

Learning Effect and Productivity Convergence of Chinese Industrial Enterprises

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ABSTRACT

The main purpose of this paper is to test the production efficiency of different Chinese property industrial enterprises. Based on the large sample panel data of industrial enterprises of the National Bureau of Statistics, we found that although the production efficiency of China-funded enterprises is generally weaker than foreign-funded enterprises, some China-funded enterprises have better learning ability. On the one hand, dynamic analysis found that private enterprises have significant learning ability. On the other hand, the results of convergence analysis show that China's private enterprises have the potential to gradually catch up with the frontier level of world production efficiency and have better learning ability to catch up potential. And state-owned enterprises tend to be more efficient at the beginning of their establishment, but their productivity is fairly slow to improve, especially for state-owned enterprises with high efficiency sub-samples, so that it's hard for them to continue improving their efficiency. Institutional analysis found that the marketization process helped the China enterprises to improve their learning ability and China should continue to strengthen the reform of property rights and promote the marketization process.

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1. Introduction

Throughout the reform and opening up over the last thirty years, China has achieved rapid economic growth and created a “Chinese miracle” (Lin and Li, 2004; Syverson, 2010; Sun et al., 2013)^[1-3]. In terms of the GDP, China is already the second largest economic power in the world, but this does not literally mean that China is a well-developed country. Under the market economy system, the fundamental of national competitiveness lies in enterprise production efficiency. After the reform, China has established a modern enterprise system and implemented shareholding, but can China’s enterprises gradually approach or even catch up with the frontiers of multinational enterprises’ production efficiency? This issue needs an empirical analysis to answer.

Productivity is a key topic in the study of microeconomics. There are many empirical studies on the efficiency of Chinese enterprises. In the longitudinal development of time, Early literatures such as (Jefferson et al., 1992; Jingwen et al., 1992; Xiaolu, 2000)^[4-6] measured the production efficiency of Chinese enterprises from different angles, and found that the level of production efficiency of Chinese enterprises has been significantly improved since the reform and opening up. In the aspect of the horizontal country, some works found that there is still a big gap between the production efficiency of Chinese enterprises and foreign companies (Y. F. Huang and Ren, 2002; Zhu and Li, 2005)^[7-8]. But the above-mentioned literatures mainly analyze cross-section data, have not carried out dynamic research on panel data, nor discussed the change in the efficiency gap between the China production efficiency frontiers represented by China and multinational enterprises in the course of time development.

So investigating the data of listed companies, some works found that there is a big gap between Chinese enterprises and companies in Japan or Korea, showing a significant catch-up trend (Yuan, 2009; Jin, 2012)^[9-10]. Based on China’s industry data, and compared the efficiency trends of China and foreign-funded enterprises, the productivity of China-funded enterprises has increased year by year, while the productivity growth rate of foreign-funded enterprises has slowed down, and the gap between the two has been shrinking (Yan, 2008)^[11]. However, the number of listed companies in China is limited, so the sample of listed companies is difficult to represent Chinese enterprises. And as the sum of individual data of the enterprise, the industry data cannot distinguish the heterogeneity of the enterprise. Analyzed the productivity overtaking performance of different ownership enterprises based on labor productivity indicators, the labor produc-

tivity of Chinese enterprises has surpassed the trend (Yu et al., 2013)^[12]. However, the single factor productivity of labor productivity cannot fully measure the true efficiency level of enterprises. Moreover, (Yu et al., 2013)^[12] their research focuses on industry-level analysis, and the analysis of the efficiency of different ownership firms is still general. These studies either stay at the industry level or perform annual data analysis of cross-sections, therefore we need to use the big data from hundreds of thousands of companies collected by the National Bureau of Statistics for research. We need to study whether the efficiency of China’s state-owned holding enterprises has improved and the efficiency of private enterprises. Moreover, the existing literature on efficiency catching up has rarely discussed the learning ability of state-owned and private enterprises. And it is necessary to analyze whether the enterprises with different property rights in China have significant learning ability.

In the efficiency catch-up process, variety in the nature of ownership may lead to changes in different production efficiencies. There are many documents on the comparison of production efficiency between state-owned enterprises and private enterprises in China-funded enterprises. In the 1990s, private enterprises could constrain agency costs and improve production efficiency (W. Y. Zhang et al., 1995; X. X. Liu, 1995; Xie et al., 1995)^[13-15]. And state-owned enterprises have a policy burden which lead to an inefficiency in production (Lin and Zhou, 1997)^[16]. However, in recent years, modern enterprise systems have been established and corporate governance has begun to regulate. Analysis of the data obtained by the World Bank in 2003 on 1,483 companies in 18 cities in China, some works found that state-owned enterprises have more innovative inputs and outputs than private enterprises (Li and Song, 2010)^[17]. Analysis of the industry data collected by the National Bureau of Statistics of China from 2003 to 2010, some works found that the efficiency growth rate of state-owned enterprises in 21 industries is better than that of private industrial enterprises (Hao et al., 2012)^[18] and the article believes that state-owned industrial enterprises have better development vitality and potential.

The new institutional background prompted us to re-examine the efficiency of state-owned enterprises and private enterprises, and we need large sample enterprise data after the 1990s to re-examine the efficiency of state-owned private enterprises. More importantly, can the productivity of private enterprises catch up with foreign multinationals? We need to thoroughly compare the production efficiency of different types of property rights enterprises, and estimate the catch-up trend of state-owned and private enterprises. In addition, it is necessary to ana-

lyze and explore the learning ability of different types of enterprises.

This paper uses the industrial enterprise database of the National Bureau of Statistics of China to analyze the annual observation points of 2.07 million enterprises. Based on the data, this paper compares the production efficiency of different property rights enterprises, analyzes the efficiency learning ability of China and foreign enterprises under different efficiency levels, studies the property rights efficiency problems among regions with different degree of marketization, uses the convergence analysis method to predict the efficiency of Chinese enterprises to catch up with the potential and while paying attention to the efficiency differences and learning ability of newly established enterprises, has obtained a more comprehensive dynamic trend of China's enterprise efficiency. As a result, this article has certain contribution to the existing literature of property rights and the literature of surpassing. First of all, through the panel data regression of large samples, this paper puts forward the priority of production efficiency of different property rights enterprises, which are foreign capital, private and state-owned, this is the consolidation and corroboration of the existing literature. Secondly, this paper finds that private enterprises have significant learning ability, while state-owned enterprises are barely satisfactory, which is an in-depth study of existing literature from a dynamic perspective. Thirdly, this paper firstly applies the convergence analysis theory of economic growth to the comparison of ownership efficiency. Through the regression analysis of the conditional convergence equation to investigate the efficiency convergence rate and steady-state efficiency level of state-owned holding enterprises and private enterprises, it is found that China's private enterprises have certain catch up with potential. Finally, this paper analyzes the efficiency level and learning ability of newly established enterprises, partially answers the doubts about the efficiency improvement of state-owned enterprises in recent years, and deepens the existing research on the efficiency catching up.

2. The Basic Facts Description of Different Ownership Companies

The sample data we use is derived from the China National Bureau of Statistics' China Industrial Enterprise Survey Database, which includes statistical data on the annual data of all state-owned and non-state-owned industrial enterprises with sales of more than 5 million yuan. Since the data after 2008 involves the lack of statistical variables, in order to be rigorous, and the data of the large sample panel for ten years is enough to analyze our problems, the data

in this paper is selected as of 2007. By the end of 2007, the database had collected more than 300,000 enterprises in China, and its output value accounted for 95% of China's total industrial output value, which can be used as an effective sample for Chinese enterprises. During the period 1998-2007, our sample contained a total of 2,226,264 observations. Drawing on (Cai and Liu ,2009)^[19], we removed the missing key indicators, the number of employees less than 8 and the observation that obviously did not conform to the accounting principles, deleted the extreme observation values of key variables, and finally obtained 2,074,240 observation samples. Such a large sample can overcome the problem of additive deviation and sample selectivity deviation.

With regard to the classification of enterprise ownership, the existing literature is usually defined according to the type of enterprise registration. However, by comparing the two types of property rights, we find that the number of enterprises registered as foreign capital is higher than the number of enterprises registered as foreign capital. Between 1999 and 2007, 6% of the enterprises registered as foreign capital in China's industrial enterprise database had a capital value of 0 (Nie et al. ,2012)^[20]. According to the article, this error stems from registration errors, lack of timely changes in registration types, and deliberate fraud in order to enjoy tax benefits. In contrast, the type of holdings defined by paid-in capital can reflect the type of ownership of the firm more realistically and in a timely manner. Drawing on (Lu ,2008)^[21], this paper classifies enterprises with paid-in capital of foreign capital or Hong Kong, Macao and Taiwan shares of not less than 25% as foreign-funded enterprises (Foreign), and less than 25% of China-funded enterprises (China). According to whether the registered capital of China enterprises exceeds 50 %, the type of enterprise holding is defined, that is, state-owned enterprises (state) account for more than 50 % of the total registered capital, private enterprises (private enterprises) account for more than 50 % of the total registered capital, collective enterprises (collective enterprises) account for more than 50 % of the total registered capital, and other China enterprises uniformly define other enterprises. Table 1 reports the proportion of the number of firms with different ownership types, output and employment in the sample data.

Table 1 shows that in terms of the number of enterprises, output and employment, state-owned enterprises have shown a decreasing trend year by year. The number of state-owned enterprises has shrunk from 30.3% in 1998 to 3.3% in 2007, the proportion of output has decreased from 38.2% to 12%, and employment has decreased from 50.2% to 12.2%. In contrast, the proportion of private

enterprises has increased year by year. In 2001, the number of private enterprises accounted for 28%, becoming the highest among all kinds of enterprises; in 2004, the number of jobs exceeded state-owned enterprises for the first time; in 2005, the proportion of output exceeded that of state-owned enterprises. These figures confirm the fact that in recent years, China's private enterprises have grown and the state-owned enterprises have quit continuously, that is, "the state-owned deteriorating with the private-owned advancing." From the perspective of foreign-funded enterprises, since 1998, both the number of enterprises, output and employment have shown an upward trend. Since 2005, business Numbers and output have fallen, but employment has not.

Overall, the average share of foreign-invested enterprises is less than one-fifth (18.3%) of the total society, while the average output is as high as 30%. This is not only the result of an open policy, but also a manifestation of the competitiveness of foreign-funded enterprises. Although the number of state-owned enterprises has dropped significantly, they have assumed an average of 27.4% of employment; to a certain extent, this reflects the policy burden of state-owned enterprises. The average number of private enterprises in China accounts for 37.4%, which is the highest among all types of enterprises, but the average output is one-fifth of the whole society. This means that the scale of private enterprises is small, and their

output capacity still has a certain gap compared with foreign-funded enterprises.

On average, state-owned enterprises have the highest labor input, and private enterprises have the highest capital investment, but the output levels of the two are far lower than those of foreign-funded enterprises. In this regard, we initially concluded that the production efficiency of China-funded enterprises may be lower than that of foreign-funded enterprises. The data will be analyzed by regression below.

3. Efficiency Gap between Different Property Rights Enterprises

Numerous literatures believe that total factor productivity (TFP) is the best measure of the productivity level of Chinese enterprises (Mao and Sheng, 2013; Gao et al., 2014; Sui et al., 2017)^[22-24]. Based on the classical literature (Christensen et al., 1973)^[25] and the data characteristics of this paper, we use the trans-log production function to estimate total factor productivity. This paper argues that total factor productivity is influenced by property rights factors, so the ownership independent variable is included in the trans-log production function. This approach can clearly compare the level of productivity of different ownership companies (Sabirianova et al., 2005)^[26]. The specific model settings are as follows:

Table 1. Statistics on the quantity, output, and employment of enterprises with different ownership

| | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | Average |
|----------------------------|------|------|------|------|------|------|------|------|------|------|---------|
| Proportion of quantity (%) | | | | | | | | | | | |
| Foreign | 15.4 | 16.4 | 17.3 | 18.1 | 18.1 | 18.8 | 19.8 | 19.5 | 18.8 | 18.3 | 18.3 |
| Private | 13.4 | 15.3 | 20.8 | 28.0 | 33.7 | 38.7 | 44.2 | 45.5 | 47.8 | 48.7 | 37.4 |
| State | 30.3 | 28.2 | 23.6 | 18.7 | 15.4 | 11.7 | 7.8 | 6.1 | 4.81 | 3.3 | 12.2 |
| Collective | 27.6 | 25.7 | 22.0 | 17.7 | 14.5 | 10.5 | 8.1 | 5.99 | 5.16 | 4.3 | 11.7 |
| Others | 13.2 | 14.4 | 16.3 | 17.4 | 18.4 | 20.4 | 20.2 | 23.0 | 23.4 | 25.5 | 20.4 |
| Output ratio (%) | | | | | | | | | | | |
| Foreign | 22.0 | 24.1 | 25.9 | 27.8 | 28.5 | 30.0 | 32.9 | 31.5 | 31.9 | 30.5 | 30.1 |
| Private | 6.2 | 7.3 | 9.8 | 12.8 | 15.3 | 18.0 | 18.0 | 21.9 | 23.6 | 25.3 | 19.2 |
| State | 38.2 | 38.9 | 34.9 | 31.0 | 26.6 | 23.3 | 20.5 | 16.2 | 13.8 | 12.0 | 20.4 |
| Collective | 15.7 | 13.9 | 11.5 | 9.5 | 8.0 | 6.33 | 5.5 | 4.0 | 4.0 | 3.7 | 6.2 |
| Others | 18.0 | 15.8 | 17.9 | 18.9 | 21.6 | 22.4 | 23.1 | 26.5 | 26.7 | 28.5 | 24.1 |
| Employment share (%) | | | | | | | | | | | |
| Foreign | 12.3 | 14.5 | 16.2 | 18.3 | 19.1 | 21.7 | 25.7 | 26.6 | 27.8 | 28.0 | 21.8 |
| Private | 6.8 | 8.3 | 11.6 | 16.1 | 19.5 | 23.2 | 26.6 | 27.9 | 29.1 | 30.0 | 21.0 |
| State | 50.2 | 46.7 | 40.8 | 34.9 | 30.7 | 25.6 | 19.7 | 16.4 | 14.0 | 12.2 | 27.4 |
| Collective | 17.9 | 16.7 | 14.8 | 12.7 | 11.1 | 8.2 | 6.8 | 4.9 | 4.64 | 4.2 | 9.5 |
| Others | 12.7 | 13.9 | 16.5 | 18.1 | 19.6 | 21.4 | 21.2 | 24.2 | 24.4 | 25.6 | 20.3 |
| Sample(ten thousand) | 13.4 | 14.4 | 14.7 | 15.5 | 16.7 | 18.5 | 26.2 | 26.0 | 29.1 | 32.8 | 20.7 |

$$\ln Y_{it} = \beta_0 + \sum_k \beta_k \ln x_{ikt} + \frac{1}{2} \sum_k \sum_l \gamma_{kl} \ln x_{ikt} \ln x_{ilt} + \rho Z_{it} + \delta I_{it} + \zeta T_t + v_i + \varepsilon_{it}$$

Among them, Y_{it} represents the output of the i enterprise in the t period, x_{ikt} is the input of k elements, Z_{it} is the ownership classification, I_{it} and T_t are the virtual variables of the industry and the year in which the enterprise is located. v_i is an individual effect that can not be observed without changing time. ε_{it} is a random disturbance term. Specifically, this paper uses industrial value added to measure the output variables, and uses the factory price index of industrial products in various industries to reduce, and then get the adjusted price index Y_{it} . The China Statistical Yearbook provided 38 industrial product ex-factory price indices in 2002-2007, but only provided industrial production ex-factory indices for 14 production sectors during 1998-2001. For the sake of consistency, we have mapped 39 double-digit industry indices to 14 industrial production sectors and converted them into the factory price index for industrial products based on 1997. Due to the absence of industrial added value in the industrial database of the National Bureau of Statistics in 2001 and 2004 during the sample period, we used (X. X. Liu and Li ,2008)^[27] methods to make relevant adjustments. The industrial added value used in this paper in 2001 is the total industrial output value minus the input of intermediate goods plus VAT. The industrial added value in 2004 equals the sales income plus the initial inventory minus the input of intermediate goods plus VAT. In the measurement of input factors, we use the annual average balance of fixed assets to measure the capital input factors, and use the fixed asset price index based on 1997 to reduce; we use the annual employment of employees to measure the labor input factors; We use the intermediate product input as an intermediate input factor, and use the raw material, fuel, and power purchase price indices to reduce. This method is similar to (Wang and Tu ,2008;Qi et al. ,2008)^[28-29].

Equation (1) can be simplified to the following model:

$$\ln Y_{it} = \beta X_{it} + \rho Z_{it} + v_i + \varepsilon_{it} \tag{2}$$

Where X is the input element vector and the dummy variable of the industry and year, and Z is the ownership classification variable, $E(v_i) = E(\varepsilon_{it}) = E(v_i, \varepsilon_{it}) = E(\varepsilon_{it}, \varepsilon_{is}) = 0$ (for any $t > s$).

Z is the object of this study. In view of the space, we omitted the report on X in the following table. In terms of measurement methods, we believe that potential owners may adjust the type of ownership based on past production efficiency shocks. That is to say, in equation (2) the ownership variable is a “pre-determined variable”, is

$E(Z_{it}, \varepsilon_{it}) = 0$, but $E(Z_{it}, \varepsilon_{is}) \neq 0$ (for any $t > s$), $E(Z_{it}, v_i) \neq 0$. In the case of this causal problem, the use of ordinary least squares and random effects models can lead to biased estimates. In contrast, fixed effects or first-order differences allow Z_{it} to be related to v_i , so fixed-effect regression methods are more feasible. However, it is important to note that the key variable in the model—ownership—is a relatively stable variable that has no change or limited variation over time. If fixed effect estimates are used, it will result in a larger estimate bias (Griliches and Hausman,1984)^[30]. Therefore, after weighing the comparison, we think that it is more suitable to use the random effects model, so the analysis in this paper is mainly based on the regression results of random effects.

Table 2 shows the comparison results of production efficiency of different ownership enterprises. The relative value between production efficiency of different types of enterprises is obtained by regression model (1). State-owned enterprises are the benchmark group, and other types of ownership include foreign-funded enterprises and private enterprises. In order to obtain more robust results, regression results of ordinary least squares (OLS), median regression (QREG), and random effects (RE) were also reported. Among them, OLS is the least squares regression using the robust variance method to control the heteroscedasticity between individuals, abbreviated as OLS_Robust. In terms of measurement methods, Table 2 illustrates the consistency of results for multiple methods in oversized samples.

Table 2. Comparison of average production efficiency of different ownership companies

| | OLS_Robust | QREG | RE |
|------------------------|------------|-----------|-----------|
| Foreign | 0.997*** | 0.881*** | 0.806*** |
| | (0.004) | (0.003) | (0.004) |
| Private | 0.899*** | 0.777*** | 0.715*** |
| | (0.003) | (0.003) | (0.004) |
| No. of obs | 1,408,381 | 1,408,381 | 1,408,381 |
| No. of firms | 463,864 | 463,864 | 463,864 |
| R ² | 0.582 | | |
| Pseudo R ² | | 0.361 | |
| Within R ² | | | 0.210 |
| Between R ² | | | 0.574 |
| Overall R ² | | | 0.580 |

Note: The values in parentheses are the standard deviation of the coefficients, ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively. State-owned enterprises (State) are the benchmark groups.

In the use of different methods, Table 2 finds that the two property rights coefficients of Foreign and Private are significantly positive. This means that compared with state-owned enterprises, the level of production efficiency of foreign-funded enterprises and private enterprises is significantly higher than that of state-owned enterprises. Table 2 further illustrates that the coefficient of Foreign is about 10 percentage points higher than Private. This means that the level of production efficiency of foreign-funded enterprises is higher than that of private enterprises. The World Bank’s data on the survey of a small number of enterprises in China, and also obtained the same results (Xu ,2004)^[31]. This paper believes that the priority of China’s enterprise efficiency level is foreign-funded enterprises, private enterprises and state-owned enterprises.

Equations 1 and 2 apply to the efficiency comparisons of different companies, but do not report productivity values. In order to observe the level of productivity of different types of companies, we use Levinsohn and Petrin (hereinafter referred to as LP method) to measure firm productivity in Table 3(Levinsohn and Petrin ,2003)^[32]. This method puts the intermediate product into a proxy variable for productivity shock, making the calculation result more accurate than using the production function method. In China’s corporate efficiency research literature, (Gong and Hu,2013)^[33] and others also adopted this method.

Table 3 reports the productivity levels of the three types of firms. We found that foreign-invested enterprises are higher than China-funded enterprises, regardless of whether they are average or median, and private enterprises in China capital are higher than state-owned enterprises.

Table 3. Actual TFP values (LP method)

| | Obs. | Mean | P50 | Sd. | Min | Max |
|---------|--------|------|------|------|-------|------|
| Foreign | 380175 | 7.05 | 6.98 | 1.25 | -3.24 | 15.1 |
| Private | 774980 | 6.72 | 6.66 | 1.05 | -2.15 | 12.8 |
| State | 253226 | 5.98 | 6.04 | 1.72 | -2.65 | 14.4 |

There are a large number of companies in China. Not only is the mean and median of productivity levels important, but the distribution of productivity is also needed to be studied. In fact, the distribution of productivity levels has become the focus of economic growth theory in recent years (Syverson,2010; Sun et al.,2013)^[2-3]. Table 4 ranks all enterprises in the National Bureau of Statistics industrial enterprise database according to the an-

nual efficiency level, with the 33rd and 66th percentiles as the demarcation point, According to different years, the samples were divided into three groups: low efficiency, medium efficiency and high efficiency, and then the distribution of enterprises with different ownership types in different efficiency groups was obtained. We found that about 44% of foreign-invested companies are in the high-efficiency group, and 47% of the state-owned enterprises are in the low-efficiency group, accounting for the highest proportion among the high-efficiency group and the low-efficiency group, private enterprises are between foreign-invested enterprises and state-owned enterprises in different efficiency groups, and the distribution is relatively uniform. This once again confirms the superior order of property rights of China’s enterprise efficiency level, from high to low for foreign capital, private and state-owned.

Table 4. Distribution of production efficiency of enterprises (Unit: %)

| | low | medium | high |
|---------|------|--------|------|
| Foreign | 23.3 | 32.5 | 44.2 |
| Private | 33.5 | 36.9 | 29.6 |
| State | 47.9 | 23.6 | 28.5 |

Since the reform and opening up, China’s economic system has changed dramatically, including the modern enterprise system. In the process of institutional changes, have the levels of production efficiency of enterprises with different property rights in China changed? In November 2002, the 16th National Congress of the Communist Party of China clearly put forward policies such as “deepening the reform of the state-owned assets management system and improving the quality and level of foreign capital utilization”; in 2003, the establishment of the State-owned Assets Supervision and Administration Commission also marked the deepening of the reform of China’s state-owned enterprises. The modern enterprise system in China was initially established. (Fan et al.,2011)^[34] found that The marketization process was slow during 1998-2002, and the marketization process accelerated in 2003-2007. Therefore, Table 5 uses 2002 as the demarcation point to divide the sample data into two time periods. We used random effects and quantile regression methods for regression, RE regression results measured the average efficiency level, and Quantile measured different quantile levels. Among them, the first column and the third column are based on state-owned enterprises (state), and the second column is based on private enterprises.

Table 5. Comparison of property rights efficiency in different time periods

| | Foreign-State | Foreign-Private | Private-State |
|-----------|---------------|-----------------|---------------|
| 1998-2002 | | | |
| RE | 0.988*** | 0.104*** | 0.884*** |
| | (0.006) | (0.006) | (0.005) |
| Quantile | | | |
| 10 | 1.552*** | -0.063*** | 1.615*** |
| | (0.008) | (0.006) | (0.011) |
| 50 | 1.027*** | 0.108*** | 0.919*** |
| | (0.006) | (0.003) | (0.006) |
| 90 | 0.876*** | 0.278*** | 0.598*** |
| | (0.005) | (0.004) | (0.005) |
| 2003-2007 | | | |
| RE | 0.723*** | 0.087*** | 0.636*** |
| | (0.014) | (0.008) | (0.013) |
| Quantile | | | |
| 10 | 1.093*** | -0.027* | 1.120*** |
| | (0.032) | (0.014) | (0.032) |
| 50 | 0.615*** | 0.104*** | 0.511*** |
| | (0.014) | (0.009) | (0.014) |
| 90 | 0.537*** | 0.180*** | 0.357*** |
| | (0.022) | (0.009) | (0.027) |

Note: The values in parentheses are the standard deviation of the coefficients, ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively.

In the first column of Table 5, we report on the efficiency of foreign-invested companies relative to state-owned enterprises. Both the RE and Quantile's Foreign-State regression results were significantly positive, with the largest regression coefficient in the 10-digit range. This shows that the efficiency level of foreign-funded enterprises is significantly higher than that of state-owned enterprises. This gap exists in the comparison of different quantiles, and the gap in the inefficient group is the largest.

Comparing the two periods 1998-2002 and 2003-2007, we found that the difference in the latter period is smaller than the previous period. In the RE regression, the efficiency of foreign-invested enterprises over state-owned enterprises has shrunk from 0.988 before 2002 to 0.723 after 2002. The three quantile regression also showed similar results, and the gap between the foreign countries with low efficiency levels has narrowed more significant. This means that as time goes by, the efficiency gap between state-owned enterprises and foreign-funded enterprises has a significant narrowing trend.

In the second column of Table 5, we report the efficiency of foreign-invested companies relative to private en-

terprises. Unlike the results of the first column, the decile return of the Foreign-Private gap is significantly negative. This means that private enterprises are better than foreign companies at low efficiency levels. However, at other efficiency levels, the gap coefficient between foreign and private enterprises is significantly positive, indicating that there is a gap between private and foreign-funded enterprises at other efficiency levels, especially at high efficiency levels. In a vertical comparison, the gap between foreign capital and private enterprises has narrowed with time, and the higher the efficiency, the faster the group gap narrows.

The third column of Table 5 compares the efficiency between private and state-owned enterprises in China-funded enterprises. We find that the private-owned and state-owned enterprises (Private-State) are significantly positive at different levels. This again shows that the efficiency of state-owned enterprises is lower than that of private enterprises in different distributions. In the time-segment comparison, the gap between private and state-owned enterprises is smaller than the previous period in the latter period; this means that the production efficiency of state-owned enterprises in China has increased.

In order to better demonstrate the distribution of relative productivity and the specific advantages of using large data samples, similar to the three subdivisions of the above efficiency levels, we divide the data into 100 sample groups based on the percentiles, and then return them one by one. The regression coefficients are made in Figures 1 and 2. The abscissa indicates the different quantile level, and the ordinate is the corresponding regression coefficient at different quantile levels. The reference group is the state-owned enterprise, and the corresponding ordinate is 0. Figures 1 and 2 show the relative efficiency trends of different types of firms at different quantile levels over two time periods. It can be seen from the two figures that foreign-invested enterprises and private enterprises are higher than the benchmark group of state-owned enterprises at different quantile levels. Among high-efficiency enterprises, foreign-funded enterprises are obviously in a leading position; however, among low-efficiency enterprises, private enterprises in China are superior to foreign-funded enterprises. In the comparison of different time periods in Figure 1 and Figure 2, we find that the gap between state-owned enterprises and foreign-funded enterprises has narrowed from 0.9-1.9 in the period of 1998-2002 to 0.5-1.4 in the period of 2003-2007. The efficiency gap with foreign-funded enterprises and private enterprises has also shrunk, and the efficiency gap has narrowed.

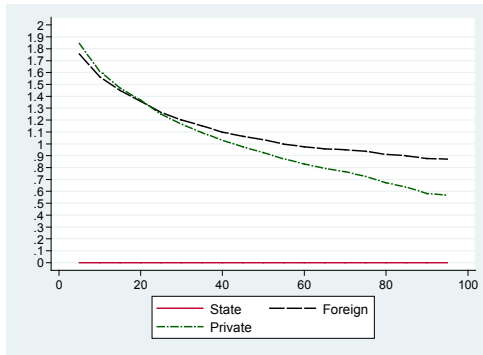


Figure 1. Comparison of relative efficiency (1998-2002)

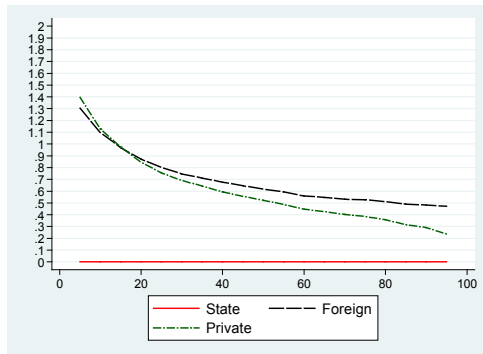


Figure 2. Comparison of relative efficiency (2003-2007)

4. The Analysis of Corporate Learning Ability

The staged regression analysis shows that there is a significant narrowing of the efficiency gap between China and foreign-funded enterprises. Relatively speaking, foreign-funded enterprises are relatively efficient, and the formation of this catch-up trend comes from the learning ability of China-funded enterprises. Due to the existence of “learning while working”, enterprise productivity may increase with the growth of the company’s establishment period, but some enterprises may also decline in efficiency due to obedience. In the existing variables of the industrial enterprise database, it is difficult to accurately describe the learning ability (Zhou et al., 2007)^[35]. However, the efficiency of the company may be improved over time, we can define the company’s ability to learn to improve production efficiency. In this section, how will the production efficiency of enterprises with different property rights change as the age of the enterprise grows? What are the learning abilities of different types of China companies?

On the basis of the model (2), we added the interaction term of the ownership categorical variable and the time trend term τ to get the equation 3.

$$\ln Y_{it} = \beta * X_{it} + \rho * Z_{it} + \zeta * \tau * Z_{it} + v_i + \varepsilon_{it} \quad (3)$$

Where τ is the time during which the enterprise has a certain ownership duration. In order to examine the trend of enterprise efficiency in the sample period with the length of ownership duration and to compare the learning ability of different property companies, Table 6 excludes companies whose ownership changes during the sample period.

Table 6. Comparison of learning ability

| | RE | QREG(10) | QREG(50) | QREG(90) |
|------------------------|-----------|----------|----------|-----------|
| Foreign | 1.068*** | 1.597*** | 0.984*** | 0.735*** |
| | (0.006) | (0.008) | (0.005) | (0.009) |
| Private | 0.916*** | 1.674*** | 0.867*** | 0.469*** |
| | (0.005) | (0.008) | (0.005) | (0.008) |
| τ * Foreign | -0.001 | 0.037*** | 0.020*** | 0.007*** |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| τ * Private | 0.031*** | 0.044*** | 0.035*** | 0.023*** |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| τ * State | -0.006*** | 0.047*** | 0.025*** | -0.006*** |
| | (0.001) | (0.002) | (0.001) | (0.002) |
| No. of obs | 1303144 | 1303144 | 1303144 | 1303144 |
| No. of firms | 442237 | 442237 | 442237 | 442237 |
| R ² | | | | |
| Pseudo R ² | | 0.339 | 0.360 | 0.411 |
| Within R ² | 0.212 | | | |
| Between R ² | 0.571 | | | |
| Overall R ² | 0.582 | | | |

Note: The values in parentheses are the standard deviation of the coefficients, ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively. State-owned enterprises (State) are the benchmark groups.

In Table 6, the foreign-invested foreign coefficient and the private-sector Private are significantly positive under different regression methods, and the efficiency is higher than that of the state-owned enterprises as the benchmark group. In the mean RE regression, the median QREG (50) regression, and the high efficiency group QREG (90) regression, the Foreign coefficient is higher than Private. Table 6 again confirms that the priority of property rights efficiency is foreign capital, China capital and state ownership. However, in the low efficiency group QREG (10) regression, the Private coefficient is higher than Foreign. This means that private companies are more efficient than foreign companies in the distribution of low-equity efficiency 10-digits.

In Table 6, the crossover coefficient of the time trend term is used to measure the efficiency of enterprises with different ownership types over time, and can test

the learning ability of enterprises to a certain extent. The results show that both the time trend term and the private enterprise's coefficient τ * Private are significantly positive, regardless of the average level or the quantile level. This means that private enterprises have significant learning ability and efficiency is constantly improving. Moreover, the time trend item and the coefficient of private enterprises τ * Private are higher than the time trend item and the coefficient of foreign-funded enterprises τ * Foreign, which indicates that the learning ability of private enterprises is generally higher than that of foreign-funded enterprises. It should be noted that the learning ability of private enterprises at a high efficiency level is 0.023, which is much higher than that of foreign-funded enterprises. This shows that the learning ability of private enterprises at the high-end efficiency level is particularly prominent compared with foreign-funded enterprises. This is consistent with the conclusion that the gap between the private enterprises found above and the foreign-funded enterprises at the high efficiency level is the largest. In Table 6, the coefficient of τ *State is different in the OLS_Robust regression method from the RE regression method, and there is a contradiction. This means that the learning ability of state-owned enterprises is not stable. To some extent, the quantile regression shows the reason for this instability. In the median QREG (50) regression and the low efficiency group QREG (10) regression, the time trend term is significantly positive with the state firm's coefficient τ * State; but in the high efficiency group QREG (90) regression, τ * State is significant negative. This means that state-owned enterprises have significant learning ability at medium and low efficiency levels, and they are lagging behind in the high efficiency group or have a downward trend. This means that the performance and efficiency of some high-end state-owned enterprises in China are difficult to continue to improve, but may be self-sufficient and gradually decline. In summary, Chinese-funded enterprises have certain learning abilities, and high-end private enterprises have the potential to catch up with the frontiers of production efficiency.

This paper agrees that property rights are not the only input factors that affect learning ability, and the institutional environment also has important influences (S. J. Liu and Li, 1998)^[36]. The advancement of marketization process can optimize resource allocation and promote the improvement of enterprise production efficiency (Fang, 2006)^[37]. Institutional changes in the process of marketization have promoted technological spillovers of foreign capital (Jiang and Zhang, 2008; H. Y. Zhang, 2008)^[38-39]. Then, with the development of the marketization process, will the learning ability of Chinese enterprises be im-

proved, and can the catch-up process be accelerated?

The regional marketization index measured by (Fan et al., 2011)^[34] is a quantitative indicator used by most recent institutional studies. The index comprehensively measures the marketization process from the aspects of government-market relations, non-state-owned economic development, product market development, factor market development, market intermediary organization development and legal system environment. This paper sorts the average marketization process index of each region from 1998 to 2007, and marks them as high, medium and low in the marketization process. Then, according to Equation 4, each group is regressed to test the difference in learning effects of enterprises under different institutional backgrounds.

Table 7. Analysis of enterprise learning ability under different institutional backgrounds

| | Low marketization process | Medium marketization process | High marketization process |
|------------------|---------------------------|------------------------------|----------------------------|
| Foreign | 1.077*** (0.029) | 0.953*** (0.015) | 0.975*** (0.007) |
| Private | 0.739*** (0.017) | 0.801*** (0.010) | 0.847*** (0.007) |
| τ *Foreign | -0.040*** (0.005) | -0.012*** (0.003) | 0.012*** (0.001) |
| τ * Private | 0.003 (0.004) | 0.055*** (0.002) | 0.031*** (0.001) |
| τ *State | -0.042*** (0.003) | -0.025*** (0.002) | 0.008*** (0.001) |
| No. of obs | 106,435 | 279,148 | 917,561 |
| No. of firms | 37,692 | 104,772 | 299,798 |

Note: The values in parentheses are the standard deviation of the coefficients, ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively. State-owned enterprises (State) are the benchmark groups. τ is the duration of the company in the different years of the sample period.

Table 7 reports on the learning capabilities of companies in different institutional contexts. The time trend item and the coefficient of the private enterprise τ * Private is 0.055 in the marketization process and 0.031 in the high zone. This means that private enterprises have significant learning ability in high marketization process areas, which indicates that the improvement of marketization process is conducive to the improvement of production efficiency of private enterprises. That is to say, with the development of marketization, the treatment enjoyed by private enterprises in investment and financing is gradually fair. These institutional environments are conducive to the development of private enterprises and the improvement of efficiency levels. Simi-

larly, in the high-subsample regression of the marketization process, the time trend term and the coefficient of the state-owned enterprise τ * State are significantly positive. That is to say, the efficiency of state-owned enterprises in areas with high marketization progress has also increased significantly. Marketization has reduced the market information held by the government and strengthened the competition faced by state-owned enterprises (Guo and Yao, 2004)^[40]. Competition can urge state-owned enterprises to improve effectiveness without changing property rights (Megginson and Netter, 2001)^[41]. Marketization can gradually weaken the credit constraints of state-owned enterprises, and the weakening of soft budget constraints can help improve production efficiency (L. W. Huang and Yao, 2007)^[42]. In the process of marketization, the capital allocation efficiency of China's state-owned industrial enterprises has gradually increased (Fang, 2007)^[43]. However, in the middle and low areas of the marketization process, state-owned enterprises are declining in efficiency due to various issues such as their monopoly status, soft budget constraints and government support. Foreign-invested enterprises also benefit from the marketization process. In the high zone, the τ * Foreign coefficient is significantly positive, but lower than the private enterprise τ * Private. This means that in areas with a high degree of marketization in China, private enterprises have higher learning ability than foreign-funded enterprises, and there is a trend of catching up with production efficiency. In general, the institutional environment in which the marketization process is gradually improved is more conducive to enterprises to improve their production efficiency. Therefore, this paper believes that market-oriented reform is an important source of productivity improvement for Chinese enterprises. The above compares and analyzes the changes in the efficiency of China's corporate property rights, and believes that the efficiency of China's China enterprises has improved. However, it has not directly analyzed whether China ally-funded enterprises can catch up with foreign-funded enterprises in the long run and gradually reach the frontier of world production efficiency. This section applies the convergence analysis method of economic growth to calculate the average efficiency steady state level and convergence speed between internal and foreign-funded enterprises, so as to study the efficiency convergence between different ownership enterprises. This will help to understand whether China companies have the potential to catch up productivity compares with others.

According to the data characteristics and research purposes, we apply the conditional β convergence model proposed by (BarroR. and SalaiMartinX, 2004)^[44], and set the dynamic condition convergence model as follows:

$$\ln tfp_{it} = \kappa Z_{it} + \eta \ln tfp_{it-1} Z_{it} + \delta I_{it} + \nu P_t + \mu_{it} \quad (4)$$

Among them, tfp_{it} is the production efficiency of the enterprise, and is calculated by the industry using the LP method. Z_{it} is the ownership variable (including Foreign and Private), κ measures the steady-state efficiency level of firms of different ownership types, and η represents the speed at which different types of ownership firms converge to their respective steady-state levels. The calculation of the specific convergence rate β is a negative value of the natural logarithm of η ; that is, when $\ln tfp_{t-1}$ is negative, the firm exhibits steady state convergence (see Appendix for the derivation process). I_{it} represents industry dummy variables that control industry-specific effects (eg, technical levels) affecting steady-state levels, and P_t is an annual variable. Equation (4) allows for differences in the steady state efficiency levels and the respective convergence speeds of firms of different ownership types.

Table 8. Conditional (β) Convergence Parameters for Enterprises of Different Ownership Types

| | OLS_Robust | QREG | RE |
|---------------------------|------------|-----------|-----------|
| Foreign | 1.231*** | 0.982*** | 1.196*** |
| | (0.019) | (0.010) | (0.012) |
| Private | 1.217*** | 0.874*** | 1.174*** |
| | (0.017) | (0.010) | (0.012) |
| $\ln tfp_{t-1}$ | 0.875*** | 0.947*** | 0.875*** |
| | (0.002) | (0.001) | (0.001) |
| $\ln tfp_{t-1}$ * Foreign | -0.137*** | -0.118*** | -0.136*** |
| | (0.003) | (0.001) | (0.002) |
| $\ln tfp_{t-1}$ * Private | -0.146*** | -0.110*** | -0.144*** |
| | (0.002) | (0.001) | (0.002) |
| Constant term | 0.926*** | 0.487*** | 0.796*** |
| | (0.045) | (0.036) | (0.009) |
| R ² | 0.645 | | |
| Pseudo R ² | | 0.451 | |
| Within R ² | | | 0.639 |
| Between R ² | | | 0.639 |
| Overall R ² | | | 0.646 |
| Obs. | 867,478 | 867,478 | 867,478 |

Note: The values in parentheses are the standard deviation of the coefficients, ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively, and the state-owned enterprise (State) is the baseline group. The explanatory variable is the productivity in the form of ln, and tfp is the productivity in the first phase. In the IV-robust regression, dfp (the difference between the second phase of the productivity and the third phase of the lag) is used as the instrumental variable of tfp . The benchmark group is state-owned and controls industry and annual effects.

The first three columns of Table 8 report the results of us-

ing OLS_Robust, QREG median regression, and RE random effects, respectively. The Foreign and Private coefficients obtained by different regression methods are significantly positive, indicating that the steady-state efficiency levels of different property rights enterprises are different. The steady-state efficiency values of foreign-funded enterprises and private enterprises are significantly higher than those of state-owned enterprises. However, the regression coefficient of Foreign is only slightly larger than Private, indicating that the gap between the steady-state efficiency of private enterprises and foreign-funded enterprises is not significant. Among the different regression methods, the coefficient of foreign-funded enterprises $\ln tfp_{t-1} * \text{Foreign}$ and private enterprises $\ln tfp_{t-1} * \text{Private}$ is significantly negative, which means that foreign-funded enterprises and private enterprises tend to converge toward their respective steady-state efficiency levels, but private enterprises converge faster. This is consistent with the strong learning ability of private enterprises found in Table 6. In the long run, private enterprises have the potential to catch up with efficiency. However, the coefficient of $\ln tfp_{t-1}$ is significantly positive, meaning that state-owned enterprises have not converge to their lower steady-state levels. What is the reason?

5. Efficiency Analysis of Newly Established Enterprises

One of the solutions to interpret the above problems is to study the efficiency of newly established companies. This paper recognizes the problems caused by the statistics of the industrial enterprise database of the National Bureau of Statistics. The newly entered enterprises are not necessarily newly established enterprises. We selected the companies that were established during the sample period, that is, the opening time of the company is equal to the screening method of the year, and we got a subsample of 47,052 newly established companies. Although the number of newly established state-owned enterprises is the least, 30.4% of them are distributed in the high-efficiency group; although the number of newly established private enterprises is large, the distribution of high-efficiency groups is only 15.2%.

Table 9 reports on the comparison between the newly established enterprises and the productivity of the incumbents. We found that the production efficiency of newly established state-owned enterprises is significantly higher than the state-owned enterprises in place at different efficiency levels. This may be an important reason for the difficulty of state-owned enterprises to converge to their own steady state. We further found that the newly established private enterprises are significantly lower than the

private enterprises in place. Table 8 shows that private enterprises can converge to their own higher steady-state levels, which should be partly derived from the learning ability of newly established enterprises. We will examine it in Table 11. The gap between the newly established state-owned enterprises and foreign-invested enterprises reported in the lower half of Table 10 is smaller than the gap between the incumbent state-owned enterprises and foreign-invested enterprises. The gap between newly established private enterprises and foreign-funded enterprises has expanded compared with the incumbent enterprises. The gap between the newly established state-owned enterprises and private enterprises has been significantly reduced at different levels of efficiency, and is very close to private enterprises in the high efficiency group. This further illustrates that the newly established state-owned enterprises are significantly more efficient than the state-owned enterprises, while the newly established private enterprises are less efficient than the private enterprises in place. Table 10 also shows that the new foreign-funded enterprises are significantly lower than the in-transit foreign-invested enterprises in the low-efficiency level, and there is no significant difference in the medium and high efficiency levels. The efficiency level of foreign-funded enterprises is not high when they are newly established. This is related to the establishment of preferential policies for foreign-invested enterprises to enjoy super national treatment (Mao and Sheng, 2013)^[19].

Table 9. Efficiency gap of newly established enterprises

| Newly established company - Incumbent enterprise | | | |
|--------------------------------------------------|---------------|-----------------|---------------|
| | Foreign | Private | State |
| Quantile 10 | -0.132*** | -0.093*** | 0.525*** |
| Quantile 50 | -0.005 | -0.030*** | 0.200*** |
| Quantile 90 | 0.005 | -0.062*** | 0.051*** |
| RE | -0.058*** | -0.056*** | 0.369*** |
| | Foreign-State | Foreign-Private | Private-State |
| Newly established company | | | |
| Quantile 10 | 0.584*** | -0.150*** | 0.734*** |
| Quantile 50 | 0.449*** | 0.132*** | 0.317*** |
| Quantile 90 | 0.479*** | 0.336*** | 0.113*** |
| RE | 0.508*** | 0.139*** | 0.369*** |
| Incumbent enterprise | | | |
| Quantile 10 | 1.560*** | -0.060*** | 1.620*** |
| Quantile 50 | 0.962*** | 0.095*** | 0.867*** |
| Quantile 90 | 0.775*** | 0.224*** | 0.551*** |
| RE | 1.083*** | 0.091*** | 0.992*** |

Note: ***, **, and * indicate significant levels at 1%, 5%, and 10%, respectively.

Table 10 examines the learning ability of newly established companies. In this regression, we excluded new companies that had ownership changes after 4.8%. The table finds that private enterprises have very strong learning ability in different levels of distribution, and the more efficient the enterprises are, the more obvious learning ability they can reflect. Foreign-funded enterprises are significantly better than private enterprises in the low-efficiency distribution group, but they are significantly lower than the private enterprises in the middle and high efficiency levels. Table 10 clearly shows that the newly established state-owned enterprises have no significant learning ability.

Table 10. Learning effects of newly established enterprises

| | RE | QREG(10) | QREG(50) | QREG(90) |
|-------------|----------|----------|----------|----------|
| Foreign | 0.508*** | 0.584*** | 0.449*** | 0.479*** |
| | (0.022) | (0.051) | (0.021) | (0.037) |
| Private | 0.369*** | 0.734*** | 0.317*** | 0.113*** |
| | (0.021) | (0.040) | (0.017) | (0.030) |
| Foreign *i | 0.069*** | 0.107*** | 0.082*** | 0.067*** |
| | (0.003) | (0.003) | (0.003) | (0.005) |
| Private*i | 0.098*** | 0.078*** | 0.092*** | 0.107*** |
| | (0.002) | (0.004) | (0.002) | (0.005) |
| State*i | 0.007 | -0.007 | 0.007** | 0.008 |
| | (0.005) | (0.011) | (0.003) | (0.007) |
| No. of obs. | 124,029 | 124,029 | 124,029 | 124,029 |

Note: The values in parentheses are the standard deviation of the coefficients, ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively. State-owned enterprises (State) are the benchmark groups.

Therefore, one of the main sources of improvement in the efficiency of state-owned enterprises is that the newly established state-owned enterprises have higher levels of production efficiency, but because of the lack of learning ability, it is difficult for state-owned enterprises to catch up efficiency. Of course, in recent years, state-owned enterprises have had a high level of production efficiency at the beginning of their establishment, not only from the government’s cautious attitude toward the establishment of new state-owned enterprises, but also from the inclination of national resources to newly established state-owned enterprises, including the allocation efficiency manager. However, the efficiency improvement of new state-owned enterprises is no longer significant. This means that the government’s care for new state-owned enterprises is also a mismatch of resources. From the above, the way of Chinese enterprises catching up the efficiency from multinational enterprises is mainly depend on the learning abilities.

This paper uses big data and micro-data in many single industrial enterprises in China to systematically analyze

the changes in production efficiency of enterprises of different ownership types, and draws the following conclusions: There is a big gap in production efficiency between China ally-funded enterprises in China and foreign-invested enterprises that represent the frontiers of world efficiency, but the gap is gradually narrowing. The reason is that on the one hand, China-funded enterprises have very significant learning ability, especially private enterprises; on the other hand, newly established state-owned enterprises are more efficient than existed state-owned enterprises. We further found that the improvement of the marketization process in the region where enterprises are located can promote China enterprises to improve their learning ability. Besides that, the results of convergence analysis show that the level of steady-state efficiency and convergence speed of private enterprises are very close to those of foreign-funded enterprises. This means that under the existing conditions, China’s private enterprises have the potential to gradually catch up with the efficiency level of foreign-funded enterprises. Of course, this is by no means a one-size-fits-all thing. It requires the Chinese government to create a superior external environment for the learning and catch-up of private enterprises.

At the same time, among the newly established China-funded enterprises, state-owned enterprises have significantly better efficiency advantages than private enterprises at the beginning of their establishment, but they have insufficient learning and lack of stamina. Despite the high efficiency of the newly established enterprises and the exit of a large number of inefficient state-owned enterprises, the overall efficiency level of state-owned enterprises has been improved. However, although the introduction of state-owned enterprises has promoted the optimal allocation of resources, the establishment of new state-owned enterprises with insufficient learning ability is also an embodiment of China’s resource allocation is not perfect. Of course, the deeper question is why state-owned enterprises have insufficient learning capacity, including newly established high-efficiency state-owned enterprises. The author of this paper believes that the possible corporate governance mechanism is an important way to answer questions, but there is no data to carry out specific and in-depth research. Last but not least, China should continue to promote the marketization process, provide a more equitable and relaxed development environment for the efficiency improvement and vitality of private enterprises, so as to achieve the efficiency catching of Chinese China enterprises.

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