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IT, R&D and Productivity of Chinese Manufacturing Firms[1]

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Abstract

This paper analyzes the productivity performance of Chinese manufacturing firms from 1995 to 2003 by using a large-scale firm-level dataset from the National Bureau of Statistics, Peoples Republic of China. Over this period, a large number of firms were converted to stock holding companies, and an increasing presence of foreign-owned companies further accelerated structural changes in Chinese industry sectors. It is found that such changes of ownership positively contribute to aggregate productivity growth. In addition, IT and R&D intensity is positively correlated with firm-level productivity growth. However, we cannot find a positive impact of either IT or R&D on productivity after controlling reverse causality of productivity on IT and R&D investments.

JEL classification: D24; D30; O57 Keywords：China, IT, R&D, Productivity

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1. Introduction

China has shown outstanding economic performance since its economic reform started in the 1980s. In over 20 years of Chinese economic development, a significant change from agriculture to manufacturing and service sectors has been observed in the industrial structure. Within the manufacturing sector, a shift in output from State-Owned Enterprises (SOEs) to shareholding companies and foreign-owned enterprises has been seen (NBS, 2008). In addition, an increasing presence of foreign-owned enterprises has further accelerated structural changes in Chinese industrial sectors.

The role of productivity in GDP growth has been widely investigated by using aggregate data. Industry-level total factor productivity (TFP) growth has been calculated under the growth accounting framework (Ho and Jorgenson, 2001; Ruoen, 2007; Wu 2008), and it was found that a substantial portion of the GDP growth rate in the manufacturing sector after the 1980s can be explained by TFP growth. However, micro-data analysis that takes into account firm-level dynamics resulting from market-based economic reforms is quite rare.

In addition, it is important to investigate innovation factors which drive productivity growth at firm level. A large number of studies analyzing the impact of R&D and IT on firm-level productivity can be found for developed countries, but empirical analysis of investigating both IT and R&D on productivity in China does not exist. In 1998, ex-President Jiang Zhemin announced the “State Development through Promoting Science Technology and Education” (ke jiao xing guo)[4] policy in the 15th Party Congress. Since then, innovation and technological progress has been a priority policy matter for economic growth. Recently, the Chinese government has stressed the importance of indigenous innovation (zizhu chuanxin) in response to the severe market competition from multinationals that Chinese firms have faced since the country joined the WTO in 2002. In this sense, it is important to analyze the productivity impact of innovation factors for Chinese firms since the late 1990s.

This paper is a first attempt at analyzing the impact that IT and R&D have on firm-level productivity by using micro-data sets from the Chinese National Bureau of Statistics. Our dataset covers about 25,000 manufacturing firms from 1995 to 2003, and is taken from NBS’s Industry Statistics as well as from Science and Technology Statistics. The

[4] The first time that the “State Development through Promoting Science and Technology” policy was announced was in the “Decisions on Acceleration of Science and Technological Progress” issued by the State Council and Party Central Committee in 1995.

dataset contains variables on inputs and outputs of conventional production functions, as well as R&D expenditures and IT-related capital stock. In addition, the data includes information on ownership type for all large and medium-sized enterprises (LMEs).

This paper is organized in the following manner. In the next section is a brief history of economic reform in China, including SOE reform and open market policy for stimulating FDI. There are a number of past studies that have investigated the relationship between SOE reform and productivity, and a literature survey is also provided in this section. The following section includes a description of the data and an overview of structural changes in the Chinese manufacturing industry focusing on changes in firm ownership. In addition, the trend of IT and R&D intensity by ownership type is presented in this section. The regression analysis for IT, R&D and productivity follows in the next session. Finally, the paper concludes with a summary of findings and some policy implications.

2. Economic system reform and its impact on productivity

Many of the economic reform policies, which started toward the end of the 1970s in China, have had some influence on the ownership structure of enterprises. In the 1980s, management control of state-owned enterprises (SOEs) was delegated to each firm, but this shift did not induce labor productivity growth matched with labor input increase. As a result, company profits dropped sharply in the 1990s. On the other hand, liberalization of small business operations in rural areas had lead to the creation of large numbers of town and village enterprises (TVEs), which were treated as a symbol of market-based structural reform in the Chinese economy during the 1980s.

During his southern visit in 1992, Deng Xiaoping called for speeding up economic reform and economic growth in order to increase the inflow of FDI. With strong competition among local governments trying to attract foreign capital through policy measures such as favorable tax preferences and low-priced land provided for production use, a remarkable expansion was achieved in FDI, which increased from $4.4 billion (actual amount used) in 1991 to $68 billion in 2006. At the same time, a series of policies on market-based reforms for SOEs were introduced since from the early 1990s. Prior to 1994, the main policy measure for improving the poor performance of SOEs was to grant them more autonomy, while leaving their state-owned status relatively unchanged.[1] In 1994 the Company Law was established for the first time in China, and

[1] For details about enterprise reforms before the early 1990s, refer to Jefferson and Rawski (1994)

corporate governance systems for stock-owned enterprises, such as board-of-directors' meetings, were formally introduced. Since then, the transformation of SOEs to shareholding enterprises has accelerated, but the initial corporate law designated that more than 60% of stocks should be owned by the government. State-owned enterprise reform was accelerated again in 1997. At the 15th Party Congress that year, Premier Zhu Rongji announced his three-year schedule for accelerating SOE reforms, which consisted of measures such as the implementation of a "modern enterprise system" that allowed SOEs to declare bankruptcy, the ability to rationalize redundant employment at SOEs, and so forth. These measures have had a significant impact on employees working for SOEs.

In the process of reforming SOEs, many were transformed into limited liability joint stock-ownership enterprises. The shares of such an organization can be owned by the government as well as individual and institutional investors. However, in most cases the government holds a major share of the new firms, meaning that this process is not full privatization, but something referred to as 'corporatization' under state control (Zhu, 1999).

Corporatization has been widely criticized; for instance, Qu (2003) argued that corporate governance changed little in most of the shareholding enterprises created from SOEs because the government still maintained tight control over those enterprises. Other case studies show how governmental intervention has a negative impact on shareholding enterprises (Watanabe, 2002, is an example). However, this series of enterprise reforms must have had a significant impact on the incentive structures for improving productivity within the firms, in comparison to the era of central planning.

At the same time, the emergence and gradual growth of private enterprise and individual businesses (often referred to as *getihu*) had been generating a new ownership component for Chinese enterprises since the beginning of the economic reforms. While an ordinance from the Chinese government was issued to protect the private enterprises and *getihu*, as well as to normalize their management behavior in the market at the same time, state protection was granted to private enterprises for the first time by constitutional amendment in 1999. This resulted from the rapid expansion of private enterprise in China that had been underway since its initial formation. The output share of private enterprises in the Chinese economy is still small, but we can find some internationally competitive Chinese companies, such as Huawei Technology.

Given the previous economic dominance of SOEs and the important consequences that reforming them would have on many aspects of the Chinese economy, it is not surprising that there has been a large body of literature devoted to enterprise reform in China. Most of the previous studies focused on the consequences to efficiency caused by enterprise reform for the SOEs. Jefferson et al. (2000) for instance, investigates productivity outcomes for three types of enterprises: state-owned enterprises (SOEs), collective-owned enterprises (COEs), and other ownership enterprises (OTEs) between 1980 and 1996. They found that productivity growth in OTEs was modest compared to SOEs and COEs, and that the productivity of stock ownership enterprises actually declined in the 1990s. Zhang et al. (2001) analyzed the impact of ownership on productivity, and found that the efficiency scores of foreign-owned enterprises were the highest, with those of state-owned enterprises being the lowest. In addition, Zheng et al. (2003) used the data of some 600 SOEs from 1980 to 1994 and evaluated their efficiency levels by using data envelopment analysis (DEA) and the Malmquist index. Movshuk (2004) provides a case study of the iron and steel industry, which experienced substantial restructuring of its SOEs. One of the major findings from this study was that the efficiency level of large SOEs is not as high as smaller ones, suggesting that the government policy of merging large SOEs in this industry is ineffective.

In terms of the relationship between innovation and productivity, Zhang, Zhang, and Zhao (2003) attempts to investigate the influence of ownership on research and development (R&D) and efficiency of productivity. The main conclusion drawn from the study was that the state sector had significantly lower R&D and productivity efficiency than did the non-state sector, and that foreign firms performed better than domestic, collective-owned, and joint stock enterprises. Jefferson et al. (2006) relied on panel data sets from the National Bureau of Statistics of China (NBS) on large and medium-sized industrial enterprises (LMEs) in China to study the determinants of firm-level R&D intensity, the process of knowledge production, and the impact of innovation on firm performance. They discovered that R&D expenditures had a positive contribution on new product innovation, productivity, and profitability. Using the same rich data set, Hu and Jefferson (2005) investigated the contribution that three technological advances - technology transfers, domestic R&D, and foreign direct investment - had on productivity and knowledge production. Among the main findings of the study was that technology transfers only affect productivity through interaction with in-house R&D. Finally, Motohashi (2008) uses the same dataset used by Jefferson et al. (2003) from 1995 to 2002 to investigate the role of IT-controlled machinery and economic reforms in firm-level productivity in 2002. It found that enterprise reforms captured by the entry and exit of firms have had a positive impact on aggregate productivity growth. In addition, IT plays a relatively important role in the productivity performance of post reform enterprises, as opposed to enterprises that are not affected by major restructuring in the course of Chinese state-owned enterprise reforms.

3. Data and descriptive statistics

The dataset used in this paper is based on NBS's statistics for all LMEs; it is the same dataset used in Jefferson et al. (2006) and Motohashi (2008). This dataset comes from NBS's survey on Science and Technology Activities, which was conducted for all LMEs in the industrial sector from 1995 to 2003. In this survey, the data for industrial output and input variables came from industrial statistics. In terms of innovation indicators, in addition to R&D investment and employment, IT-related indicators are also available, such as the stock amount of production facility controlled by IT. The LMEs are defined as firms containing a minimum level of physical capacity for production. The minimum threshold varies by industry with its units corresponding to the technical characteristics of each sector, such as 'ton' for some chemicals and 'sheets' for some textiles.[2] There were about 25,000 observations in each year.

First, descriptive statistics on ownership changes in Chinese industrial enterprises are provided in this dataset. Figure 1 shows the breakdown of value added by all LMEs in terms of ownership composition. Overall LMEs fall into seven groups: (1) state-owned enterprises; (2) collective-owned enterprises; (3) Hong Kong-, Macao-, and Taiwan-owned enterprises (TMHK enterprises); (4) foreign-owned enterprises; (5) shareholding enterprise; (6) private enterprises; and (7) other enterprises. The most noticeable trend in the figure is a sharp decline in the SOE share of total value added for LMEs, from 73.0% in 1995 to 28.2% in 2003. Although deviations are noticeable in both period and indicators, observations made here are roughly in line with those found in other studies. Jefferson et al. (2006), for example, shows the proportion of SOEs to total LMEs deceasing from 67.9% in 1994 to 50.6% in 1999.

(Figure 1)

Behind the substantial decline in SOEs is a large increase among shareholding enterprises, whose share of the total value added for all types of ownership rose from 6.8% in 1995 to 33.1% in 2003. The substantial rise in the relative importance of shareholding enterprises principally reflects the results of enterprise reforms intended to convert SOEs to shareholding enterprises. The share of foreign enterprises also

[2] For a detailed discussion of the definition of criteria, see Hu et al. (2005).

increased during the same period, growing from 7.2% to 18.3%. Similar to the foreign enterprises, TMHK enterprises also doubled their share over the period, but they trailed foreign enterprises and the difference between their share of total output relative to foreign enterprises increased from 2.8% in 1995 to 8.0% in 2003. This suggests that foreign enterprises are outpacing the TMHK enterprises. It should also be noted that the share of collectives decreased during the period under review, indicating that the collectives, similar to the SOEs, are a shrinking segment within Chinese industry.

The rate of decline in the SOEs' share of total output varies substantially by industry. As is found in Figure 2, there are some industries whose SOE share was already low in 1995, such as electronics, fabricated metals and the textile industry; while the output share commanded by SOEs in food & tobacco, primary metals and utilities are relatively high at that time. In the petrochemical and mining industry, the big change in its share of total output in 2000 is due to the reform of large state-owned companies in this industry.

(Figure 2)

These drastic structural changes among Chinese manufacturing firms were the result of substantial changes in the organization and governance mechanisms of the firms, which are treated as entry and exit in terms of this dataset. Table 1 shows the number of firms in our sample by type of ownership. The number of state-owned enterprises decreased from 10,859 in 1995 to 4,334 in 2003. On the other hand, sectors that are growing include stockholding companies (833 to 5,797), TMHK firms (738 to 2,782), and foreign-owned companies (792 to 2,755). Recently, the number of private companies has also been increasing.

(Table 1)

In terms of assessing productivity performance by firm ownership, we use the following TFP index for each firm i over time t:

$$\ln TFP_{i,t}^{j} = \ln VA_{i,t}^{j} - \overline{\ln VA_{i,t}^{j}} - S_{emp_t}^{\ j} \cdot (\ln EMP_{i,t}^{j} - \overline{\ln EMP_{i,t}^{j}}) - (1 - S_{emp_t}^{\ j}) \cdot (\ln CAP_{i,t}^{j} - \overline{\ln CAP_{i,t}^{j}})$$

where VA, EMP, and CAP are value added, the number of employees, and capital stock, respectively, for firm ‘i’ in year ‘t’, and $\overline{X_{i,t}^{j}}$ is the average of X over the category by industry, country, and firm size (‘j’). S_{emp} is the share of labor compensation, i.e., an average of the ratio of total wages to value added of category ‘j’ and that of firm ‘i’. This TFP index indicates the relative productivity of each firm within each industry, country, and firm size, and is widely used in literature on the relationship between the market dynamics of productivity (Baily et al. 1992).

Constant price value added (VA) is constructed by a double deflation method using an output deflator for gross output and input deflator for intermediate inputs. Output deflators in the manufacturing sector are available as “ex-factory prices of industrial products by sector” in the Chinese Statistical Yearbook. We use this series for the deflators of gross outputs. Intermediate input deflators are calculated by using the 1997 benchmark IO table as a weighted average of output deflators for each industry. Constant price value added is estimated as deflated gross output minus deflated intermediate inputs. Constant price capital stock for non-IT capital (non-IT) is based on the book value of capital stock for structure and machinery, deflated by fixed capital formation price series for structure and machinery, respectively, taken from the Chinese Statistical Yearbook.

Figure 3 shows the relative productivity level by firm ownership. When compared to those of SOEs, TFP indices for all types of firm ownership are positive, indicating that SOEs have the lowest productivity level. Therefore, the shift of industrial outputs from SOEs to the other types has a significant effect on aggregate productivity growth. In terms of the comparison among non-SOE firms, the productivity level of foreign-owned companies is the highest; followed in order by that of TMHK-owned, private, stockholding, and collectively-owned companies. However, the private company category shows a notable increase in its productivity growth, and moves up to the highest position in 2003.

(Figure 3)

In terms of innovation indicators, we use the share of IT-controlled machinery capital to total capital stock and the share of R&D employment in total employment. The IT indicator here is different from the conventional measure of IT capital in the sense of computer, communications equipment and software used in past literature (Jorgenson and Motohashi, 2005; Motohashi, 2007). It is broader than the conventional IT capital stock because it includes IT-controlled production facilities. However, IT equipment used in non-production functions such as finance and accounting is not included. We may interpret our IT indicator as a proxy for process innovation in production facilities.

The trend of this indicator by firm ownership is described in Figure 4. Foreign-owned and TMHK-owned companies are generally well-equipped in IT as compared to domestic companies. However, the IT intensity for these two types of companies has been decreasing in recent years, and its 2003 level did not differ much from the others that year.

(Figure 4)

In contrast to IT intensity, R&D intensity in employment is not relatively higher for foreign-owned companies. In a separate study of multinationals' R&D in China, it is shown that the major objectives of R&D by foreign-owned companies are production support and customization of products for local markets based on the original technology in home countries (Motohashi, 2006). In contrast, a domestic company's main R&D sites are located inside China, so that its R&D intensity in China becomes higher in general. As is shown in Figure 5, the R&D intensity in stock-owned companies is the highest, followed by SOEs.

(Figure 5)

4. Regression analysis of productivity, IT and R&D

In this section, regression analysis is conducted to see whether investment in IT and R&D contributes to productivity growth. Our dependant variable is the relative TFP index calculated in the previous section, whereas the IT and R&D indicators as well as other controlling factors are the independent variables. Before getting into the regression analysis, however, we must first consider the possibility of sample selection bias in our datasets.

Our datasets are not generated by a random sampling framework from an entire population of firms per industry sector, but instead by a statistical survey of all large and medium-sized firms. Therefore, entry firms that cut across the size threshold of LMEs are likely to have higher productivity in the year of entry. The same logic applies to exit firms whose productivity is likely to be lower. Such selection biases are assumed to be non-negligible due to the fact that there are significant changes among samples (entry and exit) during our data period. Figure 6 shows the trend of TFP index by cohort of entry year, and it can be seen that new entry firms are always higher in productivity level than compared to continuing firms, as is presumed. We will control these selection biases by including entry and exit dummy variables for each year.

In our regression models, we use two different types of innovation indicator, ITCAPR (IT intensity in capital stock) and RDEMPR (RD intensity in employment) as explanatory variables for TFP index, as well as the following controlling variables.

- LAGE : log of firm age
- ITAGE: cross term of ITCAPR and LAGE
- RDAGE: cross term of RDEMPR and LAGE
- SOE, STOCK, FOREIGN and PRIVARE: firm type dummies
- RDSOE and so on: cross term of RDEMPR and firm type dummies
- ITSOE and so on: cross term of ITCAPR and firm type dummies
- Year dummies, entry dummies and exit dummies for each year

First, we estimate this model by using fixed effect specification for panel data, since the results of the Hausman specification test rejected the null hypothesis that an individual firm's unobservable factors are randomly distributed. In fixed effect specification, we assume the existence of firm-specific time-invariant unobservable factors, which is a reasonable assumption for firm-level productivity regression since a firm's unobservable strength is based on superior management practices, customer loyalty, employee motivation, etc., and may not change very much over time.

The regression results are provided in Table 2. In the basic model (Model 1), both IT intensity and R&D intensity have positive coefficients that are statistically significant. In addition, the negative coefficient for LAGE suggests that younger firms are more productive. In Model 2, we included the cross term of innovation indicators with LAGE, and found a positive and statistically significant coefficient for ITAGE, implying that the productivity impact of IT intensity is found particularly among old firms, but not so much for young firms. In terms of R&D intensity, we cannot find any association with productivity. In Model 3, cross terms of innovation indicators and firm type dummies are included, indicating a positive association between IT intensity and productivity, but not for R&D intensity. Finally, when all of the variables were included in the regression of Model 4, none of the variables had a statistically significant coefficient at the 5% level, but it should be noted that the coefficient to ITAGE is positive and statistically significant at the 10% level.

(Table 2)

According to our regression results, we can conclude that the IT intensity in production facilities is positively correlated to firm-level productivity, while there is also a very weak association between R&D intensity and productivity. A positive coefficient for ITAGE suggests the existence of a learning effect of IT investment; firms require some time before they can make the most of advanced manufacturing facilities. It should be noted that coefficients for RARGE are generally positive, but not statistically significant. The need for organizational learning may also be the case for R&D investments. On the other hand, aggregate productivity growth in the Chinese industrial sector has been achieved by structural changes, mainly shifting out of SOEs to stock-holding companies. In the process of such structural changes, it may be difficult for Chinese firms to accumulate organizational knowledge by using new manufacturing facilities or innovative creation efforts.

In the fixed effect model, innovation indicators are treated as exogenous variables for productivity level. However, a firm with higher productivity may invest more in IT and R&D, and such reverse causality leads to biased estimates of the coefficients. In order to control for such an endogeneity problem, dynamic panel data specification is typically used. Here, we apply a system GMM (Generalized Method of Moments) approach to control for reverse causality of ITCAPR and RDEMPR (Brundell and Bond, 1998). We include a lag of the TFP index in addition to explanatory variables, and estimate the model using first differences as well as lagged explanatory variables as instruments for GMM estimation. The results are presented in Table 3.

(Table 3)

The statistically significant results of both ITCAPR and RDEMPR in the fixed effect model disappear, and only the age effect survives. Therefore, the positive and statistically significant results, particularly found in the IT variables in Table 2, may be due to the effect of reverse causality, i.e., higher productivity firms have a tendency to invest more in IT.

5. Conclusion

This paper analyzes the productivity performance of Chinese manufacturing firms from 1995 to 2003 by using a large-scale firm-level dataset from the National Bureau of Statistics, Peoples Republic of China. Over this period, a large number of firms were converted to stock-holding companies, and an increasing presence of foreign-owned companies further accelerated structural changes in Chinese industrial sectors. It is found that such ownership changes positively contribute to aggregate productivity growth.

In addition, innovation indicators, particularly IT intensity, are positively correlated with firm-level productivity growth. However, we cannot find a positive impact of either IT or R&D on productivity after controlling for reverse causality of productivity on IT and R&D investments. More importantly, we have found that there is a learning effect associated with IT and R&D investments, so that excessive firm-level dynamics may not be a good thing for achieving innovation-driven productivity growth. The Chinese industrial sector is still in the process of structural reforms, and the creation of new firms with higher productivity levels drives aggregate productivity growth. However, it is important to have a good balance between firm-level dynamics and knowledge accumulation at firms in order to achieve a stable economic condition.

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Table 1: Number of enterprises by ownership, from 1995 to 2003

	SOE	Collective	TMHK	Foreign	Stock	Private
1995	10,859	3,205	738	792	833	2
1996	10,485	3,497	914	1,028	962	13
1997	9,900	3,391	986	1,209	1,462	30
1998	8,838	3,046	1,152	1,224	2,324	148
1999	8,057	2,874	1316	1,642	2955	284
2000	7,794	2,639	1356	1,852	3,601	426
2001	6,698	2,151	1,887	2,341	4,873	864
2002	5,880	1,875	2,133	2,590	5,330	1,161
2003	4,334	1,817	2,782	2,755	5,797	2,736

Table 2: Regression results (fixed-effect model)

	(1)	(2)	(3)	(4)
rdempr	0.052	0.009	0.020	0.005
	(3.01)**	(0.17)	(0.38)	(0.07)
itcapr	0.021	−0.031	0.043	0.005
	(3.29)**	(1.77)	(2.58)**	(0.18)
lage	−0.004	−0.005	−0.004	−0.005
	(2.19)*	(2.81)**	(2.17)*	(1.43)
rdage		0.016		0.005
		(0.91)		(0.27)
itage		0.020		0.014
		(3.16)**		(1.86)
rdsoe			0.087	0.085
			(1.48)	(1.42)
rdstock			−0.024	−0.023
			(0.40)	(0.39)
rdforeign			0.054	0.057
			(0.87)	(0.90)
rdprivate			−0.137	−0.137
			(1.46)	(1.46)
itsoe			0.008	0.001
			(0.40)	(0.07)
itstock			−0.040	−0.038
			(1.92)	(1.83)
itforeign			−0.039	−0.029
			(2.03)*	(1.45)
itprivate			−0.045	−0.040
			(1.24)	(1.10)
lagesoe				0.003
				(0.79)
lagestock				−0.001
				(0.15)
lageforeign				0.000
				(0.03)
lageprivate				0.002
				(0.26)
Constant	0.030	0.033	0.029	0.044
	(1.61)	(1.78)	(1.58)	(2.16)*
Observations	112719	112719	112719	112719
Number of coden	34582	34582	34582	34582
R−squared	0.03	0.03	0.03	0.03

Absolute value of t statistics in parentheses
* significant at 5%; ** significant at 1%

Table 3: Regression results (System GMM)

	(1)	(2)	(3)	(4)
TFP(−1)	0.846 (15.15)**	0.813 (13.87)**	0.713 (12.37)**	0.755 (15.08)**
rdempr	−0.010 (0.08)	−0.481 (0.90)	−0.033 (0.09)	−0.352 (0.60)
itcapr	−0.032 (0.99)	0.143 (0.99)	0.042 (0.45)	0.235 (1.39)
lage	−0.006 (4.26)**	−0.006 (1.46)	−0.007 (5.52)**	−0.011 (0.33)
rdage		0.181 (1.02)		0.167 (1.03)
itage		−0.062 (1.23)		−0.059 (1.30)
rdsoe			0.031 (0.08)	−0.044 (0.11)
rdstock			0.220 (0.54)	0.041 (0.10)
rdforeign			−0.026 (0.06)	0.113 (0.26)
rdprivate			−0.212 (0.38)	−0.578 (1.07)
itsoe			0.001 (0.01)	−0.003 (0.03)
itstock			−0.119 (1.20)	−0.150 (1.50)
itforeign			−0.065 (0.61)	−0.104 (0.91)
itprivate			0.138 (0.52)	0.094 (0.39)
lagesoe				0.021 (0.44)
lagestock				0.002 (0.06)
lageforeign				−0.046 (1.21)
lageprivate				0.001 (0.01)
Constant	−0.002 (0.17)	0.000 0.00	0.006 (0.28)	0.016 (0.18)
Observations	86427	86427	86427	86427
Number of coden	27935	27935	27935	27935

Robust t statistics in parentheses
* significant at 5%; ** significant at 1%

Figure 1: Changes in output by ownership

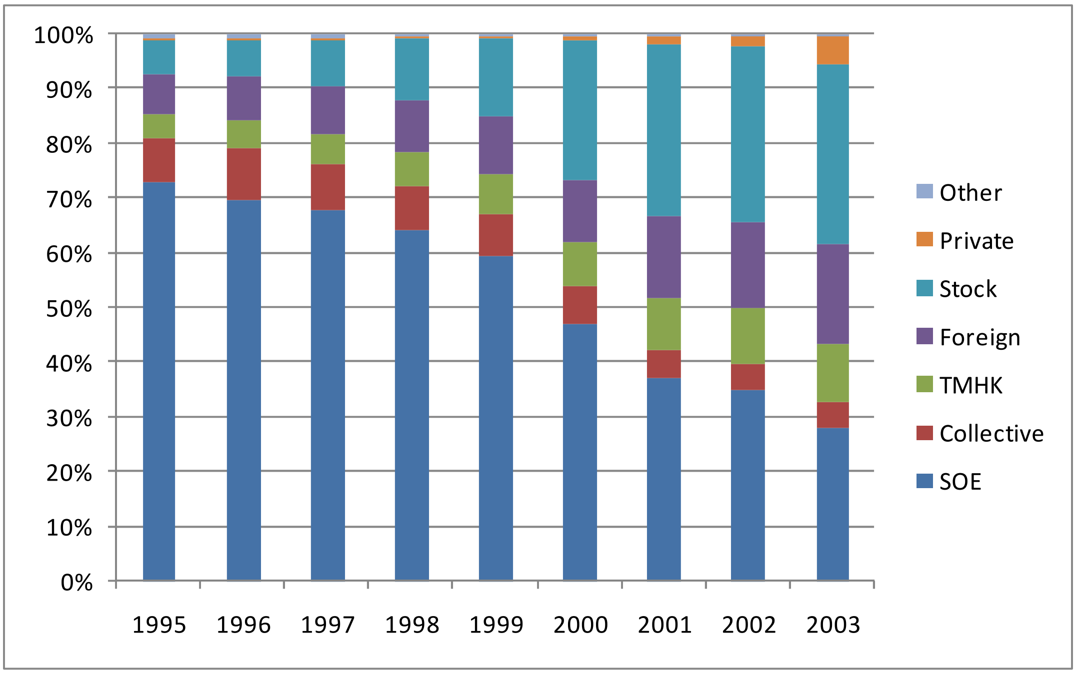

Figure 2: Share of state-owned enterprises by industry

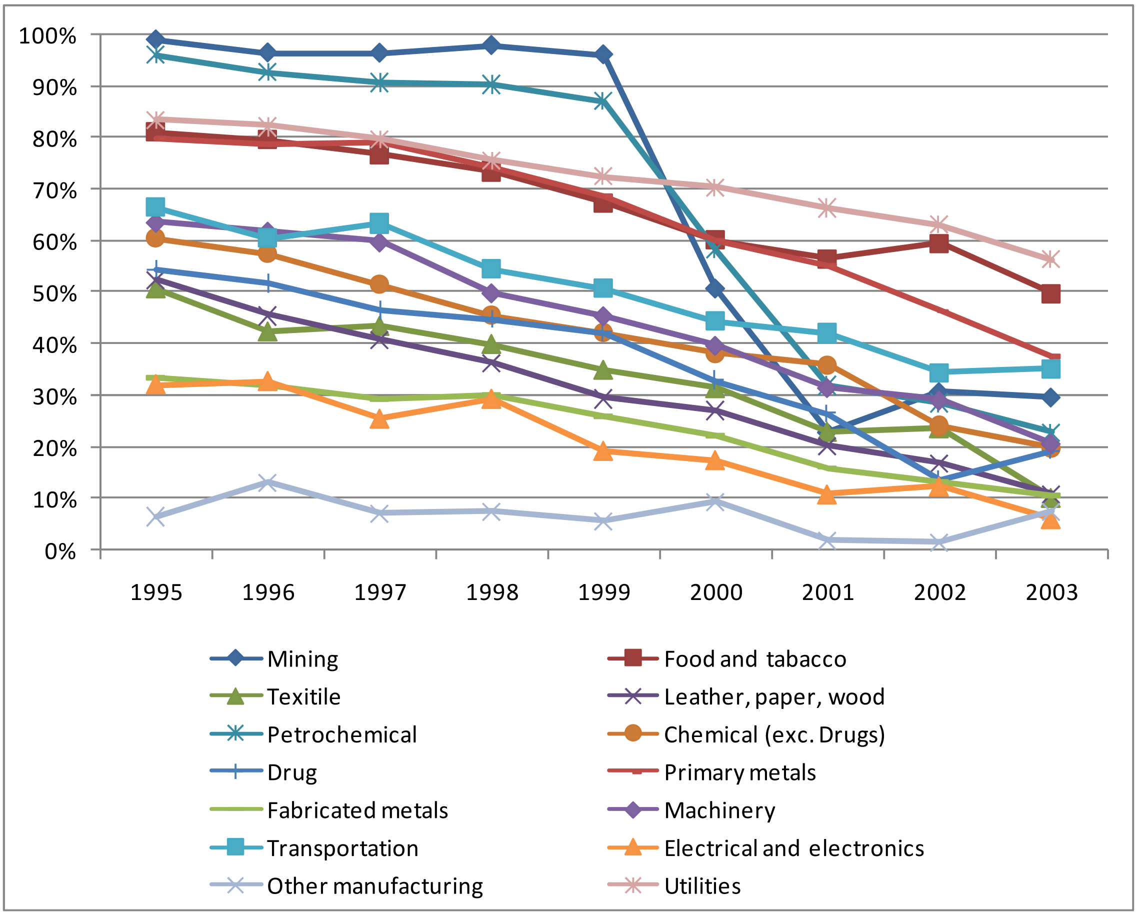

Figure 3: Relative TFP index by ownership (SOE=0)

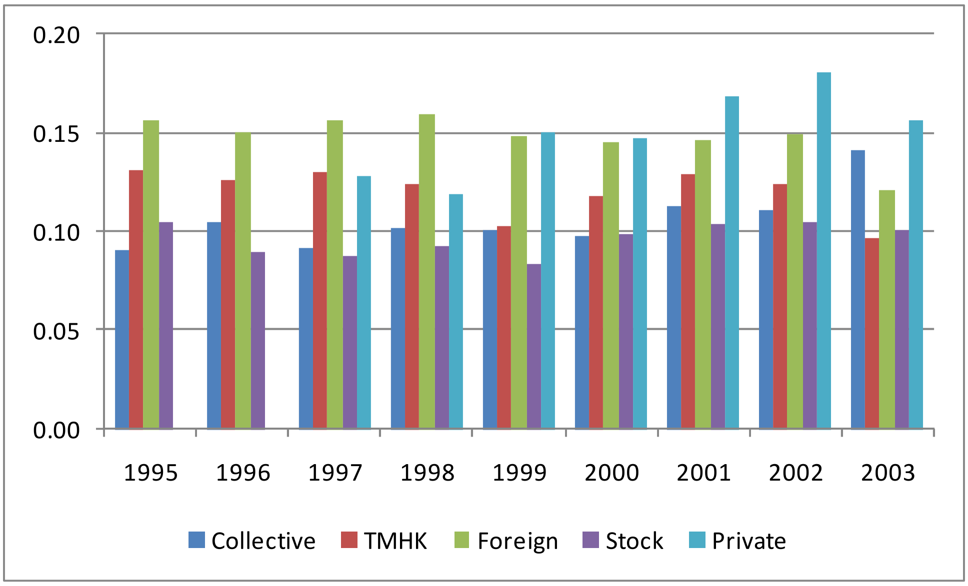

Figure 4: Share of IT-controlled machinery by ownership

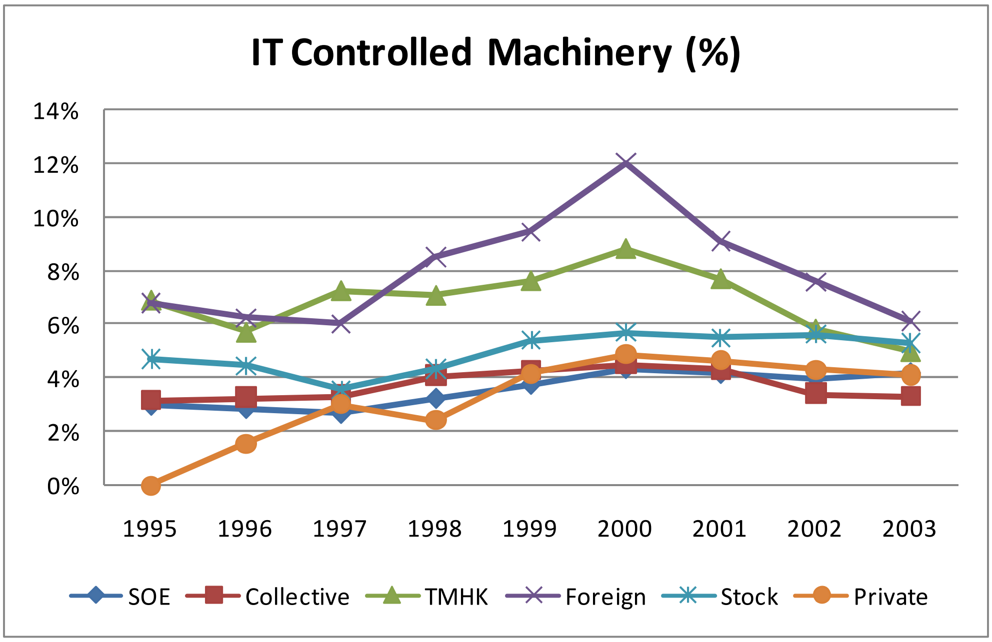

Figure 5: Share of R&D employment by ownership

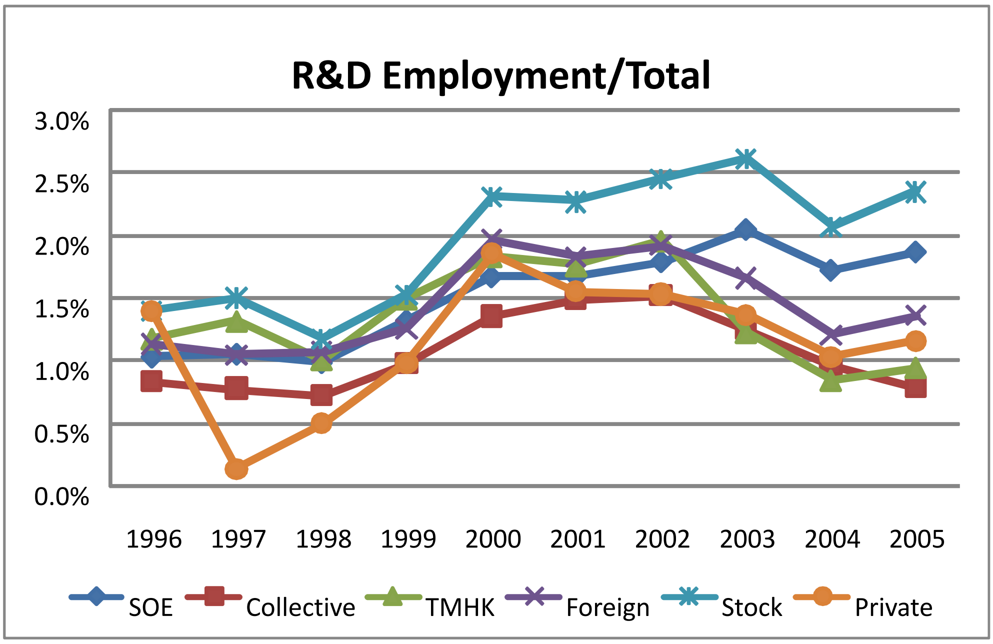

Figure 6: Productivity dynamics by cohort