Impact of Ownership and Competition on the Productivity of Chinese Enterprises

Anming Zhang*
Department of Economics and Finance
City University of Hong Kong
Tel. (852)2788-7342
Fax (852)2788-8858
e-mail efanming@cityu.edu.hk

Yimin Zhang
Department of Economics and Finance
City University of Hong Kong
Tel (852)2788-7745
Fax (852)2788-8806
e-mail efyimin@cityu.edu.hk

Ronald Zhao
Department of Accountancy
City University of Hong Kong
Tel (852)2788-7928
Fax (852)2788-7944
e-mail aczhao@cityu.edu.hk

May 2000

Acknowledgement: We would like to thank Gregory Chow for very helpful comments. Andy Leung and Winnie Lo provided excellent research assistance. Financial support from the City University of Hong Kong, the University Grant Council (UGC) and the Research Grant Council (RGC) of Hong Kong is gratefully acknowledged.

* Corresponding author

Abstract

Considered as the key to the success of economic reform in China, the restructuring of Chinese state-owned enterprises (SOEs) has encountered many difficulties and setbacks. There are two competing approaches to enterprise reform. The market competition approach assumes that if the market for products, factors of production, and corporate control are created and function well, competitive force will compel SOEs to improve their efficiency. The ownership approach argues that private ownership is necessary for enterprise efficiency because it matches residual interests more closely with control rights. Exploring a new, firm-level data set, this paper presents some preliminary findings about the effect of ownership and market competition on the efficiency of Chinese industrial firms. Empirical results reveal a strong ownership impact on the level of enterprise efficiency, with foreign-owned enterprises exhibiting the highest, and SOEs exhibiting the lowest, efficiency scores. While competition in export markets is positively associated with enterprise efficiency, no such association is found between competition in domestic markets and productive efficiency. However, a change analysis shows that SOEs have a greater efficiency growth rate, driven more by improvement in technical efficiency rather than technological progress, than collectively-owned and Hong Kong, Macao and Taiwan-owned enterprises.

Key words: Chinese enterprises, Data envelopment analysis (DEA), Efficiency, Ownership, Competition

The Impact of Ownership and Competition on the Productivity of Chinese Enterprises

1. Introduction

As China moves from a centrally planned to a more open and mixed economy, many sectors have witnessed, for the last two decades, either policy liberalization or a shift of decision-making power from central to local government. By 1993 China's economy had become essentially a market economy in the sense that some two-thirds or more of national output was produced by profit-seeking economic units. However, although rural reforms turned out to be very successful, the industrial reform proved to be much more difficult. Industry is the largest sector of the Chinese economy, accounting for 50 percent of total output and 80 percent of exports, and employing more than 100 million workers in 1992. The core of the industrial reform was to transform thousands of large- and medium-size SOEs into profit-seeking economic units capable of operating under a market economy. An official slogan at the launch of the campaign in 1980s d was that "the goal of SOE reform is to make the enterprise independent, autonomous and responsible for profits and losses." As such, the SOE reform has been characterized largely as an evolutionary process of re-assigning decision rights and residual claims from the state to the inside members of the enterprise (i.e., managers and workers). The argument for delegating decision rights to the management was based on the assumption that managerial decisions are more efficiently made at the firm level than at the central planner's level owing to information/communication problems.

An evaluation of the progress of China's industrial reform naturally focuses on the performance of SOEs. The dominant view among Chinese economists is that the SOE reform has not been very successful, at least in terms of profitability measures (Zhang, 1996). The number of loss-making SOEs has been rising, leading to an increase in the total amount of losses. In 1993, for instance, the total losses by SOEs were 45.3 billion yuan (RMB), about 14 times the losses in 1985. Due to the wide scope and huge amount of losses in the state sector, the government's subsidy to SOEs also swelled, taking a 37 percent jump from 1986 to 1992. Furthermore, SOEs' contribution to government's revenue has been declining. The ratio of profit plus tax over sales revenue for the SOEs dropped from 26 percent in 1980 to 12 percent in 1992 (Lin, 1996). Studies by economists outside of China, on the other hand, are mainly centered on the effects of reform on total factor productivity (TFP) growth in SOEs. The results have been mixed. Woo et al (1994), for example, found that TFP growth in SOEs was zero at best in the 1984-1988 period. This is in contrast to several other studies (Chen et al, 1988; Jefferson et al., 1992; World Bank, 1992), that reported significant improvements in SOEs' productivity. Their estimates of annual TFP growth in the 1980s ranged from 2 to 4 percent, compared with almost zero percent growth prior to the reform.

From the social perspective, the increase in the SOEs' TFP indicates the success of the SOE reform. But the government, as the owner of the SOEs, does not seem to directly benefit from the reform in terms of profit. The productivity improvement and the decline of profit rate may be reconciled, however. As the SOE reform is a process of delegating decision rights and residual claims from the state to the members of the enterprise, it improves the incentive of managers and workers to increase efficiency and pursue profits. However, on the other hand, managerial discretion brought by the delegation may be abused such that managers become actual residual claimants, although the state is the legal residual claimant of the enterprise (Zhang, 1996). More specifically, SOEs are owned by the state but operated by the managers and workers. Due to information asymmetry and high monitoring cost, managers might reduce the profits submitted to the state by overstating costs and/or under-reporting revenues. Although they cannot easily pocket the profits, managers have many opportunities to spend enterprise's money for non-productive purposes. For example, the average annual output growth rate was 7.6 percent during the period of 1978-1996, the SOE wage fund increased by 16 percent per year (Lin, 1998). As a result, we see an improvement in SOEs' efficiency on the one hand but a decline in profits reported in official statistics on the other.

The above discussions suggest two approaches to deepen China's SOE reform. First, given the current structure of public ownership, if the markets for products, factors of production and corporate control are created and function well, competitive forces will compel SOEs to improve their efficiency for survival. An enterprise's profit level will be a sufficient information indicator of management performance in a fair and competitive market. Second, a more fundamental approach calls for the privatization of SOEs. The ownership approach argues that change in property rights is necessary for matching residual interests more closely with control rights. Private ownership will improve enterprise efficiency by providing a better incentive and reward system. In a broad sense, the two approaches are not mutually exclusive. In effect, the Chinese industrial reform has moved along both lines since 1990s. In this paper, we use a new, firm-level data set to address the issue of how ownership and market competition impact on the efficiency of Chinese industrial firms.

Our sample consists of a panel of some 2,000 firms in 26 industries for the period of 1996-1998. We apply data envelopment analysis (DEA) to compute the level of firm efficiency by industry. We then run regressions to examine the effects of ownership and market competition on the level and change in firms' productive efficiency. Empirical results reveal a strong ownership impact on enterprise efficiency level, with foreign-owned enterprises exhibiting the highest, and SOEs exhibiting the lowest, efficiency scores. While competition in export markets is positively associated with enterprise efficiency, no such association is found between competition in domestic markets and productive efficiency. The ownership effect on efficiency level is robust to market competition and industry factors. We also use Marmquist index to measure the change in firm efficiency, which can be decomposed into technological progress and technical efficiency. Results show that the efficiency of SOEs grew at a faster rate than collectively-owned and Hong Kong, Macao and Taiwan-owned enterprises, and the growth was mostly driven by improvement in SOEs' technical efficiency.

The rest of the paper is organized as follows. Sections 2 and 3 describe, respectively, the methodology and data. Section 4 discusses multiple enterprise ownership structures. Section 5 reports efficient level tests, and section 6 examines efficiency change results. Concluding remarks are contained in section 7.

2. Methodology

The productive efficiency of an industrial firm is reflected by the relationship between the outputs the firm produces and the inputs the firm uses in a given period of time.

The efficiency measurement of one firm should be based on a comparison between the firm and other firms in the same industry. In the simple case where firms in an industry produce a single output with a single input, the most efficient firm in the industry is the one with the highest output/input ratio. Defining this highest ratio as the potential output per unit of input for all the firms in the industry, the ratio of a firm's actual output to the potential output (per unit of input) can be used as a measure of efficiency for the firm.

Alternatively, efficiency may be measured in terms of potential input per unit of output. The most efficient firm in an industry can be used to define the potential input/output ratio. The efficiency measure for any firm in the industry is then defined as the ratio of the potential input to the actual input the firm is using to produce one unit of output. In the more complicated case where firms use multiple inputs and produce multiple outputs, similar measurement can still be obtained by comparing the actual outputs (inputs) ratio of any firm to the potential outputs (inputs) ratio established by the most efficient firms in the industry. In the multiple input/output case, the most efficient firms form the efficient frontier.

Empirical applications of such efficiency measures are feasible by a non-parametric technique known as data envelopment analysis (DEA). Useful references on DEA include, among others, Farrell (1957), Banker et al. (1984), Banker et al. (1989), Charnes et al. (1978, 1981), Seiford and Thrall (1990), and Lovell (1993). We use the DEA approach to assess the productive efficiency of industrial firms in China. An estimate of the ratio of real output to real inputs provides an efficiency measure that is independent of the price level. We restrict our model to the "multiple-input and single output" case in terms of total factor productivity (TFP) which is the ratio of output to total input.

A DEA model gives an efficiency score for each firm in a given industry. For the input oriented model, the efficiency score has a value between zero and one. Firms with an efficiency score of unity (100%) are located in the efficient frontier in the sense that their inputs cannot be reduced without a corresponding decrease in output. Firms with an efficiency score below 100% are inefficient. The DEA model defines the efficiency score of any firm as the fraction of the firm's inputs that is necessary for a firm in the efficient frontier to produce the same level of output.

A graphic illustration of this concept is given in Figure 1. With two inputs (X_1 and X_2) and one output (Y), firms B and C define the efficient frontier as represented by the piecewise linear curve ABCD. The efficiency scores of B and C are both 100%. Firm E is inefficient in the sense that a linear combination of B and C can form F that can produce the same level of output as E but with only a fraction of the inputs. In other words, F represents the potential inputs that firm E need to produce the actual output. The fraction OF/OE is therefore defined as the efficiency score for firm E.

[Insert Figure 1 here]

In practice, the efficiency score for any firm can be obtained by solving for the following linear programming problem (input oriented, constant returns to scale model):

$$
\begin{aligned}
&\max_{u_j, v} e_0 = v y_0 \\
&s.t. \sum_j u_j x_{ji} - v y_i \geq 0; i = 1,..., n \\
&\sum_j u_j x_{j0} = 1 \\
&u_j \geq 0, v > 0
\end{aligned}
\qquad (1)
$$

In the above problem, e_0 is the efficiency score, y_0 is the output and x_0 is the input (vector) of the firm being evaluated. N is the number of firms in the industry. The linear programming is solved N times to estimate efficiency scores for all firms in the industry.

To investigate the effect of ownership and market competition on the productivity of the firms, we use a two-stage approach (see, for example, Ali and Flinn 1989, Kalirajan 1990, for the application of two-stage analysis). In the first stage, we calculate the efficiency scores for each firm by industry. In the second stage, we run regressions to examine effects of ownership and market competition on the productive efficiency of firms.

3. Data

The data set used in this study includes all medium and large sized industrial enterprises in Shanghai. Shanghai, with a population of 13 million, is the most important business and industrial center in China. It accounts for 4.5 percent of national GDP and nearly one-fifth of China's external trade (by value). A sample from Shanghai would present a comprehensive panorama of enterprise performance while controlling for impact of regional factors on productivity in China (Chen, 1996).

Previous research on the Chinese economy was mostly based on macroeconomic statistics from publications such as China Statistics Yearbooks. Chow (1993) discussed the quality of official Chinese statistics and concluded on its overall validity for macroeconomic research despite potential problems, including pressure for reporting units to falsify data and limited government resources for data processing. The data for this study were provided by the State Statistic Bureau of China (SSBC) from its computerized microeconomic database. This national database stores firm-level statistics from the mandatory annual reports of all qualified government and business organizations in China. Being one of the first studies based on this hitherto unreleased database, the empirical findings reported in the paper also reflect on the internal accuracy and consistency of official Chinese microeconomic statistics.

Our data set covers a three-year period of 1996-1998. This data period was determined because of the significant revision of classification criteria and statistic presentation categories that took place in 1996. The revision made pre- and post-1996 data incomparable. The reporting format has, however, remained unchanged since 1996. Three major changes made in the 1996 revision are worth noting. First, cost of direct material input became available for the first time in 1996, without which material input efficiency cannot be estimated. Second, revenue, which had not been adjusted for value-added tax (VAT) before 1996, was to be adjusted afterwards. Finally, SSBC publicized its definitions of different ownerships in that year (China

Statistics Yearbook, 1996). A clear ownership classification is of prime importance for investigating ownership effect on firm performance.

Based on the SSBC's categorization scheme, we divide Chinese enterprises into six groups: state-owned, collectively-owned, privately-owned, foreign-owned, Hong Kong-Macao-Taiwan-owned enterprises and domestic joint ventures. Their definitions are as follows (see SSBC, 1996):

- State-owned enterprises (SOEs): enterprises, institutions, government administrative organizations at various levels and social organizations with state ownership of production means;
- Collectively-owned enterprises (COEs): enterprises and institutions with collective ownership of production means, including rural economic organizations, enterprises run by township and villages (TVEs), collective enterprises and institutions run by cities, counties, town and street committees;
- Privately-owned enterprises (POEs): economic units owned by private individuals, including individually owned private enterprises, jointly owned private enterprises, and privately owned limited liability companies;
- Foreign-owned enterprises (FOEs): enterprises established by foreigners in the Chinese mainland according to related economic laws and regulations, including equity joint ventures, cooperative joint ventures and solely-owned subsidiaries;
- Hong Kong-Macao-Taiwan-owned enterprises (HMTs): enterprises established by oversea Chinese from Hong Kong, Macao, and Taiwan in the Chinese mainland according to related economic laws and regulations, including equity joint ventures, cooperative joint ventures, and solely-owned subsidiaries;
- Domestic joint ventures (DJVs): economic entities jointly invested by enterprises of different ownership or by enterprises and institutions, and the joint ownership can be of closed, semi-closed, or open partnership.

Note that DJVs are mostly joint ventures among several SOEs, COEs or between SOEs and COEs, so they are different from Chinese-foreign joint ventures, which are calssified as FOEs and/or HMTs. Section 4 below contains a more detailed discussion on the evolution of enterprise ownership structure in the context of China's industrial reform.

A firm's nominal sales revenue is used as measure for its output in a given year. Three inputs are assessed to determine the firm's efficiency: labor, capital, and materials. Labor is measured by the number of employees, capital is measured by nominal value of net productive assets, and materials is measured by nominal value of direct materials input of each firm in a given year. After deleting firms with missing values for the variables described above and industries that have fewer than 20 firms, our data sample consists of a panel of 1,989 firms in 26 industries for the period of 1996-1998. Descriptive statistics of the sample are given in Table 1.

[Insert Table 1 here]

As indicated by Table 1, SOEs form the largest group with a total of 937 firms. There are 213 COEs and 105 POEs. 276 and 407 firms are respectively classified as FOEs and HMTs. The smallest group is DJVs, which contains 51 firms. Both by year and three-year average efficiency scores are estimated for each firm. While the nominal values may be subject to biases from accounting practices and imperfect markets, the DEA efficiency score gives an estimate of the deviation of each firm's productivity from the efficiency frontier for a given industry as long as these biases are not systematic. Only regression results based on three-year average efficiency scores are reported for analysis, which are similar to results based on by year efficiency scores.

4. Industrial Reform and Multiple Enterprise Ownership Structures

SOEs have been the backbone of the Chinese economy before the economic reform. For a long period from early 1950s to late 1980s, the Chinese economy was entirely under the control of the state, which owned all factors of production other than labor. Operating under either central or local government, SOEs acted as cost centers to fulfil national production quotas and provide social services to employees. The management of SOEs had little control over input, output, investment and technological change.

The SOE reform is a critical part of China's overall reform package. The economic reform policy was determined at the Third Plenary Session of the 11th Central Committee of the Communist Party of China in December 1978. A "gradual" reform strategy was adopted (as opposed to the "big-bang" approach applied in some East European countries). Agriculture was the first area in which China implemented reforms. The results were clear: agricultural output increased by 67% between 1978 and 1985, and productivity (measured as the amount of output for a given amount of inputs) increased by nearly 50%, compared with no increase in productivity over the previous two and half decades (Lin, 1992; McMillan et al., 1989). The increase in agricultural productivity in turn spurred the growth of rural enterprises, or TVEs, by generating a pool of savings and excess labour (Byrd and Lin, 1990). Beginning from a small base, TVEs were allowed to grow with few of the restrictions that hobbled SOEs and TVEs expanded rapidly. A number of studies have made to explain the success of TVEs (e.g., Weitzman and Xu, 1994; Chang and Wang, 1994; Li, 1996).

Industrial reform was called for in 1979 and officially launched at the Third Plenary Session of the 12th Central Committee of the Communist Party of China in 1984. The core of this reform program was to transform thousands of medium and large-size SOEs to profit-seeking economic units conforming to a market economy. As indicated earlier, one particular objective was to transform SOEs from cost centers into profit centers to be responsible for a profit target. Over the past two decades, the government has delegated an increasing degree of decision-making authority to SOE management to boost their performance. However, many SOEs have remained money losers and relied on "soft loans" from state banks for survival. Known for overstaffing, low productivity and declining profitability, SOEs are nevertheless the major providers of basic industrial output for the economy, largest employer of urban workers (SOEs employed 65% of 173.5 million urban workers in 1995), and main source of government revenues (SOEs contributed RMB444.1 billion, i.e., 71% of government revenue in 1995). They still dominate the heavy industries sectors in China, including steel making, machine building, automobile manufacturing, petroleum production, and coal mining.

Organized by the local authorities, COEs used to be similar to SOEs in the sense that they were also under government control and were encouraged to provide stable employment to their employees. SOEs and COEs have provided social security to the urban and rural workforce of China for several decades. As a result of economic reform, the management of COEs has been under increasing pressure efficiency improvement and they have had to lay off employees to achieve the objective. Many of the COEs are the “township and village” based enterprises (TVEs). TVEs started in labor-intensive industries, their total asset level has remained relatively low, and export constitutes a large part of their revenues. TVEs have reported the highest growth rate and represent the most dynamic sector of the Chinese economy in early 1990s (Weitzman and Xu, 1994). In 1994, there were 24,945,000 TVEs, with a total industrial output of RMB2,588,000 million, which was 17.78 times that in 1978, recording an annual growth of 21% since that year. The increase in the export volume of TVEs has exceeded that in their output. In 1993, TVEs exported RMB235,000 million, which was 45% of China’s total export. Due to data limitation, TVEs are not separated from COEs in this study. However, it appears reasonable to assume that the overall performance of COEs is substantially driven by TVEs.

The transition from a centrally planned economy to a market economy is a marketization process. A market economy prerequisites the coexistence of multiple ownership structure and economic entities. By definition, there can be no free market economy under a monopolistic state ownership. The diversification of ownership structure can be achieved through the reform of SOEs and development of non-state-owned enterprises. A radical approach is an overall privatization of all SOEs, as in Eastern Europe and Russia, while a gradual approach would avoid the difficulties of such a challenge by fostering new economic elements outside of state-owned sectors. The economic reform in China has been characterized by the development of non-state sectors as a means to change the ownership landscape. Foreign-owned (FOEs), Hong Kong-Macao-Taiwan owned (HMTs) and privately-owned enterprises (POEs) have emerged since early 1980s as China began to open its markets. The government has encouraged the establishment of FOEs and HMTs in order to benefit from foreign capital, advanced technology, management expertise, and increased export volume. By 1994, foreign, including Hong Kong, Macao and Taiwan, investors had invested a total of US$100 billion in 198,000 joint ventures, which employed 14 million people and accounted for 37% of China’s total export. POEs came into being to meet the demand of the gradually deregulated Chinese market. However, there have been reported cases that individual and private enterprises have registered as SOEs and COEs in order to secure preferential tax treatment and/or material supply. Furthermore, more POEs have been known to take advantage of the loopholes in tax laws, accounting standards, judicial system and audit regulations than enterprises under other types of ownership. Therefore, the reported productivity measures for POEs may be downward biased compared with actual numbers, and the difference between SOEs, COEs and POEs in terms of these measures would also be affected.

We illustrate the growth of the non-state sector in China with the following statistics. In 1978 (the year before the economic reform), SOEs produced 75%, and COEs 22% of the total industrial output. POEs were almost non-existent at the time, with only 150,000 employees (1.6% of labor force) engaged in self-employed business. The number ogf POEs increased to 7.97 million in 1993, employing 13.03 million people. Furthermore, 53% of POEs have entered into international business or trade, with 22.5% forming joint ventures with foreign partners. POEs were responsible for .4% of toal income tax in 1978, and 10.8% in 1993. The industrial output of the non-state sector increased by 2% on average annually over the 1980s, and by 4% after 1992. Its output first exceeded 50% of total industrial output in 1992, and reached 65% in 1995. The contribution of the non-state sector to government revenue also rose from 18% in 1980 to 39% in 1993, demonstrating an annual increase of 1.65%. In contrast to its increasing contribution to the national economy, the non-state sector uses a relatively small portion of the resources. In 1995, the non-state sector accounted for 44% of total capital investment and 40% of total working capital. There were a total of 7,341,500 industrial enterprises in China, with 118,000 classified as SOEs, 1,475,000 as COEs, and 5,688,200 POEs, and 60,300 under other categories as of 1995. As a result of the ongoing economic reform, the contribution of SOEs to China's total industrial output has declined significantly from 75(%) in 1978 to 35(%) in 1995. While the Chinese economy grew at an average annual rate of 9.9% over the past two decades, non-state enterprises have been growing at a greater rate than SOEs.

5. Analysis of Productive Efficiency of Chinese Industrial Firms

We test the two alternative propositions about the driving force for productive efficiency in Chinese enterprises. We obtain the efficiency scores of each firm using the DEA model to examine their association with ownership and market competition. To analyze the ownership effect on enterprise efficiency, we divide the sample firms into six ownership categories. We then calculate the mean and standard deviation of efficiency scores for each group. The results are listed in Table 2. It can be seen that although the size of the groups varies widely from 937 SOEs to 51 DJVs, the standard deviations of the efficiency scores in each group are quite similar, which renders the comparison of the means of efficiency scores across ownership categpries more valid.

[Insert Table 2 here]

The mean efficiency score of SOEs (group 1) is 55.34%, the lowest of all the groups. The most efficient groups are HMTs (group 5) and FOEs (group 4) with mean efficiency scores of 69.95% and 69.77%, respectively. The COEs (group 2) and POEs (group 3) are close behind with mean efficiency scores of 68.77% and 66.79%, respectively. The last group, the DJVs (group 6), appears to be in the middle between SOEs and the other groups with a mean score of 60.25%. This may be explained by the fact that DJVs, as opposed to Chinese-foreign joint ventures, which are classified as FOEs and HMTs, are joint ventures among SOEs or between SOEs and COEs. Therefore, they have operations profile similar to that of SOEs. The close performance of COEs and POEs may be explained by the fact the group of COEs include TVEs, which is more like private ownership than collective ownership.

It is observed that the distribution of ownership groups across industries is not even. For instance, in the general machine-building industry, about 66% of the firms are SOEs whereas SOEs only account for 20% in the garment-and-fabric-manufacturing industries. To control for the effect of industry-specific factors such as conditions of technological change, market for specific assets and skilled labor, and industrial policy of the government, etc. on efficiency, we run the following regression:

$$e = a_0 + \sum_j a_j I_j + \sum_k b_k O_k \qquad (2)$$

In the above equation, e is the average efficiency score of a firm over 1996-1998. I_j is the industry dummy and O_k is a dummy representing ownership categories. To avoid perfect correlation, industry dummy for general machine-building and ownership dummy for SOEs are dropped. Therefore, the coefficient estimates should be interpreted with reference to SOEs in the general machine-building industry. The results of the regression are reported in the first column of Table 3.

[Insert Table 3 here]

The results show that there are considerable inter-industry variations in the efficiency scores of firms. Specifically, industries of furniture manufacturing, nonferrous metals, rubber products, fur and leather products, paper products, food processing, and ferrous metals have mean efficiency scores higher than the general machine-building by a minimum of 30%. On the other hand, perhaps with some surprise, the electronic-and-communication-equipment industry, which is considered more technologically advanced than the above industries, is found to have the lowest mean efficiency score, lower than the general machine-building by about 10%. However, a closer look reveals that the electronic-and-communication-equipment industry has the highest concentration of FOEs and HMTs (groups 4 and 5), which together account for 81 out of 131 firms in the industry, and SOEs account for 35 firms. The efficiency gap between SOEs and FOEs in this industry may be further widened by the different generations of technology respectively employed by them. Since the efficiency scores are upper bounded by unity (100%), the wide gap between SOEs and FOEs in this industry resulted in a lower average score for the industry as a whole. After controlling for the industry specific factors by industry dummy, the coefficient of ownership dummy still shows the same pattern of effects on productive efficiency. Specifically, SOEs and DJVs remain the least efficient, and firms with other types of ownership have, on average, 10-16% higher mean efficiency scores than SOEs and DJVs.

Degree of market competition is considered an alternative driver for productive efficiency. Next, we test the effect of market competition on enterprise efficiency in a given industry. We distinguish between competition in international versus domestic market. During the long period of command economy from 1950s to 1980s in China, industrial firms, responsible for production quotas but not responsible for profit, had little pressure from market competition. Only after the beginning of economic reform have the newly established private firms and foreign firms brought competitive forces to the Chinese market. Nevertheless, some SOEs have exported their products to international markets long before the economic reform in order to earn much-needed foreign currencies. Thus Chinese firms have been exposed to competition in the export market prior to competition in the domestic market. We first use exposure to international market as a proxy to measure the effect of international market competition on the efficiency of exporting versus non-exporting firms.

We introduce a new variable, X/A, the ratio of a firm's export revenue to its total assets, as a proxy for the firm's exposure to international markets competition and regress firm efficiency score on this variable as shown below. (An alternative proxy is the fraction of a firm's export revenue to total revenue. However, since total revenue is used as output measure in the computation of the efficiency score, we decided to use total assets as the scaler here to avoid endogeneity problem.)

$$e_{ij} = a_0 + c(X / A) \tag{3}$$

It may be argued that international markets are more competitive than domestic market for Chinese enterprises. Therefore, firms which compete in the export market should face greater competitive pressure than those which only sell in the domestic market. The results of the regression are reported in the second column of Table 3. The estimated coefficient c is positive and has a t-ratio of 7.13, indicating that firms which earn export revenues are more efficient than firms which only sell domestically.

We note that some FOEs and HMTs are under government regulations restricting their sales in the domestic market and many of these firms are located in the special economic zones for processing and re-export businesses. For the firms in these groups, the weight of their export revenue would presumably be higher than that of the firms in other groups. Hence, the extent of export market exposure and specific ownership categories may be correlated. Consequently, the effect of ownership structure on efficiency presented earlier may, to some extent, be attributed to the effect of international market competition. To separate this possible interrelation, we run regression again with both (X/A) and the ownership dummy. The results are shown in column 3 of Table 3. With the addition of ownership dummy, the coefficient on (X/A) is still positive and has a t-ratio of 4.04, suggesting that the pressure from export markets is not limited to firms of specific ownership categories. After controlling for export market exposure, ownership effect on efficiency retains the same pattern that average SOEs' efficiency score lags behind those of firms belonging to other ownership groups. Specifically, exporting SOEs have higher productive efficiency than non-exporting SOEs, but not enterprises under other ownership categories.

Beside the fact that firms with specific ownership type such as FOEs and HMTs have more exposure to the export market, some industries may also be more export oriented due to the nature of their products. Hence, the differences in the values of industry dummy shown earlier may also have been biased by the differential effect of competition from export market across industries. To account for this possibility, we add the industry dummy to the regression of efficiency score to (X/A) and ownership dummy and report the results in column 4 of Table 3. It appears that there is no significant change in industry dummy after exposure to export market is controlled for. This indicates that the extent of participation in export market does not account for inter-industry variations of productive efficiency of Chinese firms in a significant way.

After examining the effect of international market competition, we next construct the Herfindahl index as a proxy for the degree of domestic market competition to test its effect on enterprise efficiency. The Herfindahl index for each industry is calculated as

$$H_j = \sum_{i}^{N_j} s_{ij}^2 \tag{4}$$

where s_{ij} is the market share of firm i in industry j. N_j is the number of firms in industry j. The level of Herfindahl index, with maximum of 1 and minimum of 1/N, reflects the degree of concentration in the industry. We then regress the means of efficiency scores of the firms in each industry on its Herfindahl index:

$$\overline{e_j} = a_0 + d_0 H_j, \quad j = 1, 2, ..., 26 \tag{5}$$

Since a higher Herfindahl index indicates less market competition, a negative association between Herfindahl index and productivity is expected to show the positive effect of market competition on enterprise efficiency. The regression results are presented in Table 4. The coefficient d_0 is positive and has a t-ratio of 2.82. This seems to suggest that the firms in the industries with high level of concentration would on average have higher efficiency scores than firms in less concentrated industries, which is counterintuitive.

[Insert Table 4 here]

It may be argued that since the efficiency scores are upper bounded, levels of average efficiency score may not fully reflect the performance of the firms in the efficient frontier. On the other hand, if market competition would put greater disciplinary pressure on the firms at the lower end, then competition should reduce the span of the efficiency scores between the firms at the upper end and lower end. To test this possibility, we further regress the standard deviations of efficiency scores of firms in each industry on its Herfindahl index:

$$s_j = a_1 + d_1 H_j, \quad j = 1, 2, ..., 26 \tag{6}$$

A positive association is expected between a_j and H_j because market concentration would stifle competition and allow inefficient firms linger in business. Regression results are also presented in Table 4. Contrary to expectation, d_1 is negative, although not significant at the conventional level. Consequently, the result points to the same conclusion that high degree of concentration, rather than competition, seems to enhance the performance of the firms at the inefficient end.

Finally, in order to examine to what extent industry factors are reflected by the degree of industry concentration, we include the Herfindahl index in the regression of efficiency scores in addition to ownership category and export market exposure. The results are presented in column 5 of Table 3. The inclusion of Herfindahl index does not materially change the effect of ownership categories and export market exposure. The Herfindahl index has a positive coefficient with a t-ratio of 10.52, still a puzzling result. When industry dummies are added into the regression, however, the results show inflated standard errors of estimation, which are indicative of collinearity problem because the value of the Herfindahl index is industry specific.

The empirical results demonstrate a significant positive correlation between international market competition and enterprise efficiency, but domestic market competition (concentration) is negatively (positively) correlated with enterprise efficiency. The differential effect between international and domestic market competition may be due to aberrations or anomalies in the Chinese "socialist market economy". The Chinese markets are still incomplete and imperfect because of the absence of effective regulative environment, adequate corporate governance and enforceable accounting standards. There are no laws to force insolvent SOEs into bankruptcy. Instead, state banks continue to pump funds into them to avoid their closures. For example, 80% of bank loans were made to SOEs over the years. Total debts of SOEs stood at approximately RMB800 billion in 1995. Furthermore, the government policy to maintain the monopoly of the largest SOEs in selected industries would also give them unfair advantages.

6. **Growth of Productive Efficiency**

Ehrlich et al (1994) distinguish the influence of ownership on the firm's level of productivity from that on the firm's rate of productivity growth, arguing that if there is endogenous growth in some firm-specific assets, enterprises of different ownership, even facing the same production possibilities and having access to similar markets, may still have systematic differences in productivity growth rates. Using a sample of international airlines, Ehrlich et al find that a switch from state to private ownership unambiguously raises the rates of productivity growth, or cost decline, whereas its effect on the levels of productivity and unit cost may be ambiguous in the short run.

We have examined the effects of ownership and market competition on the level of firm productivity using the DEA model. Next we test their effects on the growth rate, or change, in firms' efficiency. We use the Malmquist index to analyze the change in efficiency for each firm, which is defined as:

$$M_o^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)} \right]^{1/2} \quad (7)$$

where D_o is an input distance function. The distance function is the inverse of the input-oriented efficiency score, which can be calculated using the DEA method as in equation (1) (Färe et al, 1994). The superscript on D_o indicates the time period for which the efficiency score is calculated. The superscripts on x and y respectively indicate the time period of the data used in the calculation of the efficiency score. For example, $D_o^{t+1}(x^t, y^t)$ is the inverse of the efficiency index which is computed using the observation of firm *o* in period t while the production frontier is based on period t+1. Similarly, $D_o^t(x^{t+1}, y^{t+1})$ is the inverse of the efficiency index which is computed using the observation of firm *o* in period t+1 with reference to the production frontier based on period t. Equation (7) is commonly expressed in the following form:

$$M_o^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)} \right]^{1/2} \quad (8)$$

This represents a decomposition of efficiency change of firm *o* from period t to period t+1.

The ratio outside the brackets on the right-hand side of equation (8) measures the change in technical efficiency of firm *o* from period t to t+1. Since the distance function is the inverse of the efficiency index, a ratio of

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

greater than unity implies that the technical efficiency of firm *o* has declined with reference to the production frontier in the two periods. Similarly, a ratio of less than unity indicates that the technical efficiency of the firm has improved from period t to t+1.

The brackets on the right-hand side of equation (8) represent the geometric mean of the shift in production frontier. Specifically, the first ratio in the brackets,

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

is the change in efficiency index of firm *o* due to technological change between periods t and t+1, where firm *o* is observed in period t+1. The second ratio in the brackets,

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

has the same interpretation with firm *o* as being observed in period t. When the value of these ratios is less than unity, it implies that the technology of the industry has progressed from t to t+1. Vice versa, a ratio with a value greater than unity suggests that technological regression has occurred in the industry. The Malmquist index as a measure of overall efficiency change is thus decomposed into technical efficiency change of the firm and technological change of the industry. Similar to the interpretation of its components, a Malmquist index greater than unity indicates that the overall efficiency of firm *o* has declined from period t to t+1 while a Malmquist index less than unity implies an increase in the overall efficiency of the firm.

Using our panel data from 1996 to 1998, we first compute the distance functions for each firm. $D_o^t(x^t, y^t)$ and $D_o^{t+1}(x^{t+1}, y^{t+1})$ are readily available by taking the inverse of the efficiency scores obtained earlier. Then we add observation (x_o^t, y_o^t) of firm *o* in year t into the data set (x_j^{t+1}, y_j^{t+1}) of all the firms in the same industry in year t+1 and compute efficiency score for firm *o*. The inverse of this efficiency score gives the distance function $D_o^{t+1}(x^t, y^t)$. The distance function $D_o^t(x^{t+1}, y^{t+1})$ is obtained in similar fashion. The Malmquist index can be constructed from the four distance functions for the periods 96/97 and 97/98.

To examine the effects of ownership and market competition on the change in firm efficiency, we run the following regression:

$$M = a_0 + \sum_j a_j I_j + \sum_k b_k O_k \tag{9}$$

where M is the average value of Malmquist index of a firm over the periods 96/97 and 97/98. I_j is the industry dummy and O_k is the ownership dummy. As before, the industry dummy for general machine-building and ownership dummy for SOE are dropped to avoid perfect collinearity. Therefore, the coefficient estimates should be interpreted with reference to SOEs in the general machine-building industry. The regression results are reported in the first column of Table 5.

[Insert Table 5 here]

The results show that the COEs have an average Malmquist index value which is higher than that of SOEs by 0.071, and that of HMTs is 0.057 higher than that of SOEs. Both differentials are significant at conventional level[1]. The index for DJVs is on average 0.046 higher than SOEs but not significant at the conventional level. POEs and FOEs are close to SOEs in terms of Malmquist index and that for POEs has a negative sign, though the differentials are insignificant. This suggests that on average the overall efficiency of SOEs has improved relative to that of the COEs and HMTs, although the efficiency level of SOEs are still lower than COEs and HMTs, as discussed in section 5. The decomposition of Malmquist index further provides insight into the causes of the efficiency growth for SOEs in Tables 6 and 7, where we report the decomposed results of technological change (shift of production frontier) and technical efficiency change. It can be seen from Column (1) of the Tables 6 and 7 that technological progress of SOEs lags behind firms in other ownership category on average, except for HMTs, although none of the differentials are significant at the conventional level. However, the technical efficiency of SOEs has increased at a faster rate relative to COEs, HMTs, and DJVs. The largest differential is with respect to COEs (0.059) and it is significant at the conventional level. In sum, SOEs growth in productive efficiency is basically attributable to their improvement in technical efficiency rather than technological progress, indicating that SOEs are either using less input or producing more output. We find that COEs and HMTs have, on average, a lower efficiency growth rate than firms in other ownership categories.

We now examine the variations of efficiency change across different industries. The Malmquist indexes (Table 5) for instruments, communications, and food manufacturing industries exhibit a significantly slower efficiency growth rate than that for the general machine-building industry. The rest of the industries do not have significant difference in efficiency change compared with the general machine-building industry. Table 6 shows that three industries, namely electrical engineering, fur and leather, and food processing, have technological progress rate in excess of that of general machine-building industry, but the differentials are not significant at conventional level. The other 22 industries have a technological progress rate below that of the general machine-building industry, the differentials for 15 among the 22 industries, including instruments, communications, and food manufacturing are significant at the conventional level. Table 7 reveals that 17 industries have an average faster efficiency growth rate than that of general machine-building. The differentials for 7 industries among them, including instruments, communications, and food manufacturing, are significant at conventional level. The remaining eight industries have average growth rates smaller than that of general machine-building, of

[1] Here and in the following text, by significant we mean the t-ratio of the coefficient exceeds the 5% critical value.

which the differentials of 2 industries including transport equipment and electrical engineering are significant.

From the above observations, we may speculate that the production frontiers have shifted for most industries over the period of 1996-98, but the efficiency of the average firms has not changed much. This is because the shift of the production frontier is determined by the performance of the most efficient firms only. As the production frontiers moved upward, the efficiency scores of the less efficient firms may become worse, resulting in deteriorating technical efficiency. Allowing for the effect of technological progress of the most efficient firms and the deteriorating technical efficiency (relative to the production frontier) of the less efficient firms, the overall efficiency change of average firms in most industries are insignificant.

Similar to the analysis of efficiency levels, we next include proxies for international and domestic competition, namely the exposure to the export market and Herfindahl index of each industry, into the regression. Tables 5, 6, and 7 show that these proxy variables do not have significant effects on the average efficiency change of firms in different ownership groups. There are no significant changes in the coefficients of ownership dummy and industry dummy after the inclusion of the proxy variables. International competition has a significant effect on the level, but not the growth rate, of firm efficiency. Domestic competition has no significant effect on either the level or change of firm efficiency.

The findings on the higher technical efficiency growth rate of SOEs than those of COEs and HMTs despite the higher level of efficiency for COEs and HMTs is of interest. SOEs have the lowest level of efficiency among the six groups. Market forces are likely to exert the greatest pressure on them to reduce inefficiency. However, we do not know whether the efficiency improvement reflects reduced agency costs, or is a result of increased government campaign to improve SOE performance in recent years. The Chinese government has based the economic reform on the restructuring of SOEs by allocating the majority of human, material and financial resources to support the state-owned sector. In contrast, the success of the non-state sector is not the outcome of government support, but that of its own behavior in conformity with economic laws. Unlike the SOEs, firms in the non-state sectors have to face hard budget, bottom line, threat of bankruptcy and market exit. However, the slower growth rate in technical efficiency for COEs and HMTs expose the weakness in these two sectors. COEs have similar level of efficiency as POEs, its slower rate in technical efficiency may be attributable to several causes. First, COEs are subject to more government bureaucracy than POEs because of administrative affiliations. Second, the growth of COEs has been mostly driven by TVEs, however, many TVEs lack economies of scale, which hinders their growth beyond a certain point. HMTs enjoy the highest level of efficiency with FOEs. Their difference in technical efficiency growth may be explained by their investment strategies. Hong Kong, Macao and Taiwan investors usually have a shorter investment horizon than foreign investors. Their focus on short-term profit may impair their growth potential in the long run.

7. Concluding Remarks

This study attempts to analyze ownership effect and market competition on the productive efficiency of industrial firms in China. We first obtain efficiency score by data envelopment analysis (DEA) for each of 1,989 firms in 26 industries. DEA method is employed to address potential unreliability of accounting data to the extent it may exist. Then, we use regression models of efficiency scores to examine the effect of ownership categories and other market factors on the economic performance of the firms.

The results of regression suggest that ownership is an important determinant of productive efficiency. The group of state-owned-enterprises (SOEs) has the lowest average efficiency score whereas foreign-owned (FOEs) and Hong Kong, Macao and Taiwan-owned (HMTs) enterprises have the highest efficiency scores. The average efficiency score of domestic joint ventures (DJVs) among SOEs or between SOEs and COEs lies in between but closer to the state-owned-enterprises (SOEs). Property rights and ownership structure have a significant impact on all economic transactions. It is especially the case with a transitional economy as China where economic reform is realized through the transformation of state monopoly to a diversified ownership structure.

The study also examines the effects of market competition on productive efficiency, and it is found that exposure to international market has a positive effect on enterprise efficiency, though the effect is not as strong as that of ownership category. On the other hand, the degree of market concentration in domestic market, as measured by Herfindahl index, is found to have positive effects on efficiency, contrary to the common belief that market competition rather than concentration should improve efficiency. The mixed results on market competition may be due to the lack of effective competitive mechanism characteristic of an emerging market still at an early development stage. Although free market and price mechanism become crucial to transfer assets to those who can put them to the most productive use, however, when market-oriented reform is introduced into an environment of partially reformed governance institutions, it will lead to non-market-oriented behavior.

We also examined the effects of ownership and competition on the growth rate in firms' productive efficiency. We used the Malmquist index to decompose overall efficiency change into industry-wide technological progress effect and change in technical efficiency of individual firms. The regression results indicate a higher growth rate in technical efficiency for SOEs in comparison with the more efficient firms of COEs and HMTs. This difference may be attributable to several factors, including the relative low level of total efficiency of SOEs, government support for SOE reform and internal constraints of COEs and HMTs. The proxies for international market exposure and domestic market competition, however, do not show significant effect on the change in firm efficiency over the examination period. The findings on the change in productive efficiency add to our understanding of the ownership effect. Based on both level and change analysis, the non-state sector exhibits a higher productive efficiency than the state sector despite some within group variance during the examination period.

There are several limitations to this study. First, the empirical results are based on a new database with unknown accuracy and internal consistency. If SOEs inflate, and firms under other ownership categories deflate, their productivity, ownership effect would be weakened in consequence. Data quality may also be responsible for the mixed effects of market competition on enterprise efficiency. Second, the constant returns-to-scale model used in the study excludes consideration of scale economies, which may have a significant effect on productive efficiency. Third, the efficiency score approach used here does not consider the aspect of allocative efficiency. A differential analysis would help identify potential improvement in better use of resources. We will address these issues in future research.

References

Ali, M. and J.C. Flinn (1989) "Profit efficiency among Basmati rice producers in Pakistan Punjab", *American Journal of Agricultural Economics*, 71(2):303-310.

Banker, R.D., A. Charnes, and W.W. Cooper (1984) "Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis", *Management Science*, 30(9):1078-1092.

Banker, R.D., A. Charnes, W.W. Cooper, J. Swarts, and D.A. Thomas (1989) "An introduction to Data Envelopment Analysis with some of its models and their uses", in J.L. Chan, ed., *Research in Government and Nonprofit Accounting*, vol. 5. JAI Press, Greenwich, Conn.

Byrd, W.A. and Q. Lin (1990) (eds) *China's Rural Industry*, Oxford: Oxford University Press.

Chang, C. and Y. Wang (1994) "On the nature of the Chinese township-village enterprises", *Journal of Comparative Economics*, 19:434-452.

Charnes, A., W.W. Cooper, and E. Rhodes (1978) "Measuring the efficiency of decision-making units", *European Journal of Operational Research*, 2(6):429-444.

Charnes, A., W.W. Cooper, and E. Rhodes (1981) "Evaluating program and managerial efficiency: An application of Data Envelopment Analysis to Program Follow Through", *Management Science*, 27(6):668-697.

Chen, K., G. Jefferson, T. Rawski, H. Wang, and Y. Zheng (1988) "Productivity change in Chinese industry: 1953-1988", *Journal of Comparative Economics*, 12:570-591.

Chen, Y.M. (1996) "Impact of regional factors on productivity in China", *Journal of Regional Science*, 36(3):417-436.

Chow, G. (1993) "Capital formation and economic growth in China", *Quarterly Journal of Economics*, 108(3):809-842.

Ehrlich, I., G. Gallais-Hamonno, Z. Liu, and R. Lutter (1994) "Productivity growth and firm ownership: An analytical and empirical investigation", *Journal of Political Economy*, 102:1006-1038.

Färe, R., S. Grosskopf, and C.A.K. Lovell (1994) *Production Frontiers*, Cambridge University Press, Cambridge.

Farrell, M.J. (1957) "The measurement of productive efficiency", *Journal of the Royal Statistical Society*, Series A, General, 120(3):253-281.

Jefferson, G., T. Rawski, and Y. Zheng (1992) "Growth, efficiency and convergence in China's state and collective industry", *Economic Development and Cultural Change*, 40:239-266.

Kalirajan, K.P. (1990) "On measuring economic efficiency", *Journal of Applied Econometrics*, 5:75-85.

Li, D.D. (1996) "Ambiguous property rights in transitional economies: The case of Chinese non-state sector", Journal of Comparative Economics, 23:1-19.

Lin, Y. (1992) "Rural reforms and agricultural growth in China", *American Economic Review*, 82:34-51.
Lin, Y. (1996) "State intervention, ownership and state enterprise reform in China", A paper presented at the 23rd Pacific Trade and Development Conference, Taipei, December 1996.

Lovel, C.A. Knox (1993) "Production frontiers and productive efficiency", in Fried, H.O., C.A. Lovel and S.S. Schmidt, ed., *The measurement of Productive Efficiency: Techniques and Applications*. Oxford University Press, New York, N.Y.

McMillan, J., J. Whalley, and L. Zhu (1989) "The impact of China's economic reforms on agricultural productivity growth", *Journal of Political Economy*, 97:781-807.

Seiford, L.M. and R.M. Thrall (1990) "Recent developments in DEA: The mathematical programming approach to frontier analysis", *Journal of Econometrics*, 46(1/2):7-38.

Weitzman, M. and C. Xu (1994) "Chinese township-village enterprises as vaguely defined cooperatives", *Journal of Comparative Economics*, 18:121-145.

Woo, W.T., W. Hai, Y. Jin, and G. Fan (1994) "How successful has Chinese enterprise reform been? Pitfalls in opposite biases and focus", *Journal of Comparative Economics*, 18:410-437.

World Bank (1992) Reform in 1990 and the Role of Planning, Washington, DC.

Zhang, W. (1996) "Decision rights, residual claim and performance: A theory of how the Chinese state enterprise reform works", Working Paper No. 82, Department of Economics and Finance, City University of Hong Kong, Hong Kong.

Table 1: Summary Statistics (Industrial Firms in Shanghai, 1996-1998)

Ownership	No. of firms	Mean	S.D.	Minimum	Median	Maximum
Panel A: Average Assets						
State-owned	937	99743.78	229332.28	561.33	33739.33	3906240.00
Collective	213	12988.23	29972.96	31.00	5156.67	362546.33
Private	105	54469.26	113927.09	732.67	16326.67	910969.00
Foreign	276	51838.25	104197.05	1268.00	16068.3	1044986.67
H-M-T	407	132116.07	240606.29	934.67	45702.67	2316822.67
Joint Ventures	51	32612.06	38357.52	1486.00	25740.33	242436.67
Overall	1989	86318.50	200703.53	31.00	25467.00	3906240.00
Panel B: Average Revenue						
State-owned	937	66740.35	152576.79	119.33	19803.67	2274530.00
Collective	213	9428.00	16560.61	211.67	4656.67	144750.33
Private	105	48797.94	112888.88	1316.00	14231.67	934416.33
Foreign	276	39827.07	98828.64	304.00	12160.33	1293457.00
H-M-T	407	109943.44	208832.65	433.33	33450.33	1999771.33
Joint Ventures	51	24180.40	31652.04	914.67	15542.33	157539.67
Overall	1989	63670.24	151089.41	119.33	16652.00	2274530.00
Panel C: Average No. of Employees						
State-owned	937	666.86	949.74	12.00	355.00	10169.00
Collective	213	172.41	184.28	7.00	113.67	1255.67
Private	105	347.86	505.61	16.67	162.67	4097.00
Foreign	276	191.80	328.73	5.00	85.83	3308.67
H-M-T	407	279.01	399.14	1.33	142.33	3189.00
Joint Ventures	51	250.95	313.86	17.33	166.67	1585.33
Overall	1989	441.12	734.03	1.333	201.33	10169.00

Note: Assets, revenues and number of employees per firm are the average taken over three years.

Table 2: Summary Statistics of Efficiency Scores (%)

Group	1 State-owned	2 Collective	3 Private	4 Foreign	5 H-M-T	6 Joint venture
1996	57.52[a]	66.48	69.15	71.49	69.72	60.47
	(25.25)[b]	(27.73)	(23.73)	(24.46)	(25.42)	(22.68)
1997	53.49	67.68	66.59	69.77	69.92	58.65
	(25.89)	(27.29)	(25.62)	(24.90)	(24.81)	(21.29)
1998	55.01	72.15	64.62	68.06	70.20	61.62
	(26.66)	(26.33)	(23.95)	(25.58)	(25.26)	(24.55)
Pooled	55.34	68.77	66.78	69.77	69.95	60.25
	(25.98)	(27.19)	(24.44)	(24.99)	(25.15)	(22.77)

[a] Mean Efficiency Score
[b] Standard Deviation of Efficiency Scores

Table 3: Regression Analysis of Efficiency Scores

Models	1	2	3	4	5
R^2	0.274	0.025	0.093	0.288	0.141
Intercept	43.60	61.24	55.11	43.80	49.12
	(1.57)	(0.55)	(0.74)	(1.56)	(0.92)
Ownership dummy:					
Collective	14.43		13.49	14.57	13.60
	(1.58)		(1.72)	(1.57)	(1.67)
Private	10.31		11.56	10.32	10.62
	(2.11)		(2.33)	(2.09)	(2.27)
Foreign	14.34		13.38	13.13	12.61
	(1.44)		(1.57)	(1.44)	(1.53)
H-M-T	16.62		12.46	13.88	12.21
	(1.24)		(1.44)	(1.31)	(1.40)
Joint Venture	1.96		4.49	2.01	4.12
	(2.97)		(3.26)	(2.94)	(3.17)
X/A		0.17	0.10	0.14	0.10
		(0.02)	(0.02)	(0.02)	(0.02)
Herfindahl Index					98.59
					(9.38)
Industry dummy:					
Special Equipment	6.16			6.16	
	(2.16)			(2.13)	
Transport Equipment	14.16			13.98	
	(2.52)			(2.50)	
Instruments	5.15			4.07	
	(2.53)			(2.52)	
Other Manufacturing	16.44			15.59	
	(3.70)			(3.67)	
Chemicals	7.88			8.03	
	(2.37)			(2.35)	
Pharmaceutical	21.43			21.13	
	(3.36)			(3.32)	
Printing	16.41			16.56	
	(2.76)			(2.73)	
Plastic	18.77			18.68	
	(3.11)			(3.08)	
Furniture	32.15			32.07	
	(4.23)			(4.19)	
Sport Equipment	18.13			17.07	
	(2.96)			(2.94)	
Nonferrous Metals	31.64			30.89	
	(3.79)			(3.76)	
Garment and Fabric	13.18			11.82	
	(2.78)			(2.76)	
Wooden Products	21.71			21.73	
	(4.44)			(4.40)	
Rubber Products	31.75			31.49	
	(4.22)			(4.18)	
Electronic and Communication Equipment	-9.80			-11.49	
	(2.39)			(2.39)	
Electrical Engineering	5.30			4.91	
	(2.34)			(2.32)	
Fur and Leather	33.97			33.81	
	(4.53)			(4.49)	
Textile	12.94			12.20	
	(2.23)			(2.21)	
Paper Products	35.19			35.44	

	(4.22)	(4.18)
Metallic Products	11.67	11.22
	(2.35)	(2.33)
Non-metallic Mineral Products	15.17	15.13
	(2.94)	(2.91)
Food Manufacturing	7.29	7.77
	(3.10)	(3.07)
Food Processing	34.25	34.71
	(4.15)	(4.12)
Beverage Manufacturing	21.74	22.38
	(4.63)	(4.59)
Ferrous Metals	38.81	38.77
	(4.82)	(4.78)

Notes:

1. Efficiency score, X/A (Export revenue to total assets) and Herfindahl index are the average value of 96-98.
2. To avoid perfect correlation, state-owned-enterprise dummy and general-machine-building industry dummy are dropped.
3. Standard errors of estimation are in the parenthesis.

Table 4: Effects of Industry Concentration

Dependent Variable	Mean Efficiency Score	S.D. of Efficiency Score
Intercept	0.613	0.206
	(0.034)	(0.011)
Herfindahl Index	0.825	-0.053
	(0.293)	(0.099)
R^2	0.249	0.012

Note: Standard errors of estimation are in the parenthesis

Table 5: Regression Analysis of Malmquist Index

Models	1	2	3	4
R^2	0.029	0.011	0.029	0.011
Intercept	0.991	1.024	0.991	1.030
	(43.402)	(104.870)	(43.396)	(82.736)
Ownership dummy:				
Collective	0.071	0.080	0.071	0.080
	(3.098)	(3.538)	(3.105)	(3.533)
Private	-0.006	-0.008	-0.006	-0.007
	(-0.191)	(-0.262)	(-0.191)	(-0.232)
Foreign	0.004	0.016	0.003	0.016
	(0.205)	(0.749)	(0.130)	(0.785)
H-M-T	0.057	0.067	0.054	0.067
	(3.178)	(3.522)	(2.808)	(3.534)
Joint Venture	0.046	0.039	0.046	0.040
	(1.061)	(0.916)	(1.063)	(0.924)
X/A		0.000	0.000	0.000
		(1.289)	(0.537)	(1.279)
Herfindahl Index				-0.097
				(-0.765)
Industry dummy:				
Special Equipment	0.048		0.048	
	(1.542)		(1.542)	
Transport Equipment	0.072		0.072	
	(1.960)		(1.953)	
Instruments	0.119		0.117	
	(3.225)		(3.180)	
Other Manufacturing	-0.015		-0.016	
	(-0.276)		(-0.296)	
Chemicals	-0.011		-0.011	
	(-0.325)		(-0.319)	
Pharmaceutical	0.005		0.004	
	(0.096)		(0.088)	
Printing	0.031		0.031	
	(0.772)		(0.777)	
Plastic	0.023		0.023	
	(0.513)		(0.510)	
Furniture	0.016		0.016	
	(0.254)		(0.253)	
Sport Equipment	0.055		0.053	
	(1.267)		(1.233)	
Nonferrous Metals	-0.055		-0.056	
	(-0.997)		(-1.013)	
Garment and Fabric	0.040		0.038	
	(0.985)		(0.939)	
Wooden Products	0.116		0.117	
	(1.804)		(1.805)	
Rubber Products	0.054		0.054	
	(0.888)		(0.882)	
Electronic and Communication Equipment	0.172		0.170	
	(4.953)		(4.857)	
Electrical Engineering	0.051		0.050	
	(1.497)		(1.482)	
Fur and Leather	-0.037		-0.037	
	(-0.563)		(-0.567)	
Textile	0.031		0.030	
	(0.960)		(0.929)	
Paper Products	0.003		0.004	

	(0.053)	(0.058)
Metallic Products	-0.008	-0.008
	(-0.230)	(-0.247)
Non-metallic Mineral Products	-0.010	-0.010
	(-0.235)	(-0.236)
Food Manufacturing	0.104	0.105
	(2.318)	(2.331)
Food Processing	-0.016	-0.015
	(-0.258)	(-0.248)
Beverage Manufacturing	0.107	0.108
	(1.588)	(1.599)
Ferrous Metals	-0.031	-0.031
	(-0.441)	(-0.441)

Notes:

4. Malmquist index is the average value of 96/97 and 97/98.
5. X/A and Herfindahl index are average values of 96-98.
6. To avoid multicollinearity, state-owned-enterprise dummy and general-machine-building industry dummy are dropped.
7. T-statistics of estimation are in the parenthesis.

Table 6: Regression Analysis of Technological Progress

Models	1	2	3	4
R^2	0.343	0.009	0.344	0.013
Intercept	0.953	1.026	0.953	1.037
	(98.853)	(204.307)	(98.831)	(162.397)
Ownership dummy:				
Collective	-0.010	-0.006	-0.010	-0.006
	(-1.044)	(-0.487)	(-1.065)	(-0.505)
Private	-0.000	-0.001	-0.000	0.001
	(-0.036)	(-0.081)	(-0.037)	(0.034)
Foreign	-0.004	0.026	-0.002	0.027
	(-0.399)	(2.412)	(-0.197)	(2.553)
H-M-T	0.012	0.035	0.016	0.035
	(1.543)	(3.560)	(1.946)	(3.617)
Joint Venture	-0.004	-0.021	-0.004	-0.020
	(-0.199)	(-0.960)	(-0.203)	(-0.929)
X/A		0.000	-0.000	0.000
		(0.433)	(-1.458)	(0.396)
Herfindahl Index				-0.191
				(-2.925)
Industry dummy:				
Special Equipment	0.109		0.109	
	(8.279)		(8.281)	
Transport Equipment	0.116		0.116	
	(7.488)		(7.507)	
Instruments	0.179		0.181	
	(11.533)		(11.610)	
Other Manufacturing	0.013		0.014	
	(0.561)		(0.615)	
Chemicals	0.010		0.009	
	(0.661)		(0.646)	
Pharmaceutical	0.055		0.055	
	(2.656)		(2.678)	
Printing	0.168		0.168	
	(9.915)		(9.904)	
Plastic	0.077		0.077	
	(4.017)		(4.025)	
Furniture	0.067		0.067	
	(2.579)		(2.584)	
Sport Equipment	0.004		0.005	
	(0.209)		(0.295)	
Nonferrous Metal	0.002		0.003	
	(0.065)		(0.113)	
Garment and Fabric	0.059		0.061	
	(3.475)		(3.580)	
Wooden Products	0.138		0.138	
	(5.056)		(5.056)	
Rubber Products	0.073		0.074	
	(2.830)		(2.845)	
Electronic and	0.290		0.292	
Communication Equipment	(19.758)		(19.800)	
Electrical Engineering	-0.019		-0.018	
	(-1.302)		(-1.262)	
Fur and Leather	-0.027		-0.026	
	(-0.957)		(-0.949)	
Textile	0.087		0.088	
	(6.381)		(6.453)	
Paper Products	0.027		0.026	

	(1.032)	(1.018)
Metallic Products	0.044	0.044
	(3.024)	(3.068)
Non-metallic Mineral Products	0.046	0.046
	(2.574)	(2.578)
Food Manufacturing	0.328	0.328
	(17.263)	(17.225)
Food Processing	-0.046	-0.047
	(-1.819)	(-1.845)
Beverage Manufacturing	0.033	0.032
	(1.177)	(1.144)
Ferrous Metals	0.032	0.032
	(1.092)	(1.093)

Notes:

1. Technical Change is the average value of 96/97 and 97/98.
2. X/A and Herfindahl index are average values of 96-98.
3. To avoid multicollinearity, state-owned-enterprise dummy and general-machine-building industry dummy are dropped.
4. T-statistics of estimation are in the parenthesis.

Table 7: Regression Analysis of Technical Efficiency Change

Models	1	2	3	4
R^2	0.038	0.006	0.038	0.006
Intercept	1.077	1.049	1.077	1.040
	(45.253)	(102.314)	(45.253)	(79.562)
Ownership dummy:				
Collective	0.059	0.078	0.060	0.078
	(2.477)	(3.277)	(2.486)	(3.284)
Private	-0.020	-0.021	-0.020	-0.023
	(-0.628)	(-0.657)	(-0.627)	(-0.701)
Foreign	-0.020	-0.031	-0.022	-0.033
	(-0.907)	(-1.440)	(-0.995)	(-1.493)
H-M-T	0.024	0.020	0.020	0.020
	(1.299)	(1.002)	(0.982)	(0.982)
Joint Venture	0.014	0.029	0.014	0.028
	(0.317)	(0.644)	(0.319)	(0.631)
X/A		0.000	0.000	0.000
		(0.448)	(0.709)	(0.463)
Herfindahl Index				0.153
				(1.144)
Industry dummy:				
Special Equipment	-0.066		-0.066	
	(-2.021)		(-2.020)	
Transport Equipment	0.099		0.098	
	(2.587)		(2.578)	
Instruments	-0.082		-0.084	
	(-2.141)		(-2.185)	
Other Manufacturing	-0.028		-0.029	
	(-0.497)		(-0.524)	
Chemicals	-0.018		-0.017	
	(-0.487)		(-0.480)	
Pharmaceutical	-0.070		-0.071	
	(-1.387)		(-1.398)	
Printing	-0.126		-0.125	
	(-3.006)		(-2.999)	
Plastic	0.007		0.007	
	(0.157)		(0.154)	
Furniture	0.020		0.020	
	(0.314)		(0.312)	
Sport Equipment	0.057		0.055	
	(1.270)		(1.226)	
Nonferrous Metals	-0.063		-0.064	
	(-1.092)		(-1.115)	
Garment and Fabric	-0.000		-0.003	
	(-0.011)		(-0.068)	
Wooden Products	0.023		0.023	
	(0.348)		(0.349)	
Rubber Products	-0.035		-0.035	
	(-0.547)		(-0.554)	
Electronic and	-0.100		-0.103	
Communication Equipment	(-2.767)		(-2.830)	
Electrical Engineering	0.102		0.102	
	(2.883)		(2.862)	
Fur and Leather	-0.010		-0.010	
	(-0.147)		(-0.151)	
Textile	-0.064		-0.065	
	(-1.890)		(-1.925)	
Paper Products	-0.039		-0.038	

	(-0.603)	(-0.596)
Metallic Products	-0.056	-0.057
	(-1.578)	(-1.599)
Non-metallic Mineral Products	-0.065	-0.065
	(-1.464)	(-1.465)
Food Manufacturing	-0.136	-0.135
	(-2.889)	(-2.870)
Food Processing	0.038	0.039
	(0.601)	(0.614)
Beverage Manufacturing	0.097	0.098
	(1.386)	(1.402)
Ferrous Metals	-0.085	-0.085
	(-1.165)	(-1.166)

Notes:

1. Efficiency Change is the average value of 96/97 and 97/98.
2. X/A and Herfindahl index are average values of 96-98.
3. To avoid multicollinearity, state-owned-enterprise dummy and general-machine-building industry dummy are dropped.
4. T-statistics of estimation are in the parenthesis.

Figure 1. Measurement of Efficiency