HAS CHINA'S ECONOMIC REFORM IMPROVED ENTERPRISE PERFORMANCE? A DEA EVALUATION OF CHINA'S LARGE AND MEDIUM ENTERPRISES

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Abstract
This paper attempts to investigate whether China's economic reform has improved enterprise performance, and what determine enterprise efficiency in the context of China's transition. Contrast to the results of improving enterprise performance measured by TFP from other studies, this paper find that there is a general tendency of divergence of enterprise efficiency rather than a convergence of firm's efficiency as is expected from a competitive market. Similar to other studies, this paper has also confirmed that SOEs are less efficient than COEs.

Why SOEs are less efficient, and how do Chinese firms respond to China's gradual economic reform and increasing market competition? Further econometric analysis suggests that firms of different ownership types seem to respond similarly to catch up with technology frontier, indicating that firms' efficiency gap may arise from their historical legacy; enterprise reform characterised by profit retention program have improved firms' efficiency at the initial stage of reform, but this positive effect has been diminishing; market competition seems to be working, but ineffectively.

JEL Codes: D24, L23, P31, P27

Keywords: Economic Reform, Enterprise Efficiency, DEA, China

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Has China's Economic Reform Improved Enterprise Performance? A DEA Evaluation of China's Large and Medium Enterprises

1. Introduction

Since the launch of China's economic reform in 1978, the investigation of whether the economic reform has improved enterprise performance, in particular performance of State Owned Enterprises (SOEs), and whether this improvement will be persistent has been a popular topic in the study of Chinese economic reform. To the extent that China's economic reform improves enterprise performance, it will provide useful academic and policy references to the reform in other transition and developing countries.

But, the results from the mass researches on this topic are mixed. In fact, two contradictory views about the effect of China's economic reform on SOE performance have emerged from the literature. One is that China's economic reform has improved SOE performance, characterised by the increasing TFP since 1980s' (Chen et al., 1998, Jefferson et al., 1996). The other, based on the declining of SOE profitability, is that economic reform has not improved SOEs' performance, and SOEs have actually become a destabilizer for the whole economy (Sachs and Woo, 1997).

However, neither productivity nor profitability is necessarily a good indicator of enterprise performance in transition economies. On one hand, Bai et al. (1996) suggested that improved productivity could possibly be an index of even lower economic efficiency given significant non-profit objectives of SOEs. They suggested that when the objectives of the manager differs from that of profit maximization, higher productivity can induce distorted behaviour that partially or totally offsets efficiency gains from improved technology[1]. On the other hand, the falling profitability may result from the emergence of competition from the non-state enterprises, which is a desirable effect of economic reform (Naughton, 1995; Jefferson and Rawski, 1994). Moreover, the falling profitability could possibly be an artificial result due to expanded managerial autonomy. As when managers' autonomy is expanded, managers have both the incentive and discretion to manipulate the financial account (Sicular, 1995).

In order to assess accurately the effect of China's enterprise reform, there is clearly a need to measure enterprise performance in a more robust way. As efficiency improvement is a major objective of economic reform, is considered a survival condition for firms in a competitive environment, and is central to firm's long term growth (Bain, 1969). In this paper Data Envelopment Analysis

is applied first to Large and Medium enterprises, of which SOEs dominate and where the Chinese enterprise reform have focused on, from a Chinese Province to calculate directly enterprise efficiency and to estimate whether enterprise performance, in terms of efficiency, has been improved or not. In addition to these, this paper also tries to investigate the effects of Chinese economic reforms upon enterprise efficiency and how firms respond to changing markets.

This paper is organised as follow, in section 2 the concept of efficiency and the efficiency measurement used in this chapter are introduced; In section 3, the data used in the study is described. In section 4, the estimations of DEA and Malmquist index are implemented and the results are reported. In Section 5, a number of mechanisms by which enterprise efficiency can be improved are discussed, and a panel data regression model is used to estimate the effect of economic reform, market competition, and ownership upon firms' efficiency index estimated in section 4. In section 6, a dynamic panel data analysis is applied to study the dynamic process of firms' strive to catch up with technology frontier. The final section concludes.

2. Concept of Efficiency and Efficiency Measurement

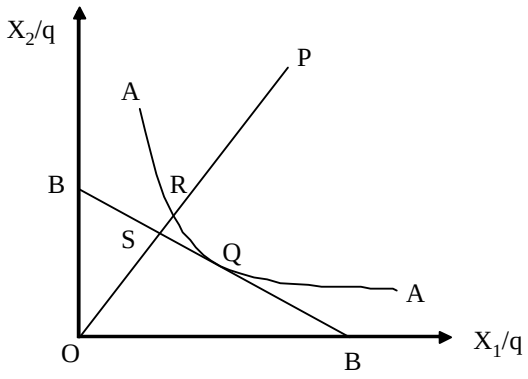
(1) Concept of Efficiency

The efficiency of a production unit is defined as the ratio of observed to optimal values of its output and input. The comparison can take the form of the ratio of observed to maximum potential output obtainable from the given input, or the ratio of minimum potential to observed input required producing the given output. Productive efficiency of a firm consists of two components: *technical efficiency*, which reflects the ability of a firm to obtain maximal output from a given set of inputs, and *allocative efficiency*, which reflects the ability of a firm to combine the inputs and the outputs in optimal proportions, given their respective prices.

Farrell (1957), who drew upon the work of Debreu (1951) and Koopmans (1951), introduced a measure of technical efficiency, which is defined as one minus the maximum equiproportionate reduction in all inputs that still allows continued production of given outputs. If prices are available, Lovell (1993) proved that a measure of economic efficiency (cost efficiency) can be provided by the ratio of minimum cost to observed cost given the objective of the production unit is cost minimisation, thereafter a measure of allocative efficiency can also be calculated by the ratio of economic efficiency to technical efficiency.

This idea can be illustrated in simple firms using two inputs x_1, x_2 to produce a single output q. The unit isoquant of the efficient firms is represented by AA in Figure 4.1, and assumes constant returns to scale. It shows various combinations of inputs producing a unit level of output.

Figure 1: Illustration of the Efficiency Measurement



The output oriented technical efficiency of firm P will be defined as:

$$\textit{Technical efficiency} = \frac{OR}{OP}$$

A producer is said to be technically efficient if production occurs on the boundary of producer's production possibilities; it is technically inefficient if production occurs in the interior of the production possibilities set. The term technical inefficiency is used to embrace all reasons for actual performance falling short of that which could be attained given inputs.

In Figure 1, the input price is represented by the line BB, so that the allocative efficiency (price efficiency) of the firm operating at P is defined as:

$$\textit{Allocative Efficiency} = \frac{OS}{OR}$$

The economic efficiency is defined as a product of technical and allocative efficiency, which is the overall cost of producing at Q relative to P.

$$Economic\ efficiency = \frac{OS}{OP} = \frac{OR}{OP} \times \frac{OS}{OR}$$

The concept of efficiency is closely linked with the issue of productivity. The productivity of a firm is generally defined as the ratio of the outputs that it produces to the inputs that it uses. Rising productivity implies either more product is produced with the same amount of inputs, or that less inputs are required to produce the same level of output, hence rising efficiency and the outward shift of a production frontier always imply productivity growth.

Productivity change generally encompasses: technical change (an outward shift in the firm's production frontier), and change in the return to scale (a movement along the firm's production surface), and change in productive efficiency (Leibenstein's (1966) *X*-efficiency) , which can be further divided into technical efficiency (a movement towards or away from the firm's production frontier) and allocative efficiency (S.Grosskopf, 1993; Lovell, 1993; and Diewart, 2000)·

(2) Data Envelopment Analysis: a Method of Efficiency Measurement

Economic efficiency has been estimated based on two frontier models: stochastic frontier and non-stochastic frontier. Econometric approaches and mathematics programming approaches have been used to estimate these two frontiers respectively.

Data Envelopment Analysis (DEA) is the most frequently used mathematical programming approach. This approach, proposed by Charnes, Cooper and Rhodes (1978), involves the use of linear programming methods to construct a non-parametric piece-wise surface (or frontier) over the data, and against which the efficiency is measured. It is a generalisation of the Farrell (1957) single-input/single-output efficiency measures to the multiple-output case by constructing a relative efficiency score as the ratio of single virtual output to single virtual input.

In DEA, there are n Decision Making Units (DMU) to be evaluated, each DMU use different amounts of m inputs to produce s different outputs. DEA try to identify which of the n DMU can determine an envelopment surface. This envelopment surface is called empirical production function or the efficient frontier. So by comparing each DMU to the envelopment surface, the relative efficiency score are calculated. Units lie on the surface are efficient, those do not lie on the surface are inefficient.

The basic idea of Charnes et al. (1978) is that each DMU should be allowed to adopt a set of weights which shows it in the most favourable light in comparison to the other units.
The algebraic model is as follows:

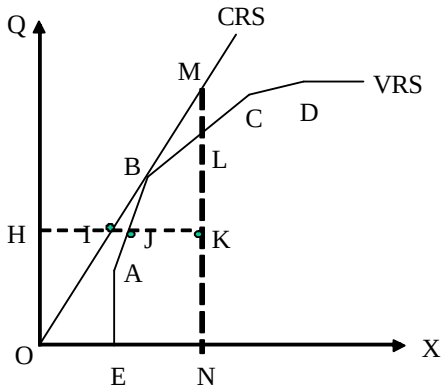
$$\text{Max } h_{j0} = \frac{\sum_r u_r y_{r\,j0}}{\sum_i v_i x_{ij0}} \quad \text{in regard to } u, v$$

$$\text{Subject to } \frac{\sum_r u_r y_{rj}}{\sum_i v_i x_{rj}} \le 1 \quad \text{for each unit } j, u, v \ge 0$$

Where (x_i, y_i) is the input output vector to be evaluated, (x_j, y_j) is the input output vector of the j th production unit in the sample. And this measure is estimated by solving N linear programs for each technology satisfying either constant returns to scale, non-increasing returns to scale or variable returns to scale.

The calculation of technical efficiency and scale efficiency is illustrated in Figure 2.

Figure 2: Illustration of DEA Calculation



CRS: Constant Return Of Scale;

VRS: Variant Return of Scale

The technical efficiency of K in the case of CRS is $\frac{HI}{HK}$. In the case of VRS,

technical efficiency is $\frac{HJ}{HK}$, and scale efficiency is $\frac{HI}{HJ}$, so that

$$TE_{crs} = \frac{HI}{HK} = \frac{HJ}{HK} * \frac{HI}{HJ} = TE_{vrs} * Scale\ Efficiency$$

DEA has several advantages for this study:

First, it places no restrictions on the functional form of the production relationship, more than one production function is admitted. It is more flexible in recognizing differences in production functions between DMUs.This is an advantage for the study on transition economies, as one of the assumptions for production function selection is perfect market competition, which is absent in transition economies.

Second, it deals with individual units rather than population average. DEA is oriented toward individual decision-making units which are regarded as responsible for utilizing inputs to produce the outputs of interest. It therefore utilizes *n* optimizations, one for each DMU, rather than the single optimization that is usually associated with the regressions used in econometric efficiency analyses. Hence, the DEA solution is unique for each DMU under evaluation.

Third, it focuses on revealing the best practice production frontier rather than on the general tendency. DMUs are directly compared against a peer or a combination of peers. And for each production unit, a single efficiency index to measure the utilisation of inputs to produce desired outputs is produced, which makes possible the following econometric analysis (Charnes et al., 1994).

Fourth, DEA provides both the sources (input and output) and amounts of any inefficiency. A deficiency of the econometric approaches is their inability to identify sources and estimate the inefficiency amounts associated with these sources. Hence, no clue as to corrective action is provided even when the inefficiencies are present.

The same characteristics that make DEA a useful tool can also create problems. It is deterministic and only gives point estimates that do not provide information about uncertainty in estimation, and the estimation depends heavily upon the correctness of frontier units, measurement error can cause significant problems. Since DEA is a nonparametric technique, statistical hypothesis tests are difficult. Simar (1996) proposed a bootstrap procedure as a solution to perform the desired inference in DEA-models.

(3) Measurement of Productivity Change: Malmquist Index

In order to measure the change of technological productivity, Malmquist firm-specific productivity indexes were introduced by Caves, Christen, and Diewert (1982). And Fare, Grosskopf, Lindgren and Ross (1989) made use of the Geometric mean of the two output based Malmquist indexes defined by the above researchers to yield the Malmquist measure of productivity.

Fare et al (1994) defines an output based Malmquist productivity change index between period s (the base period) and the period t as:

$$m_o(y_s, x_s, y_t, x_t) = \left[\frac{d_o^s(x_t, y_t)}{d_o^s(x_s, y_s)} \times \frac{d_o^t(x_t, y_t)}{d_o^{ts}(x_s, y_s)} \right]^{1/2}$$

where the notation $d_o^s(x_t, y_t)$ represents the distance from the period t observation to the period s technology. Malmquist index represents the productivity change of the production point (x_t, y_t) relative to the production point (x_s, y_s)..

The above formula can be rewritten as:

$$m_o(y_s, x_s, y_t, x_t) = \frac{d_o^t(x_t, y_{t1})}{d_o^s(x_s, y_s)} \left[\frac{d_o^s(x_t, y_t)}{d_o^t(x_t, y_t)} \times \frac{d_o^s(x_s, y_s)}{d_o^t(x_s, y_s)} \right]^{1/2}$$

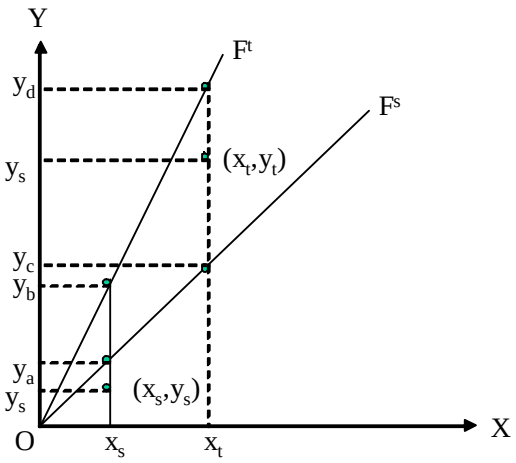
this decomposes the Malmquist output-oriented productivity index into the product of two terms. The first term is the ratio of two technical efficiency indexes from periods t and s, which indicates whether the technical efficiency has improved or not. The second term is a geometric mean of the shifts in the production frontier in two directions, which shows whether or not there is a technical change.

$$\textit{Efficiency change} = \frac{d_o^t(x_t, y_{t1})}{d_o^s(x_s, y_s)}$$

$$\textit{Technical change} = \left[\frac{d_o^s(x_t, y_t)}{d_o^t(x_t, y_t)} \times \frac{d_o^s(x_s, y_s)}{d_o^t(x_s, y_s)} \right]^{1/2}$$

This decomposition is illustrated in Fig. 3 where a constant return to scale technology involving a single input and a single output. F^t and F^s are production frontiers in period t and s respectively. The Firm produces $y^t(x^t)$ and $y^s(x^s)$ respectively in periods t and s. In each period, the firm is operating below the technology for that period.

Figure 3: Decomposition of Malmquist Productivity Index



Using the above equations, we obtain:

Efficiency change= $\dfrac{y_t/y_d}{y_s/y_a}$

Technical change= $[\dfrac{y_t/y_c}{y_t/y_d}\times\dfrac{y_s/y_a}{y_s/y_b}]^{1/2}$

And

Malmquist Productivity Index= $\dfrac{y_t/y_d}{y_s/y_a}\times[\dfrac{y_t/y_c}{y_t/y_d}\times\dfrac{y_s/y_a}{y_s/y_b}]^{1/2}$

3. Data

The data used in this study is an unbalanced panel data from a Northern Chinese province, Liaoning, covering all the large and medium industrial enterprises in this province. These enterprises includes various ownership forms, various administration structure, and distributes in various industrial sectors for the period of 1987-1996, a period when the economic reform gradually transited from 'crossing the river by groping the stone' to establishing market economic system, and the SOE reform gradually changed from expanding managerial autonomy and allowing profit sharing to establishing modern enterprise system and large scale privatisation of small SOEs.

Liaoning province is the sixth largest province in China in terms of GDP, and is an area where the central planning system has perhaps most deeply rooted. It used to be the centre of China's manufacturing industry, its industrial output accounted for more than one tenth of the total industry output in China, and the number of large and medium sized State Owned Enterprises in this province account for one tenth of the number of large and medium state owned enterprises in China. The foundation of Liaoning's industrial structure was laid down in China's first five-year plan period (1952-1957), and was characterised by heavy industry and huge SOEs. Before 1979, gross industrial output from heavy industry accounted for more than 80% of the provincial gross industrial output, and gross industrial output from large and medium enterprises accounted more than 60% of provincial gross industrial output. The most famous case of large SOE in Liaoning is Anshan Steel and Iron Company, which had long been the biggest enterprise in China before 1995, and workers employed by which typically accounted for 15% of the urban population of AnShan city where the company located.

Historically, the economy in this province to some extent is a snapshot of the entire Chinese economy. Compared with China in general, Fig. 4 shows that SOE share of Gross Output in Liaoning Province shows a similar declining tendency, and Fig. 5 shows that the GDP growth rate in Liaoning has experienced similar ups and downs, although more volatile.

Figure 4: SOE Share of Gross Industrial Output in China and Liaoning Province (%)

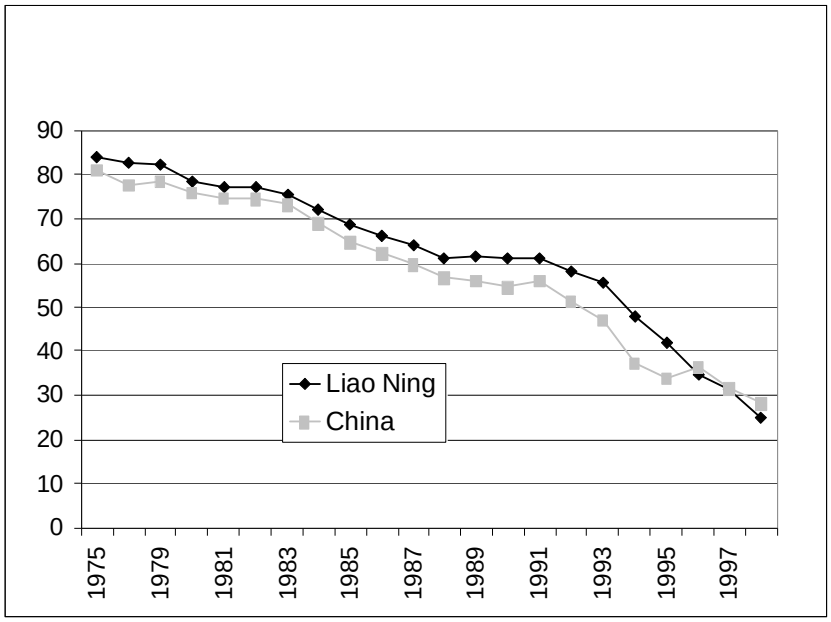
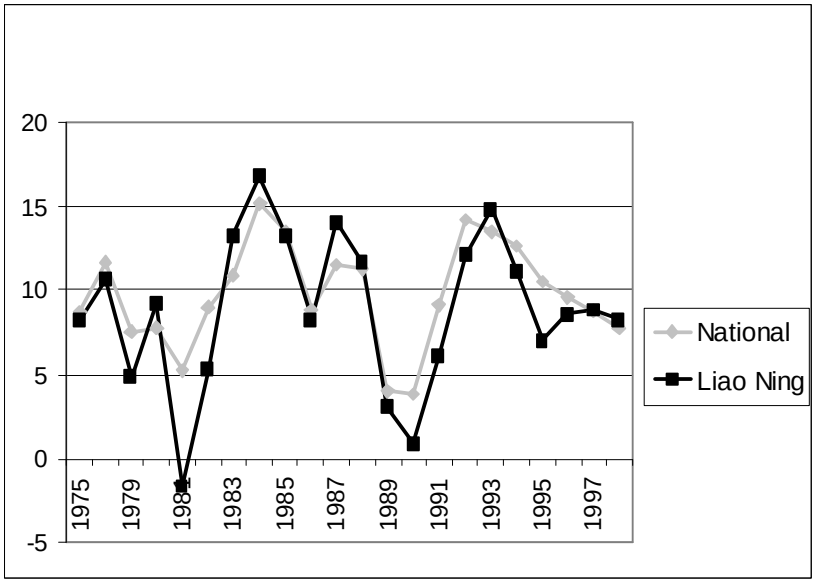


Figure 5: GDP Growth in China and Liaoning Province (%)



Liaoning province has been a pioneer in several reform initiatives, for example the first case of bankruptcy and the first case of Shareholding Company all occurred here, recently the reform of social security system are being

experimented in large scale in this province. This province has 14 cities, five of them are coastal cities; one of these latter - Da Lian - was one of the earliest cities to have been opened up to the outside world. Now it is here the problems of state owned enterprises are the most serious and it is here that the Chinese Government wants to make a breakthrough in the reform of state owned enterprises.

In the process of reform, this province has also shown some common marketisation characteristics of the whole economy. Table 1 below shows the similarity of the provincial marketisation to that of the national economy. The table gives a few indicators of the degree of marketisation of China's regions. From this table, we can also see that Liaoning to some extent on the on the national average degree of marketisation. It has the lowest multinational share, the highest state-owned share and the highest wage premium among provinces with open costal cities or special economic zones (SEZ), and its import share and tariff level are below the group average. However, compared with the averages in provinces not including "open Coastal Cities" or SEZ, the multinational share and wage premium are higher, the state owned share and tariffs are lower, the import share is smaller than only three provinces in this group.

Table 1: Selected Data from China's Regions in 1995						
	Output	**Multinational Share**	**State owned Share**	**Import Share**	**Wage Premium**	**Tariffs**
Beijing	1909	0.215	0.555	0.075	0.366	0.413
Tianjin	2094	0.240	0.284	0.430	0.522	0.306
Include "Open Coastal Cities" or SEZ (Group II)						
Liaoning	**4975**	**0.042**	**0.389**	**0.022**	**0.475**	**0.227**
Hebei	3996	0.066	0.327	0.007	0.360	0.289
Shandong	8456	0.054	0.274	0.007	0.308	0.282
Jiangsu	11813	0.102	0.176	0.008	0.353	0.223
Shanghai	5129	0.290	0.294	0.080	0.452	0.163
Zhejiang	8088	0.075	0.082	0.010	0.270	0.240
Fujian	2801	0.270	0.068	0.035	0.387	0.298
Guangdong	9535	0.271	0.000	0.075	0.330	0.215
Guangxi	1666	0.065	0.357	0.014	0.357	0.252
Hainan	193	0.204	0.054	0.348	0.436	0.172
Average	5665	0.144	0.202	0.061	0.373	0.236
Do Not include "Open Coastal Cities" or SEZ (Group III)						
Average	1736	0.035	0.551	0.028	0.418	0.214

Notes:
1. Table 1 is extracted from Branstetter and Feenstra (1999)
2. SEZ: Special Economic Zone
3. Output is measured in 100 million RMB, where 8 RMB≈$1. Multional share, State owned share and Import shares are the shares of domestic spending on multionals, state owned enterprises and imports. The wage premium equals wages paid by multinationals minus that in urban collectives, divided by that in multinationals.

Arguably therefore, the enterprise reforms in this province, especially the reform of State Owned Enterprises (SOEs), are a representative of the enterprise reform in China's manufacturing sector more generally.

In this study we use data from large and medium enterprises from Liaoning province to study the effect of enterprise reform, as the reform of large and medium SOEs is the focus of the reform of SOEs. In China, enterprise's size is classified according to criteria put forward in 1988 and amended in 1992 by National Economic and Trade Committee, National Planning Committee, National Statistics Bureau, National Financial Ministry and National Personnel Ministry. According to this criteria, enterprises can be classified into Extremely Large, Large I, Large II, Medium I, Medium II and Small Enterprises according to their productive capacity and/or productive fixed assets. For example, in Iron and Steel Industry, enterprises are classified according to their Steel Production capacity and/or their productive fixed asset. See the table below:

Table 2: Enterprise Size Classification Criteria for Iron and Steel Industry						
	Extreme Large	Large I	Large II	Medium I	Medium II	Small
Capacity	>=1.5 million tons	>=1 Million tons	0.6 - 1 million tons	0.3 - 0.6 million tons	0.1 – 0.3 million tons	<0.1 million tons
Productive Fixed Asset	>1 billion Yuan RMB					

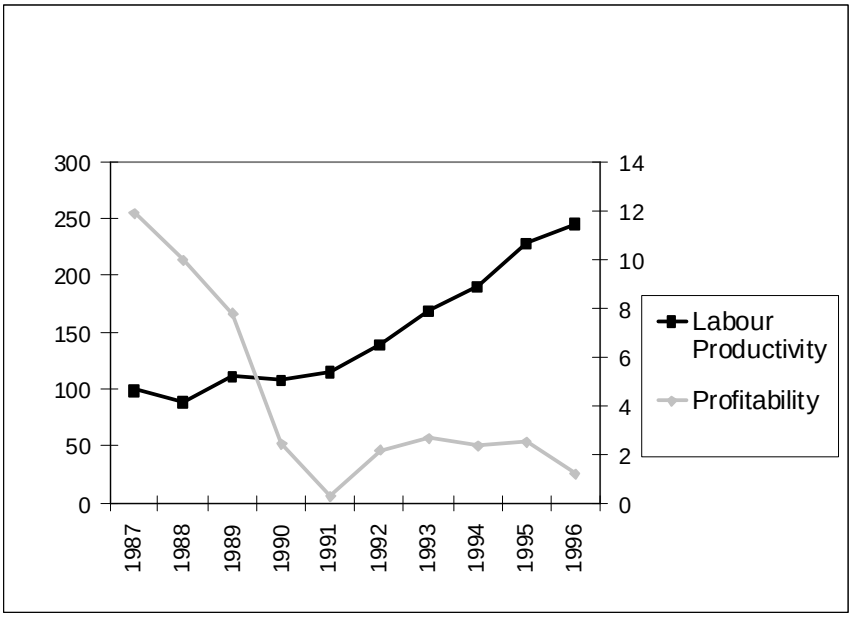
Each year, enterprises can apply to upgrade their classification as long as they have reached the required standards. Therefore, this data set is dynamic and unbalanced.

Most of the large and medium enterprises are SOEs, however the share of SOEs is decreasing. In 1987, 87.5% of large and medium enterprises are SOEs; this share decreases to 66.4% in 1996. The share of COEs has been relatively stable at around 15%. The number of non-public large and medium enterprises has increased rapidly from 1 in 1987 to 286 in 1996.

Table 3: The number of Large and Medium Enterprises							
	Number of Firms	SOEs	COEs	Domestic Private	Joint Venture	Foreign Owners	Share holding
1987	784	686	97	1	0	0	--------
1988	812	688	121	2	1	0	--------
1989	938	782	149	4	3	0	--------
1990	970	806	153	5	6	0	--------
1991	1054	866	169	0	14	5	--------
1992	1258	1012	224	1	16	5	--------
1993	1315	1020	182	47	36	5	25
1994	1318	952	188	42	69	20	47
1995	1559	1052	241	31	128	45	62
1996	1488	988	214	27	130	61	68

Similar to the picture of manufacturing enterprises at the national level, the performance of these enterprises have also shown the trends of declining profitability and rapidly increasing labour productivity, see Fig. 6. For the period between 1987 and 1996, labour productivity has more than doubled, but profit sale ratio has declined from around 12% to less than 3%.

Figure 6: Rising Labour Productivity (1987=100) and Declining Profitability (%) of Large and Medium Enterprises in Liao Ning (1987-1996)



4. Efficiency and Productivity: DEA and Malmquist Analysis

In this section, efficiency index and Malmquist productivity index are estimated for each enterprise for over 10 years, the average efficiency index and Malmquist index are reported, and the features of the frontier firms will be discussed.

(1) Input and Output Variables

There are five main variables involved in the estimation, four input variables: labour, fixed capital, current capita, intermediate inputs, and one output variable: industrial output. The definitions of the variables are defined in the following:

Industrial Output: I use gross value of industrial output (GVIO) in current prices as the measure of industrial output. This is a more appropriate measure than value-added, as value added can take negative values which is not allowed in DEA. However, this measure also has its problems. For instance, due to the government regulation of strategic important industries, the prices of important products, such as coal, iron and steel, and oil etc., have long been subject to state controls and been set lower than market prices, hence using gross value as the output measure of these products may underestimate the efficiency of firms

in these industries. Another problem associated with using gross value of industrial output is that emphasising output maximization deviates from the market-oriented objectives of economic reform. In order to solve this problem, we include both intermediate inputs and current capital as inputs, as the unsold products are recorded as inventory, a component of current asset, according to China's accounting practice.

Labour (including production workers, technicians, and management): the yearly average number of employees, which captures the employment situation through the whole year rather than just year-end employment situation, is used in this study. But the data does not distinguish between production workers, researchers and management. In general, large SOEs have the highest ratio of management to production workers. TVEs and Private Enterprises have the lowest management- production ratio.

Fixed Assets*:* Fixed assets consist of two components: productive assets and non-productive assets, both measured at their historical prices. Productive capital includes infrastructures, machinery and equipment for industrial production, whereas non-productive capital refers to apartment buildings for employees, hospitals, and sometimes even schools.

Current Assets: Current assets are the capital that can be consumed or refunded in a year or in an operating cycle, including product inventory, short-term investment, etc. For all enterprises, both year-end value of current capital and annual average value of current capital have been recorded. Here I use the annual average current capital to capture the characteristics of current capital in a whole year.

Intermediate input: Intermediate inputs are measured as values in current value. Intermediate inputs in general include raw materials, energy, depreciation, and other material consumption.

As DEA is carried out in a single time period, therefore measuring gross industrial output, fixed capital, current capital and intermediate inputs in current prices is not a problem. However, in order to calculate a Malmquist index, which estimates the change of efficiency and the shift of production frontiers over time, these variables have to be deflated. As a Malmquist Index is estimated for a firm over two consecutive years in this study, inputs and output are only deflated to the previous year's price level. For fixed assets, only the new investments are deflated. The fixed asset deflator can be found from the Statistical Yearbook of China. The intermediate input deflator can also be found

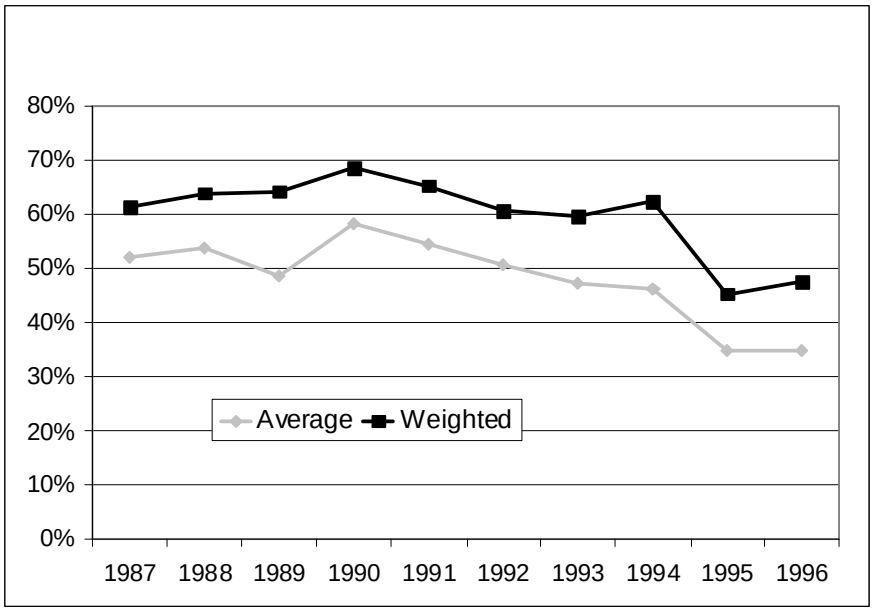
from the same source. For current assets, due to its mobility, the inflation rate is used as the deflator. For Gross Value of Industrial Outputs (GVIO), we have the growth rate of GVIO in constant prices as given, the deflated GVIO is calculated therefore by multiplying the previous year's GVIO in current price by the growth rate of GVIO.

(2) Economic Efficiency Index: DEA analysis

The actual calculation process of DEA efficiency index is conducted by *EMS (Efficiency Management System)* Version 1.3 developed by Scheel (1998). We did not distinguish scale efficiency and allowed for super efficiency.

The average efficiency index and the market share weighted average efficiency index are presented in Fig. 7. We can see that between 1987 and 1990, there is a slight increase in average efficiency index. However, from 1990 onwards, there is a general tendency of widening gap between the best practising firms and the majority of the firms, as DEA estimates the comparative efficiency. The average efficiency index has decreased from 58.36% in 1990 to 34.67% in 1996. The fact that market share weighted average efficiency index lies above the simple average efficiency index indicates that larger firms tend to be more efficient.

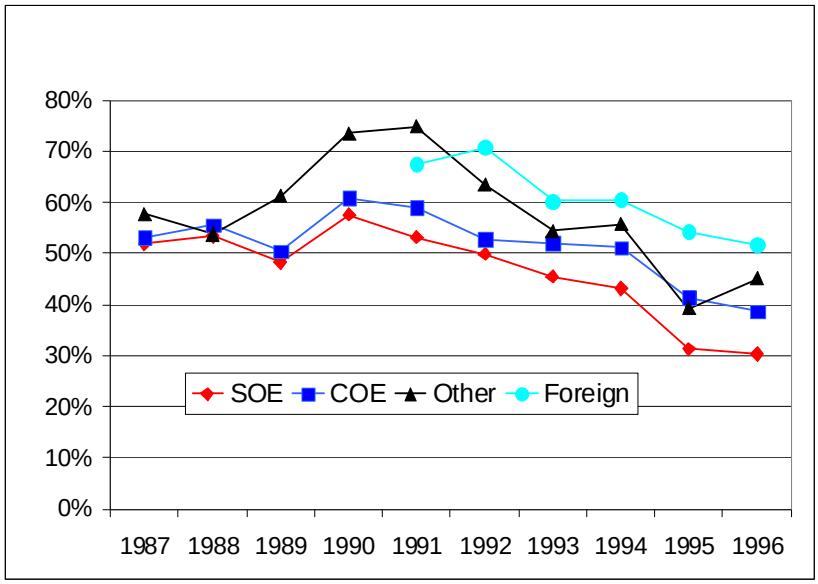
Figure 7: Average Efficiency Index



When we compare average efficiency index of different ownership forms, SOEs in average are the least efficient, with its average efficiency index below the

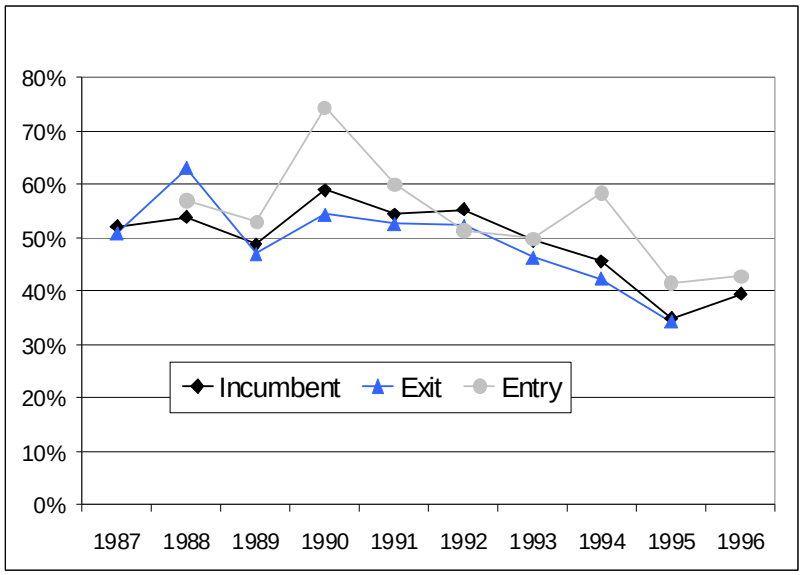
population average. The average efficiency index of foreign invested firms is more than 15% higher than that of SOEs, even though entered this dataset only after 1991. COEs also show higher technical efficiency, however, they are dominated by foreign invested firms.

Figure 8: Technical Efficiency by Ownership



This widening efficiency gap might have been caused on one hand by the entry of new firms, and on the other by the inability for inefficient firms to exit. Taking into account the dynamic feature of the dataset, the average efficiency indexes of incumbent firms, new entries[2] and exits[3] are calculated. Figure 9 shows that new entries are indeed more efficient than incumbent firms on average, exits are less efficient than incumbent firms. These imply that this increasing efficiency gap should be studied endogenously rather than exogenously.

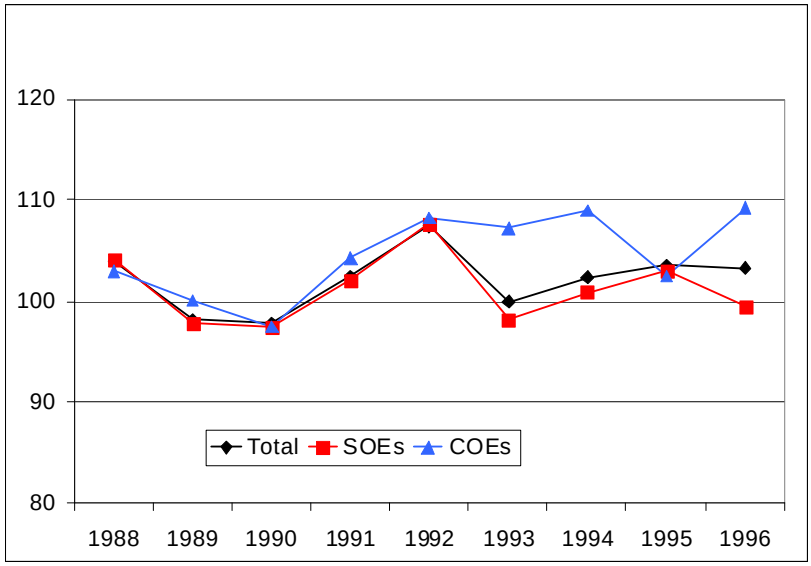
Figure 9: Efficiency Index by Entry, Incumbent and Exit



(2) Productivity Growth: Malmquist Index

In this section, we try to estimate and decompose the productivity growth by calculating enterprises' Malmquist Index. Due to the unbalanced feature the data set, the Malmquist Index can only be calculated for firms surviving the two continuous years. The calculation is also done by *EMS*. The results of average Malmquist indexes are shown in Figure 10.

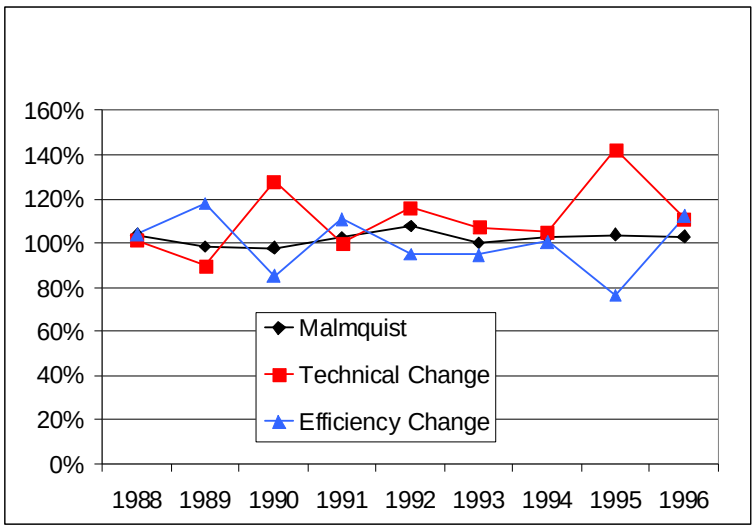
Figure 10: Productivity Change: Malmquist Index (%)



Except in 1989 and 1990, the Malmquist Index has been increasing, although the average Malmquist index has been fluctuating. And for the 10-year period, the annual average growth of productivity is 2.1%. In terms of ownership, it shows a similar picture as that of efficiency index. COEs in this aspect again outperform SOEs. And the Malmquist Productivity Index seems to be correlated with the growth of Gross Industrial Output.

By decomposing the Malmquist index into the efficiency catch up effect and the technology catch up effect, we can see that the contribution to productivity improvement orienting from technical change seems to dominate the contribution from efficiency improvement in most years especially after 1991, indicating that the productivity growth comes mainly from technical progress rather than from efficiency improvement.

Figure 11: Decomposition of Malmquist Productivity Index



(3) The Features of the Frontier Firms

With a panel dataset, it is of interest to study the stability of the efficient units. It strengthens the reliability of the approach if the same units appear on the frontier over time. It is also of importance to investigate the features of firms on the production frontier and the churning of firms on the frontiers in the context of China's economic reform. Table 4 shows the re-occurrence of some of the frontier units and the occurrence of new entries on the frontier. Before 1993, the frontier units are relatively stable. For example, 40% of the frontier units in 1987 were still on the frontier in 1992, and 50% of the frontier units in 1988

were still on the frontier in 1992. However, after 1992, the churning of frontier units accelerated. For example only 2 of the 19 frontier units in 1992 were still on the frontier in 1996.

Another significant feature need to be noted is the extent of the occurrence of new entries on the frontier. In fact, more than half of the frontier units entered into the sample in the previous three years. For example, of the 21 frontier units in 1990, 9 of them entered the dataset in the past three years; and of the 17 frontier units in 1996, 11 of them entered the dataset only in the past three years.

Table 4: The Stability of Frontier Firms (the reoccurrence of the frontier units) and The Occurrence of New Entries on the Frontier

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1987	10	7	6	6	3	4	1	0	0	1
1988	(3)	12	10	8	4	6	2	1	1	2
1989	(5)	(4)	16	9	5	6	2	1	1	2
1990	(9)	(6)	(4)	21	9	7	4	2	1	2
1991		(10)	(8)	(4)	17	10	4	3	2	1
1992			(9)	(7)	(4)	19	5	4	1	2
1993				(11)	(8)	(5)	23	5	3	1
1994					(15)	(10)	(3)	25	4	3
1995						(7)	(4)	(4)	12	4
1996							(11)	(10)	(4)	17

Note: the numbers inside the brackets are the number of frontier units in year x but do not exist in year y, where x is row, and y is column.

Although, they might not on the frontier anymore in the following years, the former frontier firms tend to have far higher efficiency scores than the population average (See table 5). For example, the average efficiency index of year 1987 frontier firms in 1996 is nearly twice as high as that of the population average, and the average efficiency index of year 1992 frontier units in 1996 is 2.2 times as high as that of the population average.

Table 5: The Average Efficiency Score of Frontier Units (%) in the Following Years									
	1988	1989	1990	1991	1992	1993	1994	1995	1996
1987 Frontier	116.14	110.30	98.78	94.72	99.77	72.93	70.91	51.50	62.61
1988 Frontier		117.15	102.36	93.92	92.39	69.32	72.25	53.29	69.82
1989 Frontier			99.84	91.75	88.66	68.49	67.55	49.07	64.51
1990 Frontier				108.50	100.18	74.18	77.94	53.83	59.60
1991 Frontier					116.79	81.24	85.26	74.10	74.30
1992 Frontier						82.69	78.37	67.06	74.48
1993 Frontier							92.50	59.66	58.51
1994 Frontier								74.66	75.02
1995 Frontier									82.28
Average	53.83	48.73	58.36	54.62	50.67	47.28	46.10	34.59	34.67

Examining the distribution of frontier units by ownership for the period between 1987 and 1996 (See table 6),

Table 6: The Distribution of Frontier Units by Ownership						
Year	SOE	COE	DPE	FOR	SHARE	Total
1987	10					10
1988	12					12
1989	14	2				16
1990	18	2		1		21
1991	11	4		2		17
1992	12	3		4		19
1993	7	6	2	5		20
1994	8	7	1	7	2	25
1995	2	5		5		12
1996	3	3	2	8	1	17
SOE: State Owned Enterprises; COE: Collective Owned Enterprises; DPE: Domestic Private Enterprises; FOR: Foreign Invested Firms; Share; Share Holding Companies						

We can see that at the beginning of the period, all of the frontier units were state owned. Since 1989, non-state owned enterprises began to occur on the frontier. Most significantly thereafter are the recede of SOEs from the frontier and the

occurrence of foreign invested firms (joint ventures and foreign owned) on the frontier. By 1996, of all 17 frontier units, only 3 are State owned, but 8 of them are foreign invested. The number of COEs on the frontier is on the increase as well, especially during the early 1990's. As such, we may argue that the newly entered firms such as COEs in 80's, and the joint ventures in 90's tend to bring into the product markets new technologies or new governance mechanisms, which make them more efficient then their counterparts in state sectors. This result is contrary to what Jefferson et al.'s (1999) idea of SOEs lead in innovations, and others follow, in some sense, it can give evidence to support the opposite.

5. Economic Efficiency, Ownership, Competition and Internal Incentive: A Panel Data Analysis

Why firms' efficiency are different, in particular why SOEs are less efficient, what are the effects of economic reform and increasing market competition on firms' efficiency? Using a panel data analysis, this section tries to answer these questions by estimating what determines firms' efficiency in the Chinese context.

(1) Determinants of Enterprise Efficiency

According to the theories of the firm, firm's inefficiency arise due to the separation of ownership and control. As firm's ownership and control are separated, there exists the agency problem, managers tending to pursue their own goals at the expense of those of shareholders (Edlin and Stiglitz, 1995; Williamson, 1964; Holmstrom et al., 1986). This agency problem cannot be dealt with through a complete contract that can be monitored without cost (Hart, 1995; Mayer, 1996; Shleifer and Vishny, 1997). To induce firms' managers to maximize profitability and to make the firm more efficient, the principal can provide incentives to managers, making their pay depending on the observed cost (Lafont and Tirole, 1986), therefore firms' efficiency can be improved by giving managers stronger incentives, or shortening the hierarchy.

Competition in capital market, product market and managerial market can reinforce the internal discipline based on performance contingence incentive contracts. Competitive markets and the ease of entry and exit are assumed to be able to reinforce firm's internal discipline and enhance firm's performance (Vickers, 1995; Nickell, 1996). There are two ways that competition may affect the behaviour of firms. The first effect is described by Vickers (1995) and Nickell (1996) as "discovery and selection", in which a low cost entrant will generate "disturbance' to the market equilibrium and may drive high cost

incumbent exit. The second effect of competition is to sharpen managers' incentives. It is argued that both manager's explicit incentives and implicit incentives will be improved as the number of competitors increase (Holmstrom, 1982; Nalebuff and Stiglitz, 1983; Hart, 1983; Nickell, 1995). Besides, in a competitive managerial market, competition help to reveal the true ability of managers, and the concern for a future career induces efficient managerial behaviours (Fama, 1980; Holmstrom, 1999). The existence of the threat of 'take over' in the capital market also acts as an incentive mechanism that deters management from the pursuit of policies that are substantially at variance with the interests of its shareholders (Yarrow and Vickers, 1988; Fama and Jensen, 1983; Grossman and Hart, 1980).

As such the differences in firms' efficiency can be attributed to the difference in the efforts of workers and managers, the organisation structure of production and the use of innovations, what Nickell termed as 'technology', and the differences in market conditions, including product market competition, market for corporate control and financial discipline (Nickell, 1997). In addition, firm's size is also associated with firm's efficiency (Hopenhayn, 1992).

(2) Determinants of Efficiency in Chinese Enterprises

Based on the above theoretical background and bearing in mind the debates on Chinese enterprise performance, we will discuss the effects of ownership, market competition, and financial discipline upon enterprise efficiency in the Chinese context, together with socialist legacy.

Ownership

Chinese enterprises typically have five different ownership forms: State Owned Enterprises (SOEs), Collective Owned Enterprises (COEs), Share ownership, Domestic Private Owned Enterprises, China-Foreign Joint Ventures and Foreign Private Owned Enterprises. SOEs are argued to be less efficient due to its SOE's social obligation other than profit maximization, government intervention, and the resulting soft budget constraints (Kornai, ; Shleifer and Vishny, 1990; Yarrow and Vickers, 1988). COEs are often assumed to be more efficiently than their state counterparts due to greater autonomy, harder budget constraints, and probably their cooperative spirits (Weitzman and Xu, 1994; Roland, 2000; Li. D., 1996).

Private ownership is considered more independent from government intervention and more profit maximization oriented, and be more efficient

consequently (Yarrow and Vickers, 1988). However, the positive effect of privatisation is not conclusive yet even in western economy (Laffont and Tirole, 1995). And the relationship between ownership and enterprise performance is not clear either in transition economies (compare, for example, conclusions in the recent reviews by Estrin and Wright, 1999 and Djankov and Murrell, 2000).

Internal incentives.

Without changing ownership, China's enterprise reform has significantly expanded SOE's contractual profit sharing rights and managerial autonomy. The retained profit can be used for R&D, employee's wage and bonus, all of which are supposed to lead to efficiency improvement. We use the ratio of the retained profit to sale revenue to capture this incentive effect.

But, as SOE's managerial autonomy having been expanded, SOE managers have more managerial discretion and face less monitoring, which consequently lead to the so called "insider control" (Aoki, 1995), SOE insiders pursuing objectives other than profit maximization, such as income appropriating and asset stripping, which is easier than improving SOEs' efficiency. Under such a condition, SOEs managers have little incentives to resist workers' wage demands. Therefore we use the wages and bonus in excess of industrial average as a measure of the degree of 'insider control'.

Market Competition

Since the start of economic reform in 1978, enterprises in China began to face increasing competition pressure coming from both SOEs and non-SOEs. However, enterprises in different sectors are not exposed to the same degree of competition. Market mechanisms were first introduced into sectors that were of no strategic importance and sectors where state owned enterprises only account for a comparatively smaller fraction of sector outputs. As a result, while consumer goods industries now have relatively lower concentration of SOEs and stronger market competition, investment good industries are still under high level of government control. Furthermore, while the entry of new non-state owned firms are encouraged, another perspective of competition pressure, the exit of non-performing SOEs, is still lagging behind due to various social and economic concerns, which consequently weaken the threat coming from takeover and exit.

The usual practice of measuring the degree of market competition in the literature is to proxy the market competition using an index of concentration.

The most popular measures of them are concentration ratio and Herfindahl Index. However, market competition is difficult to determine with any precision, and cannot be completely captured by just one variable. To avoid the problems thus created, we have used 4 measures of market competition: the four largest firm market concentration ratios (CR4), the number of competitors (the number of large and medium enterprises in three-digit industrial sector), the number of new entries in the three digit industrial sector, and firm's capital Intensity as a barrier to entry and exit.

As we look at the output share of the four largest firms (CR4) in the two-digit sectors as an indicator of the market competition, we can see that over the ten years the ratio has been staying stable in most sectors, which however has concealed a significant industrial dynamics. We expect to see competition pressure drives up enterprise's efficiency index in a more competitive market.

Financial discipline

Soft Budget Constraints has been charged for the enterprise inefficiency under socialist system and consequently its collapse (Maskin and Xu, 1999; Kornai, 1980). Hardening budget constraint has been one of the objectives of China's enterprise reform. Whether Soft Budget Constraints still exist during the reform era and its effect upon enterprise efficiency is another our concern. It is argued that in China SOEs' budgets are still soft due to their easy access to bank loan, government subsidizes, and the concern of political and social stability associated with bankruptcy (Lin and Tan, 1999).

As the State direct finance has been reduced, bank loan has become SOEs' main source of finance for Chinese firms. However, bank loans in China are considered soft, and become another form of soft budget constraint. Taxation arrear and intra-firm arrears have come out as some other forms of soft budget constraints. Soft bank loans and intra-firm arrears arguably increase the possibility of not being bail out. Compared with SOEs, Non-state enterprises, especially private owned enterprises have to face harder budget constraints. The consequence of the harder budget constraint is that activities of Non-state owned enterprises are more market-oriented, because they have to make profit to survive.

Here, the ratio of net interest expenditure to revenue is used as an indicator of firm's financial discipline. For the period after 1992, debt asset ratio is also available to capture the gearing effect of capital structure. As for the effect of soft budget constraint, for the period before 1993, there are data on profit and

tax should have been submitted to the government and the data on profit and tax have been submitted, the difference of these two values can be a proxy of the indirect soft budget constraints. For the same period, my data also have information on intra-firm arrears, which is another form of soft budget constraint. After 1993, we have data on direct government subsidy to SOEs.

Socialist Legacy

Our last concern is SOEs' historical legacies and the reform costs bore by SOEs, and their effect upon SOEs' efficiency. It is argued that SOEs have inherited from the socialist system far more social responsibilities than their non-state counterparts have, such as social security, medical care and housing, etc. As the lifelong employment policy has been gradually broken since reform, SOEs also face large pension and insurance entitlement. As SOEs' social burden to a large extend expressed in the form of unproductive asset, such as hospital, school, etc., therefore we use the ratio of unproductive fixed asset ratio as a proxy of SOEs' social obligations.

(3) Empirical Result

In estimating the impact of economic reform, ownership, market competition, financial discipline, and socialist legacy upon productive efficiency, a regression model with unbalanced one-way error component disturbances is estimated. We base our model on a production function:

$$y_{it} = \alpha_{it} f(X_{it})$$

and

$$\alpha_{it} = \beta' Z_{i,t} + u_i + e_{i,t} \qquad i = 1,....,N; \quad t = 1,....,T_i$$

where $f(X_{it})$ is linear combination of X_{it}, and is firm i's production frontier at time t, $\alpha_{i,t}$ represents firm i's efficiency at time t, $z_{i,t}$ is a vector of explanatory variables, and $u_i \sim IIN(0, \sigma_u^2)$ is firm specific factor and independent of $e_{it} \sim IIN(0, \sigma_v^2)$. We don't have time specific variables, as efficiency index is estimated against the concurrent envelopment frontier.

Following our discussion in the last section, the explanatory variables to be included in the regression are shown in table below:

Table 7: Explanatory Variables	
Ownership	
COE	Collective Owned Enterprises, dummy variable
Foreign	Foreign Funded Enterprises (joint ventures and private owned)
Other	Firms other than SOEs, COEs and Foreign
Internal Incentives	
Retain	the ratio of retained profit to revenue
retain93	interaction of retain and P93
lnpcwage	Logarithms of wages per employee
dpcwage	Deviation of the average wage per employee from industrial median
lnpcbonus	Logarithms of bonus per employee
dpcbonus	Deviation of the average bonus per employee from industrial median
Market Competition	
CR4	defined as the output ratio of the four largest enterprises in 2-digit industry in the region
numfirm	Number of firms in 2-digit industry
numnew	the number of new firms
dpcasset	Deviation of firm's asset labour ratio from that of minimum efficient size
markets	Firm's market share, defined as firm's share of sales in the market.
Financial Discipline	
interest	the ratio of interest expenditure to revenue
interest93	the interaction of interest with P93
arrear	the ratio of tax arrear to revenue
subsidy	the ratio of government direct subsidy to revenue
debtrate	The debt asset ratio
Socialist Legacy	
upasset	the ratio of unproductive to productive asset
Dummy variable	
P93	P93=1 if year>1992, otherwise p93=0 to capture the acceleration of reform since 1993.

In order to make full use of the available data (as data on taxation arrear are only available before 1993, and data on debt and government subsidy can only be found since 1993), four models have been estimated using one-way error component method for unbalanced panels. The results from the experimental estimations are reported in Table 4. Column 1 is applied to data between 1987 and 1992, Column 2 is applied to data between 1993 and 1996. Column 3,4,5, 6 are applied to full sample period.

Table 8: Efficiency and Efficiency Determinants: Fixed Effects vs. Random Effect								
	Pre-1993		After 1993		Full Sample		Full Sample with Interactive Term	
	Fixed	Random	Fixed	Random	Fixed	Random	Fixed	Random
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
Firm's Ownership								
coe	-0.010	0.022**	0.001	0.052***	0.018	0.045***	0.019	0.047***
Fore			-0.051	0.070***	0.109	0.113***	0.112	0.111***
others	-0.060**	-0.007	0.001	0.030***	-0.047***	-0.006	-0.046***	-0.005
Internal Incentives								
retain	0.282***	0.376***	0.000	0.000	0.000***	0.000	0.327***	0.510***
retain93							-0.327***	-0.511***
lnpcwage	0.190***	0.183***	-0.170***	-0.080***	-0.103***	-0.155***	-0.097***	-0.145***
dpwage	-0.036***	-0.012	0.155***	0.141***	0.069***	0.102***	0.066***	0.096***
lnpcbonus	-0.014***	-0.017***	0.036***	0.015	0.035***	0.042***	0.034***	0.041***
dpbonus	0.000*	0.000*	-0.009***	-0.008***	-0.002***	-0.002***	-0.002***	-0.002***
Market Competition								
markets	0.003***	0.002***	0.003***	0.003***	0.001***	0.001***	0.001***	0.001***
numfirm	0.001***	0.000**	-0.160***	-0.083***	-0.192***	-0.092***	-0.196***	-0.093***
cr4	0.039	0.039*	-0.001***	0.000***	-0.001***	-0.001***	-0.001***	-0.001***
numnew	-0.005***	-0.004***	-0.003***	-0.003***	-0.002***	-0.001***	-0.002***	-0.002***
lnpcasset	-0.090***	-0.030***	-0.134***	-0.059***	-0.130***	-0.072***	-0.129***	-0.071***
dpasset	0.015***	0.006***	0.011***	0.007***	0.012***	0.009***	0.012***	0.008***
Socialist legacy and Financial Discipline								
upasset	0.017	-0.018	-0.012	-0.088***	-0.046***	-0.089***	-0.046***	-0.090***
interest	-0.789***	-0.642***	-0.003*	-0.005***	-0.005***	-0.007***	0.001	-0.010
interest93							-0.006	0.003
arrear	-0.137***	-0.101**						
debtrati			-0.001***	-0.001***				
subsidy			-0.002***	-0.003***				
_cons	0.659***	0.517***	1.269***	0.888***	1.073***	0.908***	1.059***	0.888***
Statistics								
LR chi2		556.29		762.09		1629.37		1953.41
F	52.65		62.72		145.24		137.33	
R^2	0.0812	0.1405	0.0317	0.2455	0.0678	0.0891	0.0753	0.1031
Hausman	273.61		274.39		541.19		561.91	
Obs	5778	5778	5666	5666	11467	11467	11467	11467
*** = significant at 1% ** = significant at 5% * = significant at 10%								

We noticed that the Random effect estimators are superior to the fixed effect estimators, as they have considerably smaller standard errors, and the overall R-squares are also bigger. However, both Hausman test and Breusch and pagan Lagrangian multiplier test have rejected random effect models, suggesting that the assumptions underlying the random effect models are not met. Therefore,

we turn to Generalised Estimating Equations (GEE) approach described in Liang and Zeger (1996) for general linear model, under this approach standard errors do not hinge on the assumptions. The results are presented in Table 9.

Table 9: Efficiency and Efficiency Determinants: GEE				
	Pre-1993	After 1993	Full Sample	Full Sample
	Coef.	Coef.	Coef.	Coef.
Ownership				
coe	0.0299**	0.0521***	0.0460***	0.0477***
fore		0.0665**	0.1030***	0.1014***
others	0.0070	0.0293***	-0.0039	-0.0032
Internal Incentives				
retain	0.4146***	-0.0005	-0.0003	0.5460***
Retain93				-0.5463***
Lnpcwage	0.1929***	-0.0683*	-0.1595***	-0.1493***
dpwage	-0.0042	0.1349***	0.1052***	0.0997***
lnpcbonus	-0.0194***	0.0128	0.0422***	0.0420***
dpbonus	-0.0004	-0.0080***	-0.0024***	-0.0023***
Market Competition				
markets	0.0018***	0.0026***	0.0014	0.0013*
numfirm	0.0002**	-0.0004***	-0.0009***	-0.0008***
cr4	0.0313	-0.0808***	-0.0827***	-0.0834***
numnew	-0.0041***	-0.0033***	-0.0015***	-0.0016***
lnpcasset	-0.0167*	-0.0567***	-0.0650***	-0.0641***
dpasset	0.0040	0.0070***	0.0079***	0.0078***
Financial Disciplines and Socialist Legacy				
interest	-0.6035***	-0.0047**	-0.0070**	-0.0185
Interest93				0.0115
arrear	-0.0848*			
debtrati		-0.0015***		
subsidy		-0.0034***		
upasset	-0.0383	-0.0920***	-0.0954***	-0.0960***
_cons	0.4738***	0.8661***	0.8847***	0.8643***
Statistics				
Wald Test	666.37	1052.59	1967.66	2042.62
Obs	5778	5655	11467	11467
*** = significant at 1% ** = significant at 5% * = significant at 10%				

In fact, the results presented in Table 8 and 9 are similar. Evident from these regressions for the whole sample period are positively the effect of Collective ownership and higher average wage per worker, and negatively the effect of high concentration, the number of new entries, the higher than average bonus per worker, and the level of unproductive asset. Most interesting of them all is

the negative effect of concentration ratio (*CR4*) and the number of new entries (*newfirm*). I will discuss the results in more detail.

(4) Interpretation

(a) Ownership and Efficiency

For the whole sample period between 1987 and 1996, the effect of non-state ownership upon efficiency is controversial. While COEs have always been positively related to efficiency index as we have expected, the effects of foreign related firms and firms labelled others (including domestic private owned firms, shareholding companies, etc.) are not conclusive. For example, the coefficient of foreign ownership is positive in model (2), but not significant, and only weakly significant and positive in Model (4)-(6). Interestingly, this is contrasted to the conclusion we drew from section 4 that foreign firms and firms labelled others are more efficient than SOEs, which indicates that the efficiency advantages enjoyed by non-public firms (foreign invested, domestic private and shareholding firms) may not oriented from ownership structure.

(b) Efficiency and competition

All measures of competition, the number of competitors (numfirm), the number of new entry (newfirm), and the concentration ratio have significant negative effect upon firm's efficiency for the period after 1993. And the effect of newfirm was significantly negative as well for the period between 1987 and 1992, while the effect of CR4 was negative but not significant. All these suggest that competition increase the efficiency gap, and firms in more concentrated sectors lagged further behind. However, in an effective competition environment, firms' profit maximising behaviour and the pressure to survive will lead firm's efficiency to an equilibrium level.

One possible reason for the Chinese puzzle is that there are strong exit barrier within China's markets, as new firms are relatively easier to enter, the inefficient ones are difficult or not bother to exit. As such with the entry of more efficient firms, the disparity efficiency between frontier firms and majority firms becomes larger. This aspect of the market competition will not be discussed in this paper in detail.

(c) Efficiency and Internal Incentives

The effect of incentive measures has also been significant for the whole sample period. The regression results suggest that at the initial stage of reform, the profit retention does have a significant positive effect upon efficiency. However, its positive effect seems to fade away. For example, the coefficient of RETAIN in model (1) is 0.53, and is only 0.053 in model (2). By incorporating an interaction variable of retain and P93, we find that the effect of retain93 is significantly negative. Average wage per worker, another indicator of incentive mechanism, are positively correlated with efficiency index over the two periods. Interestingly incentive effect of excess bonus has been significantly negative for the two periods, which indicates the existence of insider control, under which SOEs managers distribute excessive bonus rather than wages to workers, probably because the level of wage were more closely regulated by the government.

(d) Efficiency and Financial Discipline

Regression results do show that firms respond positively to the gradually hardened budget constraints. However, even 20 years into the reform, soft budget constraints still persist. As a proxy of inexplicit government subsidy, enterprise's tax arrears are negatively associated with efficiency index for 1987-1992. Government's direct subsidy is negatively associated with efficiency index as well for 1993 to 1996. However, another form of soft budget constraint, intra firm arrears, has positive effect upon firm's efficiency. This can be explained as the effect of firms trying to get round of the hard budget constraint imposed by the government as the result of economic reform.

6. Whether Firms' Efficiency Gap Are Persistent: A Dynamic Panel Data Analysis

The above regressions have emphasized the static relationship between firms' efficiency and the determinants of firms' efficiency. However, it inadequately addresses how firms response to the dynamic competition, such as the intense competition between large firms despite the high concentration ratio, the entry of new firms, etc., and some other dynamic firm characteristics, such as the change of ownership, etc. Such dynamic characteristics may be better captured by examining the persistence of firms' efficiency gap with technology frontier.

If competition is intense and the market selection process is effective, there is likely to be a convergence in the efficiency of competing firms. As firms strive

to catch up with technology frontier to improve efficiency in order to be profitable and to survive. Those lagging behind will be sorted out. If competition is intense, but the market selection process is not effective, there is likely to be divergence in firms' efficiency. As inefficient firms do not exit, which provides disincentives for firms to improve efficiency, at the same time new firms enter which drive forward the technology frontier. With less intense competition, efficiency differences between firms may be more persistent.

This is essentially Schumpetarian perspective on the competition process. Similar to Glen et al. (2003)'s account of corporate profitability and dynamic competition, the above process is estimated based on the following first-order auto-regressive equation:

$$\beta_{it} = \gamma_i + \lambda_i \beta_{i,t-1} + U_{it}$$

where β_{it} is defined as the gap between the efficiency of firm i in time t and the technology frontier, γ_i and λ_i are the parameters to be estimated, and U_{it} is error term. The coefficient λ_i is interpreted as the speed of catch up with the technology advance (technology frontier), if $\lambda_i \in (-1,1)$, the equilibrium level of efficiency gap will be:

$$\lambda_{iLR} = \gamma_i /(1-\lambda_i)$$

Geroski (1990) suggests that this equation can be regarded as a reduced form of a more elaborate structural model involving entry, threatened entry and exit of firms, however it does not differentiate between different sources of efficiency gap persistency.

In order to account for the different sources of efficiency gap persistency, the following equation is considered:

$$\beta_{it} = \gamma_i + \sum_{j=1}^{p} \lambda_j \beta_{it-j} + x_{it}\lambda + \varepsilon_{it}$$

where γ_i is a firm specific random effect, x_{it} is a vector of covariates determining firm's , and ε_{it} is an error term. This equation is estimated via the Arellane-Bond estimator.

We report below estimation results from 4 model specifications: model 1 and 2 include one year lag, model 3 and 4 include 2 year lag. Model 2 and 4 include interactive terms

Table 10: Persistence of Firm Efficiency Gap: A Dynamic Panel Data Study

	1 year lag		1 year lag with interactive term		2 year lag		2 year lag with interactive term	
	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z
nscore(-1)	0.309***	0.00	0.314***	0.00	0.336***	0.00	0.348***	0.00
nscore(-2)					0.072***	0.00	0.077***	0.00
Ownership								
soe93			0.029***	0.00			0.034***	0.00
coe	-0.018	0.50	-0.001	0.97	-0.004	0.89	0.000	1.00
coe93			0.014	0.48			0.034	0.11
fore	0.062	0.66	0.061	0.76	0.042	0.75	0.083	0.53
dome	0.038	0.22	-0.014	0.85	0.047	0.13	0.044	0.63
dome93			0.083	0.29			0.021	0.83
share	-0.015	0.59	0.013	0.65	-0.020	0.47	0.010	0.72
venture	0.013	0.72	0.074	0.21	0.017	0.67	0.018	0.80
venture93			-0.050	0.37			0.030	0.65
owncha1	0.004	0.77	0.001	0.94	0.007	0.64	0.006	0.70
Internal Incentives								
retain	-0.158**	0.05	-0.164**	0.04	-0.205**	0.02	-0.187**	0.04
retain93	0.158**	0.05	0.165**	0.04	0.205**	0.02	0.188**	0.04
lnpcwage	0.141***	0.00	0.123***	0.00	0.105***	0.01	0.085**	0.04
dpwage	-0.057***	0.00	-0.056***	0.00	-0.054**	0.03	-0.050**	0.04
lnpcbonus	-0.054***	0.00	-0.049***	0.00	-0.042***	0.00	-0.038***	0.00
dpbonus	0.003**	0.03	0.003**	0.03	0.002	0.31	0.002	0.36
Market Competition								
markets	-0.004***	0.00	-0.004***	0.00	-0.004***	0.00	-0.004***	0.00
lnmes	0.090***	0.00	0.079***	0.00	0.082***	0.00	0.072***	0.00
numnew	0.004***	0.00	0.004***	0.00	0.004***	0.00	0.005***	0.00
numnewl	-0.001***	0.00	-0.001***	0.00	-0.001**	0.03	-0.001***	0.00
dpcasset	-0.006***	0.00	-0.006***	0.00	-0.005***	0.00	-0.005***	0.00
Socialist Legacy and Financial Discipline								
passet	-0.044***	0.00	-0.043***	0.00	-0.062***	0.00	-0.062***	0.00
interest	0.003	0.36	0.004	0.28	0.004	0.30	0.005	0.21
_cons	0.005*	0.07	0.004	0.18	0.006**	0.03	0.004	0.22

*** = significant at 1%
** = signiicant at 5%
* = significant at 10%

The Variables included in the regression is explained in Table 11:

Table 11: Explanatory Variables for Persistence of Efficiency gap	
nscore(-1)	firm's efficiency gap to technology frontier in year-1
nscore(-2)	firm's efficiency gap to technology frontier in year-2
Ownership	
soe93	interactive term of SOE and P93
COE	Collective Owned Enterprises, dummy variable
coe93	interactive term of COE and P93
Foreign	Foreign Funded Enterprises (joint ventures and private owned)
dome	Domestic private enterprises
dome93	interactive term of Dome and P93
share	Shareholding companies
venture	domestic joint ventures
venture93	Interactive term of Venture and P93
owncha1	ownership change, towards private ownership =1, towards state ownership =-1
Internal Incentives	
Retain	the ratio of retained profit to revenue
Retain93	interaction of retain and P92
lnpcwage	Logarithms of wages per employee
dpcwage	Deviation of the average wage per employee from industrial median
lnpcbonus	Logarithms of bonus per employee
dpcbonus	Deviation of the average bonus per employee from industrial median
Market Competition	
markets	Firm's market share, defined as firm's share of sales in the market.
lnmes	logaritham of minimum efficient scale in three digit industrial sector.
numfirm	Number of firms in 2-digit industry
numnew	the number of new firms
numnewl	The number of new firms in year-1
dpcasset	Deviation of firm's asset labour ratio from that of minimum efficient scale
Socialist Legacy and Financial Discipline	
passet	the ratio of productive to productive asset
interest	the ratio of interest expenditure to revenue

The results indicates *first*, that firm's efficiency gap to the technology frontier is not persistent. As the value of $\lambda_1 + \lambda_2$ is in the range of [0.3,0.45], implying that the gap will dissipate within 3 years.

Second, Non-state firms' speed to catch up with technology frontier seems to be not statistically different from that of SOEs, as none of the coefficients on ownership related variables are statistically significant. This is especially true

for COEs. This implies that firms regardless of ownership respond similarly to the competitive pressure, and firms' efficiency difference may result from their historical legacy. However, after 1992, SOEs seems to be slower in catching up.

Third, the effect of internal incentives is complicated. The profit retention program initially serves to encourage firms to catch up technology frontier (the coefficient for *retain* is negative), however after 1992, this effect turns to be around zero. Higher wages tend to increase firms' efficiency gap to technology frontier; however if it is higher than industrial average, the opposite is true. Higher bonus tends to help firms to catch up; yet, if it is higher than industrial average, then the opposite applies.

Fourth, firms with bigger market share and higher capital intensity tend to catch up the technology quickly. While firms in sectors with more new entries increased their efficiency gap with technology frontier, as is indicated by the statistically significant positive coefficient of *numnew*, they seems to learn from the new entries, as is indicated by the negative coefficient of *numnewl*, however this learning effect is much weaker than that of the lagging effect, indicating that the entry threat effect is not that effective. The results also suggest that firms in sectors with higher minimum efficient scale tend to increase their efficiency gap with technology frontier.

Fifth, firms with less socialist legacy tend to catch up with the technology frontier quicker. Yet, the effect of finical discipline is not significant.

7. Conclusion

In this paper, we applied DEA technique to estimate enterprise efficiency and productivity change in the context of Chinese large and medium enterprises during the period between 1987 and 1996. Contrasted to the results of improving enterprise performance measured by TFP from other studies, we find that there is a general tendency of divergence of enterprise efficiency rather than a convergence of firm's efficiency as is expected from a competitive market.

By estimating firms' static efficiency and firms' dynamic progress to catch up with technology frontier, it suggests that the effect of ownership upon firm's static efficiency is not conclusive. While COEs s are generally more efficient and more productive that SOEs, the ownership effect of foreign ownership, and domestic private ownership are not clear. However, firms of different

ownership types seem to respond similarly to catch up with technology frontier. These suggest that firms' efficiency difference might result from their different historical trajectory and legacy.

The analysis also suggest that profit retention program does have positive effect upon improving a firm's efficiency at the initial stage of reform, this positive effect phase out in later stage reform. As for performance wage and bonus, their effects are complicated and need to be designed properly to achieve a positive effect upon efficiency improvement.

Market competition seems to be working, but ineffectively. As new firms enter driving up the technology frontier, incumbent firms are slow to respond. Hence, we suspected that the market competitive process is not working effectively. This needs further investigation, which will be dealt with in the next chapter.

Notes

[1] For example, when SOE's performance is assessed by output level, manager's objective will be biased toward increasing output, and deviate further from profit maximizing output level. One such evidence in China is the high level of inventory. According to China Statistical Yearbook (2000), inventory build-up accounted for 6.1% of GDP on average between 1990 and 1997.

[2] As the firms in this dataset are large and medium enterprises, new entries are new to the dataset, as some of the new entries are previous small enterprises developing into medium enterprises.

[3] Large and Medium Firms exit normally in the forms of merger, and bankruptcy.

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