describe each DMU's output maximization with given inputs at a given time t, DEA uses the following linear programming model (ignoring the superscript t for the time being).

$$\begin{aligned} \underset{(\phi,\lambda)}{\text{Maximize}} \quad & \phi \\ \text{subject to} \quad & \sum_{j=1}^{n} x_{ij}\lambda_j \le x_{io} \quad i = 1, 2, \ldots, m \\ & \sum_{j=1}^{n} y_{rj}\lambda_j \le y_{ro} \quad r = 1, 2, \ldots, s \\ & \lambda_j \ge 0 \quad j = 1, 2, \ldots, n, \\ & \phi \quad \text{is unrestricted} \end{aligned} \tag{1}$$

λ_j is the weight specified for each DMU in input usage and output production. The optimal value ϕ^* indicates the "maximum" proportional expansion of the output vector given inputs. This model is an output-oriented Charnes–Cooper–Rhodes model (Charnes et al. 1978). Constant returns to scale is assumed in the above model. When the $\sum\lambda_j = 1$ constraint is added, we have a variable returns to scale model (Banker et al. 1984).

The DEA estimate of ϕ is an indicator of efficiency. It measures the distance between the observed input/output combination and the common efficiency frontier. The MPI is based on similar ideas as DEA but it allows comparisons between two periods. Suppose the technology at t is implied in a set A^t, where all feasible (x^t, y^t) are included, i.e., $A^t = \{\text{all feasible } (x^t, y^t)\}$. The output distance function, based on A^t, is $D_0^t(x^t, y^t) = \min\{\lambda : (x^t, y^t/\lambda) \in A^t\}$. The distance function increases output y^t/λ as much as possible for given input x^t and technology at time t. Following Färe et al. (1989) and Boisso et al. (2000), the MPI is defined as:

$$M_o^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \cdot \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)}\right]^{1/2}. \tag{2}$$

Rearranging the terms in Eq. 2, we have an equivalent way of stating the MPI:

$$M_o^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t) = \Delta E \cdot \Delta T \tag{3}$$

where

$$\Delta E = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}$$

and

$$\Delta T = \left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \cdot \frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}\right]^{1/2}.$$

The MPI is thus decomposed into two elements, efficiency change (ΔE) and technological change (ΔT). The distance functions in the MPI can be calculated using linear programming methods similar to those used in DEA. DEA constructs a production frontier according to all the data in the sample. Different time periods have different production frontiers. Each observation then is compared to the frontier. Technological change ΔT measures shifts in the frontier between period t and period $t + 1$. Efficiency change ΔE calculates the change in the distance between observed production and maximum potential production. The product of these two elements provides a frontier based measure of the productivity change.

3 Variable selection and data adjustment

To engage in the empirical research of SOE efficiency and productivity, the elements of SOEs' economic environment and data availability have to be taken into account. This implies that the choice of input and output variables will differ from familiar standards. Furthermore, due to the quality and the availability of statistical data, some data need to be adjusted. This section will focus on these two elements, namely, variable selection and data adjustments. A historical background will also be provided.

3.1 Variable selection

Standard input variables are labor and capital. The number of employees at the end of each year is used to represent labor input. For the capital input, net fixed asset value and working capital are used. All these items are yearly average values. Generally speaking, these variables are quite standard in China's industrial productivity empirical research.

We will use net output value[3] (i.e., value-added) to represent output. Even though it is standard to use value-added to represent output, one needs to realize that in the early years, under China's socialist system, total output value was a measure that the government used to evaluate the SOE performance. It affected the ranks and benefits of managerial officials. Most firms strived to increase output to outperform the industry average without considering market demand. Even though profit maximization became more vital during the reform, the focus on output amplification and large-scale operations still subsisted for quite a

[3] Most value-added data of 1986–1991 were taken from China Provincial Statistical Yearbook while the data of 1992–2003 were from China Statistical Yearbook.

period of time. This phenomenon disappeared gradually because of various reforms. In later years, the central government started to use operating profit/loss to evaluate SOE performances.

To evaluate SOE performance from a different perspective, we will use taxable profits as the sole output variable in a separate model. Note that this is a supplementary model to the previous model that specifies net output value as the only output variable. This supplementary model is a non-traditional model that is used to provide additional insights about SOE performance under China's unique political and economic system. Taxable profits are operating profits before tax, defined as total sales minus cost of goods sold. Out of these taxable profits, SOEs pay taxes, which include sales tax and value added tax. The remainder would normally be thought of as retained earnings, to be used by the SOE itself. However, since China did not have a complete market economic system and profits were not determined completely by market competition, some of the profits were transferred back to the government. Altogether, therefore, regardless of any possible variations in the tax system, taxable profits appear to be a consistent measure for SOE performance.

3.2 Data sources and adjustment

SOEs were found in agricultural, industrial, transportation, and business sectors. This article focuses on the largest sector alone, namely the industrial sector. Due to data availability, only financially independent SOEs will be included in this research. Since 1998, the Statistics Bureau of China revised statistical coverage and classification. In addition to state-operated enterprises, financially independent SOEs also include firms where the state has majority stock holdings.[4]

Concerning the choice of a DMU, an ideal DMU should be formed according to micro-perspective industrial information. Constrained by data availability, this paper uses 30 provinces in China as DMUs. The average value of all SOEs in each province will be used. Though the average value does not reflect a specific enterprise, it represents an average operating standard of SOEs in each province. However, one possible consequence of using the average province data is that the measured changes in productivity and efficiency over time could be due to changes in the firms' composition in each province rather than to changes in the efficiency or technology of individual firms. In particular, the pressure on SOEs to improve may cause local governments to eliminate some of the worst performed SOEs within the province.

[4] The official term is state-owned and state-holding enterprises.

All five variables, except the number of employees, are measured by means of published current-price data. We use the ex-factory price index of industrial products to deflate the annual average balance of working capital and fixed asset. The GDP deflator is used to deflate net output value and profit before tax. Since statistical data concerning SOEs are available since 1986, this paper will use data from 1986 to 2003.

3.3 Historical background

Since SOEs encounter different environments and have different policy missions, the choice of an appropriate time period to evaluate SOE performance is quite crucial. Two essential elements stand out as we reflect on SOE reforms and development. The first element is the overall economy's business cycle. The co-existence of the planned system and the market economy often resulted in a vicious sequence: deregulation initiated a distortion, the distortion resulted in regulation, and regulation led to the demise of an enterprise. One may take an early 5-year economic planning period as an example. In the first 2 years of the 5-year plan, governments had slack controls and investments increased dramatically. That enhanced economic growth and led to a higher price level, which induced a policy switch in the third year. That resulted in a decline in investment and slower growth in the fourth and fifth years. In the early years, the vicious cycles of a planned economy were mingled with the impacts of overall economic fluctuations. On the one hand, because of the development of a market-oriented economy, a gradually more competitive market reduced monopoly profits for most SOEs (except natural monopolies). On the other hand, as the overall economy became prosperous and the pressure of competitiveness was relieved, higher profits induced SOEs to make large investments. But whenever the boom stopped, the excessive investments backfired and SOE efficiency declined sharply. Using China's construction data from 1985 to 1991, Parker (1997) showed that the excessive investments of expanding autonomous firms were the primary cause of the decline in efficiency.

The phenomenon described above is reflected in Table 1, which exhibits three indicators, namely, economic growth rate, industrial output price change, and fixed assets growth rate. These indicators provided insights about the economy. In 1987–1988, 1992–1993, 2000, and 2003, economic growth rates were high and industrial output price changes were positive, indicating industrial sectors' greater demand than supply. Those circumstances were conducive to SOEs' development and SOEs should have decent performances. But the fixed assets growth rates of 44.4 and 61.8% in 1992 and 1993 had negative impacts on SOE efficiency in the later years.

Table 1 Relevant macroeconomic indicators

Year	GDP growth rate (%)	Industrial output price % change*	Fixed asset growth rate (%)
1986	8.8	3.8	22.7
1987	11.6	7.9	21.5
1988	11.3	15.0	25.4
1989	4.1	18.6	−7.2
1990	3.8	4.1	2.4
1991	9.2	6.2	23.9
1992	14.2	6.8	44.4
1993	13.5	24.0	61.8
1994	12.6	19.5	30.4
1995	10.5	14.9	17.5
1996	9.6	2.9	14.8
1997	8.8	−0.3	8.8
1998	7.8	−4.1	13.9
1999	7.1	−2.4	5.1
2000	8.0	2.8	10.3
2001	7.5	−1.3	13.0
2002	8.3	−2.2	16.9
2003	9.3	2.3	27.7

* Compared with the preceding year

Source: China Statistical Yearbook (1987–2004)

The second element that stands out as an important determinant of SOE performance is the progress of a systematic reform. Before 1986, SOE reform was focused on enterprise independence. The focus in 1987–1992 was on the subcontract system. In 1993–1997, SOE property ownership reform was initiated and implemented. During the subsequent 3 years, in 1998–2000, the focus was on reducing operating losses and laying off redundant workers. As for 2001–2003, there was a push toward SOE privatization through mergers, reorganization and bankruptcy.

As reform progressed, policymakers in China started to evaluate SOE performance by the following two measures: (i) the percentage of SOEs that suffered an operating loss, and (ii) the amount of total operating loss. According to Table 2, SOEs' total operating loss climbed to a peak in 1998 and declined gradually afterwards. An issue related to the operating loss was the excessive number of employees. The expenditure on various fringe-benefits (especially retirement benefits) was a huge burden on SOEs. Table 2 showed that the number of employees peaked in 1995 and started an obvious decline in 1998. In general, the growth rates of retirement cost after 1998 were smaller than those before 1998.

Instead of using financial operating loss to judge SOE performance, we will use DEA and MPI methods. The numerical values provided by DEA and MPI will be examined from the perspectives of various SOE reforms and macroeconomic fluctuations. Table 3 characterizes China's macroeconomic phenomena and systematic SOE reforms at various points in time between 1986 and 2003.

Two additional data issues need to be mentioned. First, Hainan became an independent province in 1988.

Table 2 Informative SOE related indicators

Year	% of SOEs with operating loss in industrial sector (%)	SOE operating loss in industrial sector (billion yuan)	SOE employment growth rate in urban areas (%)	SOEs retirement cost growth rate (%)
1986	13.0	54.5	3.8	21.1
1987	13.0	61.0	3.4	22.3
1988	10.9	81.9	3.4	28.3
1989	16.0	180.2	1.2	17.4
1990	27.6	348.8	2.4	23.5
1991	25.8	367.0	3.1	19.1
1992	23.4	369.3	2.1	24.6
1993	30.3	486.0	0.3	31.4
1994	33.0	448.0	2.7	40.5
1995	33.5	540.6	0.4	24.8
1996	37.7	726.7	−0.2	19.7
1997	39.2	744.4	−1.8	16.0
1998	41.4	1,023.3	−18.0	13.7
1999	41.4	851.4	−5.4	16.7
2000	35.1	615.8	−5.5	12.9
2001	35.9	688.6	−5.7	12.4
2002	35.3	633.2	−6.2	19.1
2003	35.5	628.8	−4.0	13.4

Source: Data before 1991 were collected from Liu and Yang 1994 (p. 15). Data from 1992 to 2003 were from China Statistical Summary (1993–2004) and China Statistical Yearbook

Table 3 The macroeconomic and policy environment surrounding SOEs

Year	Macroeconomic condition	Stage of the systematic reform
1986	Due to the inflationary pressure caused by the wage reform in 1985, the government implements a tight economic policy	Push forward the subcontract system nationwide
1988	With an overall price reform and a quest for higher economic growth, an economic expansion occurs	Keep pushing forward the subcontract system
1990	Due to the "Tienanman Square" event in Beijing in June1989, there is an overall tightening policy	Implement the subcontract system nationwide
1993	In response to Deng Xiao-Ping's various speeches in the South in 1992, there is an overall economic recovery	Push modern corporation system and start the stock system as a pilot program
1995	Macroeconomic fine-tuning policies are implemented and the expansion gradually moves into a contraction	Start to push forward the stock system
1997	Macroeconomic fine-tuning policies become effective; inflation rate is satisfactory	Continue the property ownership reform
1998	The Asia financial crisis affects China. Expansionary fiscal policy is used to stimulate the economy	Initiate and implement operating-loss reduction reform; a huge lay-off ensues
2000	A gradual economic recovery takes hold, and expansionary fiscal policy is maintained	Emphasize restructuring and corporate governance
2003	There is an economic boom after SARS event	Emphasize merger, reorganization, and bankruptcy

Nevertheless, Hainan was included in the data of Guangdong province in 1986. Second, even though Chongquing became a separate municipality in 1997, it is included in the province of Sichuan to maintain data consistency.

4 Empirical results

4.1 Results from traditional DEA models

The performance measure produced by DEA is an indicator of efficiency. According to the axioms of the production possibility set,[5] all the DMUs' input and output intersection sets induce a definite efficiency frontier. In this section, two different kinds of efficiencies are calculated, namely, Panel-Data (PD) efficiency and Cross-Sectional (CS) efficiency. They differ in the way that the common efficiency frontier is calculated. For PD efficiency, all the relevant data of SOEs in all 18 years (1986–2003) and from all 30 provinces are pooled together to derive a common efficiency frontier. For CS efficiency, data from all provinces in a given year are used to construct the common efficiency frontier for that year. In each case the distance between each DMU's input/output coordinate and the efficiency frontier is calculated. Note that all the calculations are based on CRS. Let E_{ij} denote the thus derived efficiency indicator for the ith year and the jth province; and r_{ij} be the ratio of each province's SOEs number to the total SOE number in that specific year. Using r_{ij} as a weight, a nationwide SOE weighted average efficiency indicator E_i can be calculated.

$$E_i = \sum_{j=1}^{30} r_{ij} E_{ij}, \qquad i = 1986, 1987, \ldots, 2003. \tag{4}$$

PD efficiency is considered as an indicator of overall efficiency. Note that PD efficiency assumes no technical change. If there has been technical change (as suggested by MPI), then PD efficiency reflects a combination of efficiency change and technical change. This PD indicator can be used to compare SOEs efficiency variations among different years. CS efficiency is used to indicate efficiency variations of the average (within each province) SOE efficiency among the provinces for a specific year. Thus, the comparison of PD efficiencies in different years reveals the variation of efficiency over time, while the assessment of CS efficiencies shows the dispersion of efficiencies across different provinces in a specific year. The numbers in Table 4 are efficiency indicators calculated according to Eq. 4. The numbers without parentheses use net output value as the only output variable while the numbers in the parenthesis use taxable profits as the only output in a separate model. Our discussion will focus mainly on the DEA results using net output value as the output variable. A value of unity implies that the province is on the production frontier in the associated year. Values below unity imply

[5] DEA is founded on a production possibility set derived from four axioms (Yu et al. 1996; Chen 1997, chapter 4).

Table 4 SOE efficiency scores computed by DEA[a]

Year	Panel data efficiency	Cross sectional efficiency
1986	0.6143 (0.5195)	0.8170 (0.5661)
1987	0.6291 (0.5104)	0.8183 (0.6549)
1988	0.6832 (0.5327)	0.8493 (0.6170)
1989	0.7557 (0.5143)	0.8109 (0.5223)
1990	0.6772 (0.3785)	0.7256 (0.4041)
1991	0.6172 (0.3434)	0.7179 (0.4039)
1992	0.4523 (0.2148)	0.7164 (0.4062)
1993	0.5848 (0.2459)	0.7112 (0.3644)
1994	0.5677 (0.2547)	0.5883 (0.2430)
1995	0.4939 (0.2174)	0.5728 (0.2357)
1996	0.4561 (0.1887)	0.5602 (0.2241)
1997	0.4436 (0.1883)	0.5844 (0.2385)
1998	0.5831 (0.1744)	0.6382 (0.2231)
1999	0.4961 (0.1969)	0.6828 (0.4614)
2000	0.5560 (0.3800)	0.7066 (0.3979)
2001	0.5824 (0.3211)	0.7325 (0.4152)
2002	0.6387 (0.3628)	0.7546 (0.4683)
2003	0.7450 (0.4939)	0.7653 (0.4440)

Note: [a] Values outside parentheses refer to the primary DEA model, which uses value added as the output variable. Values inside parentheses refer to the supplementary DEA model, where the output variable is taxable profits

that the province is below the frontier. If the value is lower, the inefficiency increases. According to PD efficiency, the efficiency improved steadily since 1986, reached the highest level in 1989 and declined afterwards. In the 1990s, it declined steadily except 1993 and 1998. After 2000, the efficiency improved progressively.

The PD efficiency improvement in the late 1980s was strongly related to the systematic reform at the time[6] that workers had more incentives to work, which, in turn, stimulated productivity. The general declines in the 1990s were affected first by the Tiananmen Square event in June 4, 1989 (i.e., "64"). Due to the impact of "64", the economy was in contraction in 1990. The speed of various reforms slowed down. SOE efficiency appeared to decline. An additional contributing factor to this decline was related to the introduction of the market mechanism, which increased competition and lowered market prices. In the spring of 1992, Deng Xiao-Ping gave various speeches supporting the market-oriented economic system. These speeches stabilized nationwide confidence toward market-oriented reform. That led to massive investments and a speedy SOE expansion. The huge investment that was unable to be capitalized to increase output in the very short run had a negative impact on 1992 efficiency value. In 1998, SOE reform focused on loss-reduction. SOEs laid off huge numbers of redundant workers and the PD efficiency of 1998 improved.[7]

For the years after 2000, expansions in public infrastructure brought about by the expansionary fiscal policy, together with strong housing demand, stimulated steady demand for energy, steel and construction production. Those industrial sectors are located in the major area where SOEs are located. These positive impacts on SOEs caused a gradual increase in SOE efficiency since 2000.

Generally speaking, 1987–1988, 1992–1993, 2000, and 2003 were the years of economic expansion. Except for 1992, PD efficiencies showed a positive stimulus in those years respectively. Table 4 indicated that 1989 had the highest PD efficiency of all years: 0.7557. Though both GDP and fixed asset growth rates in 1989 were not impressive (Table 1), 1989 was a year following the high growth rates in 1987 and 1988 and the growth was disturbed by "64." The PD efficiency of 0.5848 in 1993 was the highest around the surrounding years, 0.5560 in 2000 was the highest since 1995, and 0.7450 in 2003 is the highest since 1990. A prosperous macroeconomic situation seemed to have a positive impact on SOE performance.

In addition to systematic reforms and the surrounding macroeconomic environment, there were other factors that affected the variations in efficiency. Due to their historical and systematic role in China's economy, SOEs were partially obligated to provide workers' benefits and job security for a period of time, especially in the early years. Under the protection and regulation of local government, SOEs with huge operating losses would not be shut down. When market circumstances changed, SOEs could not react with lay-off or with downsizing operations in the early years. But with the gradual disappearance of the local protectionism, the entry of the non-SOE firms, and China joining the World Trade Organization, which led to the inflow of foreign investments, SOEs did face stronger competition. In response to these forms of market competition and in order to improve their performance, SOEs strived to use more capital in their production processes. SOEs' large capital stock accumulation was partly associated with their easy access to national banks and partly related to fast technical progress that led to a constant demand for newer equipment. This large capital stock was part of the reason that PD efficiency was tied closely to the cyclical fluctuations in market demand. When the economy was in a boom, strong market demand enhanced full utilization of the capital stock. Together with the reduced pressure of market competition in a boom, a prosperous economy had a positive impact on SOE performance.

[6] These reforms focused on enhancing SOEs' independence in the process of deregulation, taking the responsibility of disposing the operating profit or loss, and distributing rewards according to productivity.

[7] Note that the value in the supplementary model did not improve (see also Table 2).

As mentioned, CS efficiencies show the efficiency dispersions across different provinces in a specific year. CS efficiencies were above 0.8 before 1989; between 0.7112 and 0.7256 during 1990 and 1993; within 0.5602 and 0.5883 during 1994 and 1997; steadily increasing since 1998 and reached 0.7653 in 2003. In the late 1980s, the values of CS efficiency were high, implying that the efficiency dispersions across different provinces were small. This period was related to the early stage of reform where SOEs were well protected and the performances of various SOEs were similar. The deregulation of SOEs and the corresponding macro environment in the 1990s enhanced the dispersions of SOE performance. In 1994, the credit tightening macro policy implemented by Zhu Rongji decreased the funding availability for poorly performed SOEs. That worsened the dispersion of SOE performance. The value of CS efficiency declined to 0.5602. Nevertheless, the prosperous economy since 2000 has decreased dispersions in SOE performance significantly.

When we examine the efficiency variations among different provinces, the SOEs in Yunnan Province stand out. Based on PD efficiency, except in 1988 where Tibetan SOEs had a better performance, Yunnan's SOEs outperformed those of other provinces. Figure 1 showed the provincial average PD efficiency over the period of 1986–2003, where Yunnan had an average value near 0.9. According to CS efficiency, except 1986 and 1987, Yunnan's SOEs also had outstanding performance from 1988 to 2003. The cause of the superior performance is related to the tobacco industry in Yunnan. The tobacco industry had been highly regulated and highly profitable; it was the major source of government taxable revenues among the SOEs. Similar examples were SOEs situated in provinces with well-endowed oil fields such as Heilongjiang, Guangdong, and Xinjiang, which also performed well. SOEs in coastal provinces such as Guangdong and Fujian exhibited pretty good ratings as well. However, the advantage of a SOE being a monopoly or an oligopoly in the industry seemed to outweigh the benefit of being in the coastal area.

Most of the evaluation results of DEA based on taxable profit (i.e., the numbers in the parentheses) are similar to those that use net output value as the only output measure. The main difference is that the former yields much lower values than the latter. A lower value implies a larger dispersion in SOE performance. Since the efficiency measure is the weighted average of all 30 provincial SOEs, a lower average value implies a distribution skewed more to the left. In other words, some provinces' SOEs had very low efficiency values when taxable profits were used as the only output measure. That is consistent with our earlier discussion about SOEs historical and systematic role in China's economy, e.g., government intervention and inflexibility to exit the market.

4.2 MPI and its decomposition

China had two important missions in its social economic transitional periods: to push for economic growth and to carry out systematic reform. Since these two missions had significant impacts on SOE performance, the evaluation periods of MPI and its components will be divided according to the various reform stages and macroeconomic fluctuations in Table 3. They are 1986–1988, 1988–1990, 1990–1992, 1993–1995, 1995–1997, 1998–2000, and 2000–2003.[8]

MPI can be decomposed into efficiency change and technological change. When the value of the MPI or of its components is less than 1, there is deterioration in performance; and when it is greater than 1, performance is improving. Table 5 provides a summary description of the MPI and its components. From the overall MPI evaluation, the period of 1986–2003 showed an average of 1.6% improvement in performance. There were large variations among those seven time periods. Besides 1990–1992 and 1995–1997 where the values of MPI were less than 1, all the other five periods (i.e., 1986–1988, 1988–1990, 1993–1995, 1998–2000 and 2000–2003) had MPI values greater than 1.

A positive MPI of 1.151 during 1986–1988 indicated that SOEs experienced a tremendous improvement in productivity. Given the circumstances during that time period, the improvement should not come as a surprise. Note that both 1987 and 1988 had GDP growth rates around 11%. That was also the time period that the subcontract reform sped up. The combined influence of a prosperous economy and a favorable reform had a clear positive impact on SOE performance. Yet, the largest MPI number, i.e., 1.382, showed up in 2000–2003, which had a positive warm-up in the previous period, 1998–2000, with an MPI of 1.031. Note that 2000 and 2003 were also the years with prosperous economic growth, with GDP growth rates being 8 and 9.3% (see Table 1). Though the growth rates were not extremely impressive in the light of China's history of growth since the mid 1980s, they were both higher than the growth rates of previous 2 years, respectively. Even so, the productivity improvement among SOEs during 1998–2000 may be attributed to the positive impacts of operating-loss reduction reform, which restructured the SOEs through a huge lay-off of the redundant workers. The follow-up of the reform effort to eliminate inefficient SOEs through bankruptcy and merger during 2000–2003 had a similar impact in improving SOE productivity.

[8] Due to a minor revision in China Statistical Yearbook in 1993 and a substantial revision in 1998 that relate to firm coverage and classifications, we allow for breaks between 1992–1993 and 1997–1998.

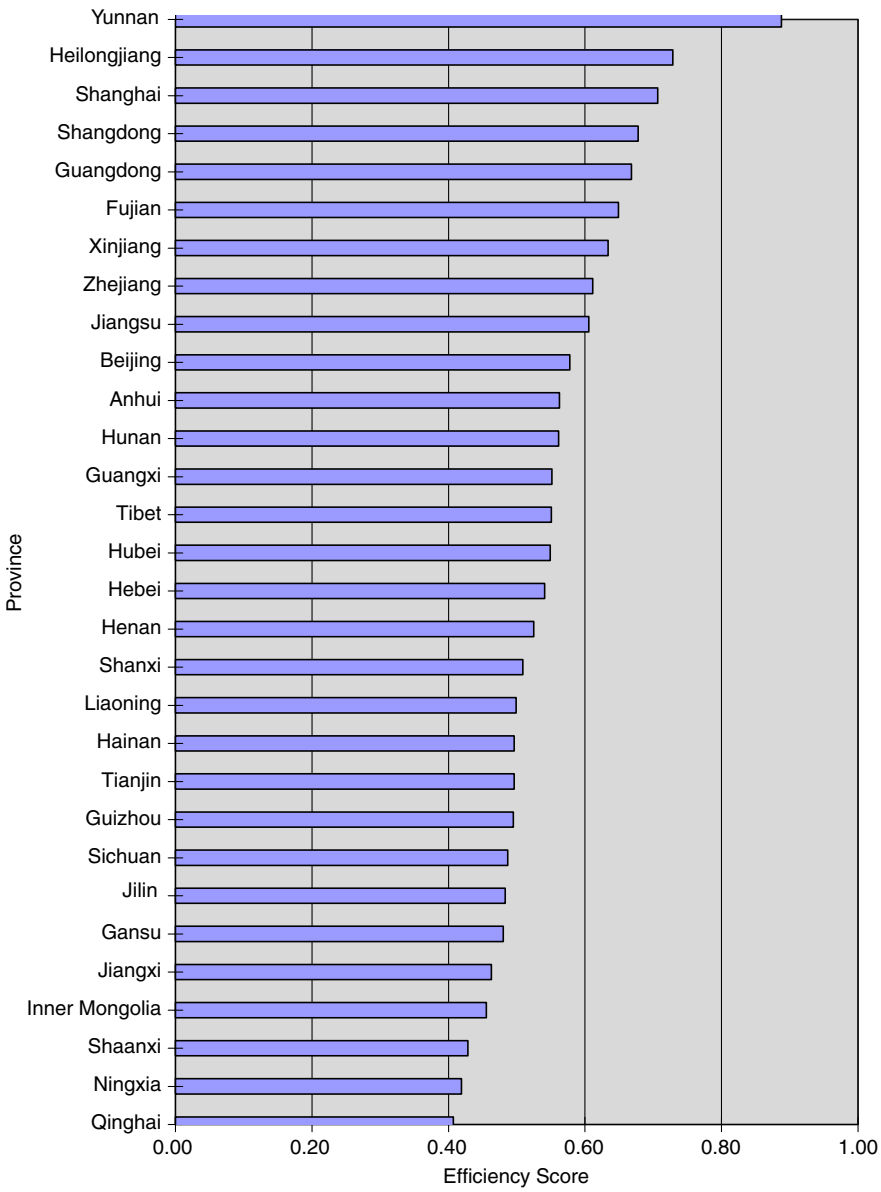

Fig. 1 Average PD efficiency by province for 1986–2003

Table 5 MPI and its components

Time	MPI	Efficiency change	Technological change
1986–1988	1.151	1.067	1.079
1988–1990	1.009	0.846	1.192
1990–1992	0.698	0.986	0.708
1993–1995	1.079	0.803	1.343
1995–1997	0.922	1.025	0.899
1998–2000	1.031	1.076	0.959
2000–2003	1.382	1.120	1.234
Average	1.016	0.983	1.036

The MPI values in 1990–1992 and 1995–1997 indicate that SOEs productivity declined. Values that were less than unity during these time periods seem to be in contradiction with the fact that the GDP growth rates were relatively high in the early 1990s. Nevertheless, this phenomenon may be explained partly by the huge and, in some instances, unnecessary investments that were made with little consideration of profitability during times of prosperity. As Table 1 showed, GDP growth rates were 14.2 and 13.5% in 1992 and 1993, respectively, while fixed assets grew at an astronomical rate of 44.4 and 61.8%, respectively. The excessive investment backfired when the economy slowed down; and SOE performance suffered as a consequence.

Table 5 shows that the efficiency change in MPI amounted to an average of 1.7% for the period of 1986–2003. The efficiency change in MPI measures whether production is moving closer to or farther away from the frontier between two time periods. When the ratio is less than one, the weighted average of the distance between the

efficiency frontier and those provinces not on the efficiency frontier becomes larger. Thus, the variation of SOE efficiency among provinces becomes larger. If the indicator is greater than one, the dispersion of SOE efficiency among provinces drops. The results of the efficiency change in Table 5 are similar to those of CS efficiency in Table 4. Note that a high (low) value of CS efficiency implies that the efficiency dispersion across different provinces were small (large). For example, CS efficiency was 0.8170 in 1986 and 0.8493 in 1988. The higher value in 1988 indicates that the dispersion of SOE efficiency among provinces was reduced between 1986 and 1988, which appears as 1.067 in Table 5. For the period of 1993–1995, the efficiency change in MPI was 0.803, implying a wider dispersion of SOE efficiency among provinces: CS efficiency was 0.7112 in 1993, falling to 0.5728 in 1995. Altogether, therefore, reforms and macroeconomic conditions impact efficiency changes in MPI in the same way as CS efficiency level, which was discussed above.

Technological changes in MPI showed an average increase of 3.6% between 1986 and 2003. Except 1998–2000, the technological change rates in those seven time periods were mostly consistent with the results of MPI. In 1986–1988 and 2000–2003, technological change (i.e., 1.079 and 1.234) and efficiency change (i.e., 1.067 and 1.120) both were major contributors of the impressive MPI values (i.e., 1.151 and 1.382). During these time periods, the prosperous economy and the reform greatly decreased the variations in efficiency among the provinces and rapidly moved production frontiers outward. Nevertheless, in 1986–1988 efficiency change and technological change were equally significant in their contribution to MPI, during 2000–2003 technological change was a much stronger driver of MPI performance than efficiency change. As for other time periods, the over-investment issue was one element keeping the values of the technological change below unity. For instance, the speeches that Deng Xiao-Ping gave in 1992 concerning the central government's support of the market-oriented economic system induced massive investments. The huge investment, to some degree excessive, led to a speedy drop of the technological change value to 0.708 in 1990–1992. The following government policy in restricting the investment growth brought the technological change back up to 1.343.

5 Conclusion

The empirical results of DEA and MPI provide the following new insights about SOE performance. SOEs performances could be divided into three stages. The first stage was in the late 1980s when SOEs, though still being regulated, were gradually given the responsibility in sharing their own operating profits and losses. The economy was prosperous and the incentives given to workers through the reform had positive impacts on SOE performance. The second stage was in the 1990s. Due to the development of a market-oriented economy, a gradually more competitive market reduced monopoly profits for most SOEs. In addition, whenever the economy became prosperous, there was the issue of excessive SOE investment, which had negative impacts on SOE performance. The third stage belongs to the years after 2000. Most SOEs entered the stage of privatization through mergers, reorganization and bankruptcy, while the remaining SOEs were natural monopolies or protective industries with high entry barriers. SOEs performed well during this time period.

SOE performance may be evaluated from two different dimensions: cyclical and systematic dimensions. First, we find that cyclical fluctuations appear to be closely related to SOE short-term performances. However, at different time points, the impacts were different. In the years that the economy was expanding with a higher growth rates, e.g., 1987–1988, 2000–2003, both PD efficiency and MPI showed an obvious increase from year-to-year. Though a prosperous economic environment is not a long-term determinant of SOE productivity, a favorable economy did enhance the results of a systematic reform. Nevertheless, the 1992–1993 over-investment brought a prosperous economy but impacted SOE performance negatively. Second, the impact of the systematic reform on SOEs' productivity was obvious during the time period after 2000. From the reform perspective, before 1998, the focus of the reform was on the subcontract system and modernizing the corporation system. Some of these reforms were initially implemented as pilot programs, which had smaller impacts on the economy than the cyclical factor. After 1998, the focus switched to operating-loss reduction. The implementation was to restructure SOEs through a huge lay-off of redundant workers. This reform was nationwide and the impact was significant. The operating loss did drop substantially from 1023 billion yuan in 1998 to 615.8 billion yuan in 2000. Due to the external Asia financial crisis, unfavorable economic environment negated the positive impacts of systematic reform. But mostly, SOE productivity still improved. Together with the reform in 2000–2003, which emphasized corporate governance, merger, reorganization and bankruptcy, SOE performance experienced obvious improvements, especially in the area of technological change.

As mentioned in Sect. 3.3, the Chinese government used certain financial indicators (e.g., SOEs' operating profit or loss) as measurement sticks to evaluate SOE efficiency. These measuring sticks gave the impression that SOE efficiency had declined quite sharply (Table 2). But a decline in financial indicators is not equivalent to a decline

in productivity or efficiency. Our results indicate that SOE performance did decline in the 1990s. However, the decline was not as pronounced as the decline of financial indicators alone. Thus, our method provides a different insight about SOE productivity and efficiency during the 18-year period of 1986–2003.

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