Privatization, Soft Budget Constraint, and Social Burdens: A Random-Effects Stochastic Frontier Analysis on Chinese Manufacturing Technical Efficiency

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Keywords: Panel data, random effects, technical efficiency, stochastic frontier, privatization, soft-budget constraint, managerial incentives, social burdens

JEL classification: C1, C4

Abstract

Traditional panel stochastic frontier studies on privatization of Chinese State-owned firms face a major challenge, namely, the endogeneity problem. The endogeneity problem is present because decision-making process of privatization in China is very likely influenced by some unobserved characteristics of a firm. In particular, better-performing SOEs are more likely to be chosen for privatization because the local governments may have incentives to attract private investors or to retain momentum for future reform. To deal with this challenge, this paper proposes a two-step stochastic frontier model. The first step addresses the endogeneity issue by estimating the probability of privatization with a random effects probit model. The second step estimation investigates the causes of Chinese manufacturing's inefficiency with a random-effects stochastic frontier model. The estimation results suggest that privatization, hardening budget constraint and reducing firms' social obligations have significantly contributed to the improvements of firms' efficiency. However, no evidence is found that more autonomy for managers and lower debt asset ratio may help improve firms' efficiency.

"Even if a minefield or the abyss should lie before me, I will march straight ahead without looking back."

Zhu Rongji (*Former Prime Minister of China*)

1. Introduction:

China's economic reform in the last three decades has dramatically transformed the once centralized economy to a vibrant market economy. As one of the most challenging stages of this unprecedented reform, privatization of Chinese State-Owned Enterprises (SOEs) has yielded very controversial results. Unlike the massive privatizations in other former central-planned economies, privatization in China has been characterized with gradualism. As result, the state still tightly controls some of the largest and most profitable companies in China after three decades of reform. Although the influence of these SOEs on China's economy has significantly faded with varieties of measurements, they are still largely favored by government policies and vital to today's Chinese economy. Given the current declining interests to further privatize these large SOEs, it is important to reassess impacts of privatization on Chinese firms, particularly on firms' performances from a historic perspective.

This paper studies impacts of privatization on Chinese firms' technical efficiency by revisiting a very critical phase of privatization in China, namely from 1995 to 2001. During this period, privatization had started to accelerate after a decade of policy debates and gradually gained its popularity among officials at different levels as means to improve firms' performance and reduce governments' budget burdens. Thus, a study from this particular period may help one understand the impact and importance of privatization in the overall history of Chinese reform. Further, it may also shed lights on future reforms of Chinese SOEs. Impacts of privatization on Chinese firms' performance have been studied extensively. However, various empirical studies show ambiguous effects of privatization on Chinese firms' productivity. *Dong et al (2006)* finds that privatization significantly improves productivity of urban firms in China. *Otchere and Zhang (2001)* investigate long-term stock market performance of privatized firms in China. Their study shows that the privatized firms outperformed their competitors only after the third year of privatization. However, *Chun (2008)* argues that what causes SOEs to fail in China is not

because the majority stakes of the failing SOEs are owned by the state, but rather due to the massive and abrupt transition from a command to a market economy.

This paper differs from previous studies in a few important ways. First, in addition to privatization, effects of several reform measures not involving ownership changes on firms' efficiency are also examined simultaneously. The need to consider impacts of privatization along with other non-ownership reform measures on firms' efficiency is due to the fact that the central government also tried several reform policies to boost performance of the retained large SOEs without giving up controls. These reform policies include reducing excessive labor force, hardening soft-budget constraint, and offering incentives to managers, etc. Therefore, without considering these non-ownership reforms designed to improve SOEs' performance, the effects of privatization on firms' efficiency may be underestimated. Moreover, impacts of a firm's financial condition on its efficiency are also examined. A privatized firm does not necessarily perform better than SOEs if it faces large debts. So, without controlling for the state of a firm's finance in the estimation, the effect of privatization may also be underestimated. Finally, an unexpectedly worsened macroeconomic environment may also increase a firm's inefficiency in short term because the firm will find it very hard to adjust its resource allocation to the unanticipated economic shocks. Without taking into account of these unanticipated shocks, the effects of privatization may be underestimated as well. One possible solution is to use time dummies as controls in the efficiency estimation.

Second, this paper attempts to address the endogeneity problems encountered in other studies. Endogeneity has been one of the stickiest problems for empirical studies on privatization in China. It arises when some unobserved causes of privatization correlate with explanatory variables in the production function. Then, as one can expect, the estimated results would be bias. To address this problem, a two-step approach is proposed in this paper. First, a random effect probit model is estimated to fit the probability of privatization. Second, the fitted value of privatization probability is introduced to the second-step stochastic frontier estimation to capture the effects of privatization on firms' inefficiency. To diagnose endogeneity problem, a Heckman endogeneity test is performed and the results of which confirm the existence of endogeneity. In addition, the usage of stochastic frontier models requires the distribution of residuals to exhibit a

left skewed shape. Data used in this paper are investigated and it appears that the distributions of output values at each observed time period indeed exhibit left skewed shapes, justifying the use of stochastic frontier estimation.

To measure a firm's efficiency, this paper adopts a stochastic frontier model first introduced by Aigner et al. (1977) and Meeusen and Van den Broeck (1977). A stochastic frontier model is designed to capture the deviations of a firm's realized production level from its production frontier. Different from classical production estimations, a stochastic model divides the residual of a production function into two components. One is a symmetrically distributed error term and is considered as measurement error or production risk. The other is an assumed asymmetric distributed positive inefficiency term that may be caused by market structures, types of ownership or inadequate corporate governance, etc. The panel nature of stochastic frontier models has been well explored by the existing literature. A primary question in this group of studies is whether it is appropriate to model inefficiency as fixed over time. Such a question is important because different assumptions on changes of inefficiency over time may bear different implications on the sources of inefficiency. *Schmidt and Sickles (1984)* and *Lee and Schmidt (1993)* develop fixed effects and random effects models respectively in which inefficiencies are considered as time-invarying firm-specific effects. However, numerous attempts have been made since then to modify these models by adding time-varying features since it is unlikely that firms' inefficiency would stay fixed over time. Among these extended models, a generalized formulation of *Battese and Coelli (1995)*'s model is used in this paper because of its fitness with the data and its random-effects feature. In this formulation, the presence of inefficiency is attributed to both the time-varying and time-invariant sources. The time-varying source is modeled as a scaling factor on the distributions of the random-effects. It includes all variables that may change a firm's efficiency over time. The time-invariant source is modeled as a random firm-specific effect. All individual characteristics that may affect a firm's efficiency can be included in the time-invariant term. Although a random-effects model may be subject to more restrictive assumptions, the merits of such a model, as *Greene (2008)* argues, may outweigh its pitfalls under certain conditions. With a random-effects model, the impacts of time-invariant firm-specific attributes on efficiencies can be estimated whereas policy implications of those

variables cannot be estimated in a fixed-effects setting. To justify the usage of this random-effects model in this paper, a Hausman test is later conducted and its results are supportive.

The estimation results suggest several policy implications on privatization process in China, particularly on impacts of privatization on firms' efficiency. First, it is found that the overall technical efficiency of Chinese firms had declined continuously from 1996 to 2001. The decline of efficiency at both SOEs and the privatized firms from 1996 to 1998 may be largely due to tightened bank credits to all firms by the central government in an attempt to cool down the overheated economy, bad bank loans and unexpected Asian financial crisis. Second, the results also suggest that the efficiencies of SOEs and the privatized began to diverge after 1998. That is, contrary to the quick recovery and continued improvements of efficiency at the private firms, efficiency at SOEs had continued to deteriorate after 1998. This disappointing result on SOEs may suggest the failures of reforms at Chinese SOEs and the design of privatization policy in China. Any reforms at SOEs without seriously addressing ownership issues seem unlikely to be really effective in China. Moreover, by implementing the policy of "retain the big and let go of the small" and forbidding private firms from entering some "critical" industries, the Chinese government may have shielded the retained large SOEs from competition and subsequently indulge them to remain inefficient. Third, it is found, among time-invariant variables, the industry and location in which a firm operates can significantly affect its efficiency. Finally, among the time-varying causes of inefficiency, privatization, as oppose to social burden and soft-budget, is found to be significantly improving a firm's efficiency. Nonetheless, no evidence is found that managers' shares and financial wellbeing may affect a firm's efficiency.

The remainder of the paper is organized as follows. Section 2 provides some preliminary description and analysis of the data. Section 3 introduces the two-step stochastic frontier model implemented in this study. Section 4 presents and discusses estimation results. Section 5 concludes the paper.

2. Data and Descriptive Analysis

The data used in this paper come from a survey conducted in 2002 by International Finance Corporation and National Bureau of Statistics on 863 firms in 11 cities.I It provides information from 1995 to 2001 on ownership structure, accounting, employment and corporation governance.[1] The selection of these cities is not random. Harbin, Fushun, Tangshan, Lanzhou and Chengdu used to be the heart of traditional manufacturing of Chinese economy during the planned economy era. Most of the residents in those cities were employed by medium or large SOEs. As result, these cities suffered the most, with the shutdown of many SOEs as the reform of local SOEs progressed. Profitability and employment of SOEs in these cities had decreased considerably in 1990s. Xining and Guiyang are located in more remote and less developed areas. However, due to their unique geographical and strategic location, they had been chosen as sites for some large military SOEs. Therefore, the presence of SOEs in these two cities is also significant. Weifang, Zhenjiang, Huangshi, and Hengyang are cities close to coastal regions of China. The less important roles that these cities played during the centrally planned-economy era allow these cities to embrace the economic reform and privatization more enthusiastically.

2.1 Changes of ownership

As shown in the survey, the landscape of Chinese firms' ownership structure has shifted dramatically from 1995 to 2001. Figure 1 summarizes the percentages of private firms over all observations in the sample in different locations from 1995 to 2001. Prior to 1997, northern and western provinces were leaders in the share of private firms although on average the weight of private ownership was merely around 4 percent in all areas. As of 1997, 7 percent and 5.71 percent of firms in the North and the West were privately owned, respectively. In contrast, there was almost no presence of private firms in the East in the sample from 1995 to 1997. This weak presence of private firms during this period, though contrary to the overall "open-up" economic policy since 1980s, can still be explained. The Chinese communist party did not formally endorse privatization until the launch of the Ninth Five-Year Plan in 1996. Before 1996, the emphasis was not on privatizing but reviving SOEs by way of measures such as granting legal

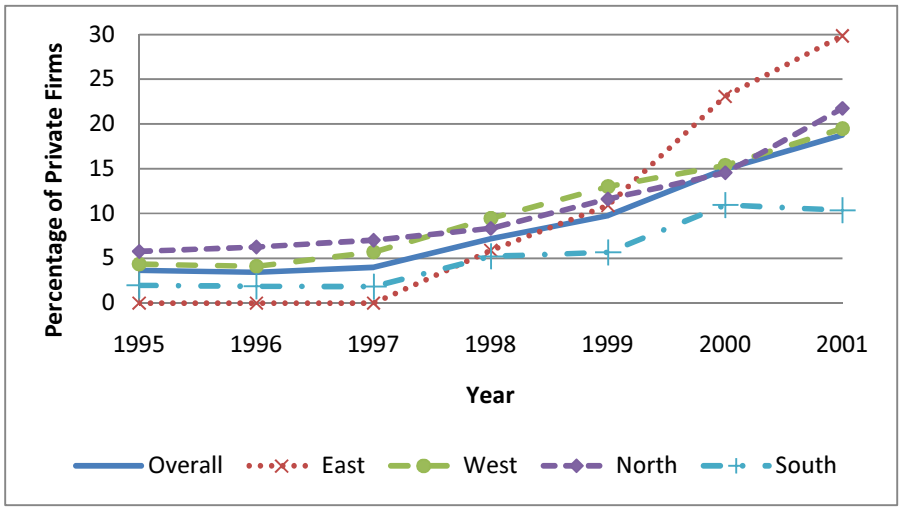
[1] These 11 cities include Harbin, Fushun, Tangshan, Xining, Lanzhou, Chengdu, Guiyang, Weifang, Zhenjiang, Huangshi and Henyang.

status to firms, allowing more autonomy, and providing incentives to managers. However, the government realized that it is very costly to keep the loss-making SOEs after a series of reforms on input prices, market entry, employment contracts, and bank lending rules. The resulting solution is to introduce a policy called "grasp the big and let go of the small" in the mid-90s. According to this policy, the central government would only preserve 500 key SOEs and the rest would be let go ultimately. The impact of this policy on the share structure of Chinese SOEs can be readily seen. Figure 1 shows that privatization of SOEs has accelerated rapidly since then. By 2001, the ending period of the survey, overall, the share of private firms has increased to almost 19 percent. Moreover, different areas exhibit different pace of privatization. Notably, the share of private firms had reached 30 percent in the East coastal regions by 2001. The inland regions were lagging behind with only 10.37 percent of firms owned privately. This finding is echoed by the disparities of reform process across China. As the engine of Chinese economic growth, the eastern region has been more aggressive in terms of adopting and implementing radical reforms.

Besides the significant increase in the number of private firms in the survey, the increasing importance of private sector in the whole economy after 1997 can also be seen in other indicators. Figure 2 shows that the share of gross revenue generated by SOEs had declined from 96 percent in 1995 to 77 percent, whereas the share of private firms had increased from 4 percent to 23 percent during the same period. Likewise, the share of gross value of output from SOEs (Figure 3) had dropped from 95 percent in 1995 to 74 percent in 2001, whereas that of private firms had climbed from 5 percent to 26 percent. On the labor market front, private firms also had employed more workers since 1997. Figure 4 reports that private firms employed 24 percent of labor force in 2001, compared to only 5 percent in 1995.

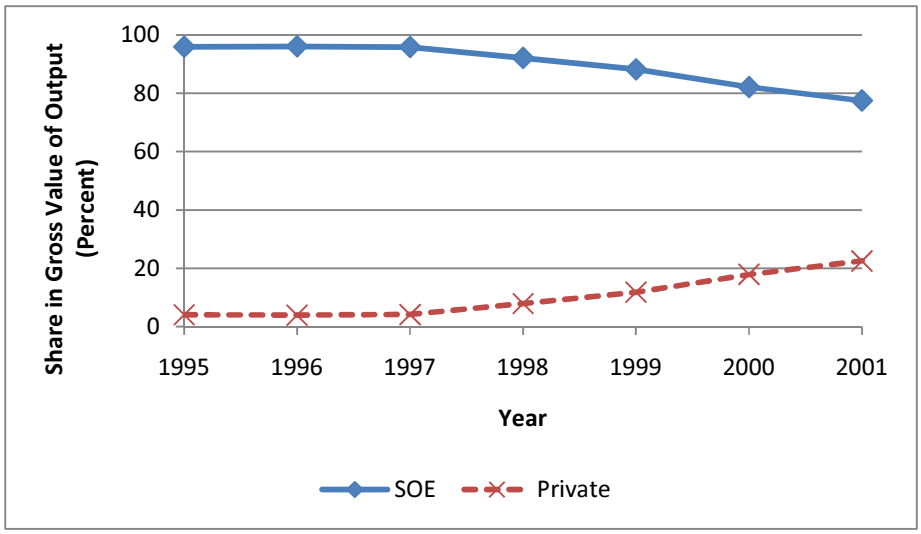
To conclude, privatization has progressed rapidly after receiving approvals from the policymakers and yet SOEs were still the dominant force in China with respect to overall economic importance during the period covered by the survey.

Figure 1 Changes of Ownership, 1995-2001



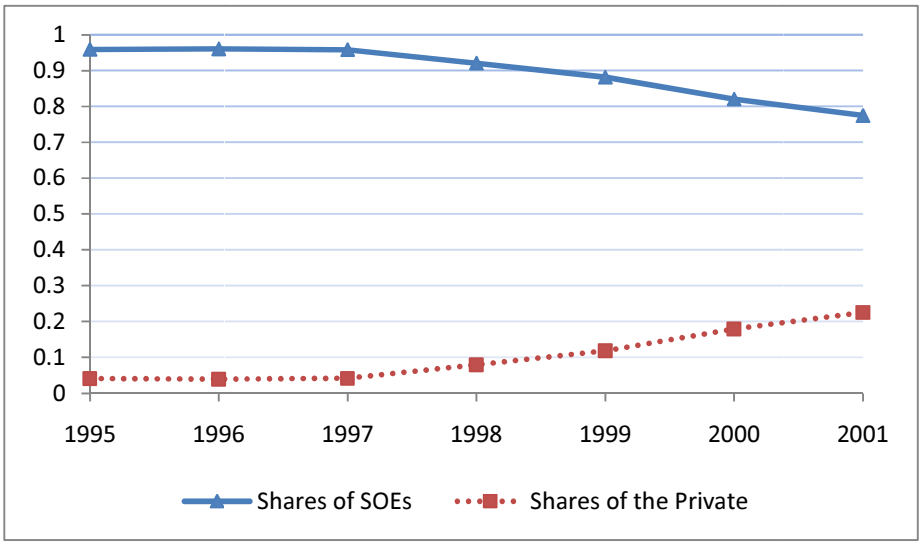
Note: Overall is the percentage of number of private firms among all observations. East includes cities of Weifang and Zhenjiang; West includes cities of Lanzhou, Xining, Guiyang and Chengdu; North includes cities of Harbin, Fushun, and Tangshan; and South includes Huangshi and Hengyang.

Figure 2 Revenue Shares by Ownership, 1995-2001



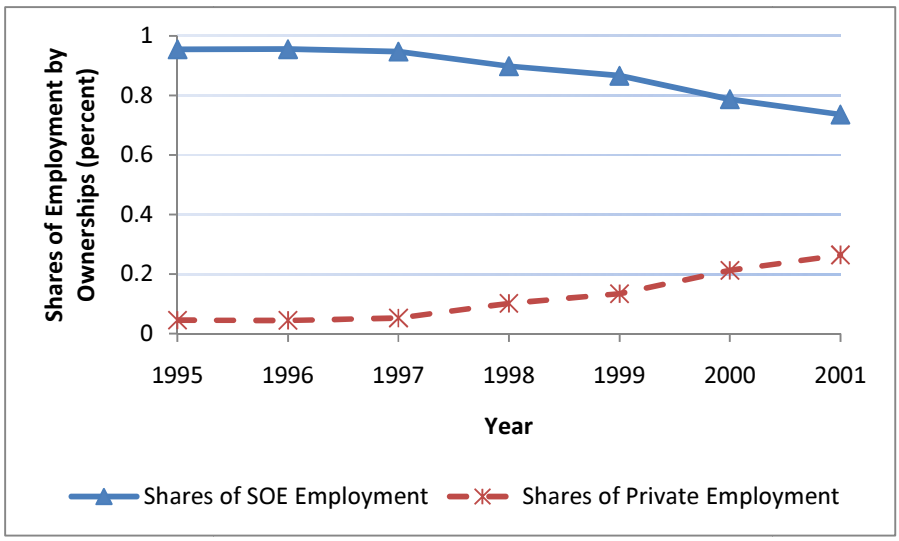
Note: SOE is the total revenue of State-Owned Enterprises divided by that of all observations in the sampleand private is computed as the total revenue of private firms divided by that of all observations.

Figure 3 Shares of Gross Output by Ownership, 1995-2001



Note: SOE is the total value added of State-Owned Enterprises divided by that of all observations and private is computed as the total value added of private firms divided by that of all observations in the sample.

Figure 4 Changes of Employment Shares by Ownerships, 1995-2001



Note: Shares of SOE employment is obtained by dividing the number of working employees at SOEs with total number of working employees in all observations. Shares of private employment is obtained by dividing number of working employees at private firms with that in all observations.

2.2 Selected performance indicators and production factors

Plagued by principal-agent problem, soft-budget constraint, and social welfare obligations, SOEs are often accused of lacking of efficiency. To examine this common conception in the context of Chinese firms, several performance indicators are selected and compared across different ownerships and time periods. First, private firms generally had outperformed SOEs in terms of value added per employee (Table 1). Value added per employee at private firms on average was 0.97 compared to 0.59 at SOEs and 0.60 for all firms in 1995. This indicater peaked in 2000 for private firms at 1.33; however it was only 1.12 for SOEs and 1.16 for all firms. Second, standard deviations of value added per employee at SOEs were larger than those at private firms before 1999 and lower thereafter. This may reflect the effects of the "grasping the big and let go of the small" policy; small and money-losing SOEs were likely to be sold to private or foreign investors as privatization accelerated after 1998. The remaining SOEs are more homogeneous judged by their performance. Third, the Chinese firms' average performance as measured by value added per employee had improved consistently from 0.60 in 1995 to 0.91 in 2001. Lastly, a close examination of Table 1 suggests that all firms' performance dipped in 1997 and soon recovered in 1998. This sudden decrease may largely attribute to the worsened macroeconomic environment in 1997 caused by the Asian financial crisis and hardened credit environment when the government tried to tame inflation in the mid-1990s.

Table 1 Value Added per Employee by All, State-Owned, and Private Firms, 1995-2001

Ownership		Year						
		1995	1996	1997	1998	1999	2000	2001
All	Mean	0.60	0.53	0.57	0.65	0.71	0.88	0.91
	Stdv.	0.64	0.61	0.75	0.91	0.91	1.16	1.40
	Median	0.47	0.40	0.41	0.44	0.51	0.62	0.57
SOE	Mean	0.59	0.52	0.56	0.64	0.66	0.82	0.88
	Stdv.	0.65	0.61	0.75	0.93	0.90	1.12	1.45
	Median	0.45	0.39	0.41	0.43	0.49	0.58	0.51
Private	Mean	0.97	0.79	0.85	0.75	1.11	1.17	1.07
	Stdv.	0.53	0.51	0.74	0.65	0.92	1.33	1.20
	Median	0.98	0.67	0.63	0.66	0.85	0.73	0.77

Note: All refers to all observations; SOE refers to firms whose majority shares are owned by the state or other SOEs; Private refers to firms whose majority shares are owned by private investor, private firms or foreign entities. Value added is in unit of 10,000 yuan and adjusted with 1978-1980 price level as base year. Total number of working employees is used as total number of employees in the computation.

SOEs in China are more likely to focus on capital-intensive industries than private enterprises. Table 2 shows that total assets per employee at SOEs are consistently larger than those at private firms. This difference can be explained by the large entry barriers blocking private firms from competing in heavy industries and the discrimination against private firms in banks' lending practice. The high entry barriers for heavy industries are mostly caused by the government economic policies. Political interventions are often cited as to why the state-owned banks are reluctant to lend money to private firms (*Yusuf, Nabeshima and Perkins (2006)* pp. 73). Table 2 also indicates that total assets per employee at SOE had increased continuously from 1995 to 2001. The absence of the similar trend in private firms suggests two explanations. First, a large scale of lay-off had occurred at most SOEs from 1995 to 2001. Second, the government had continued to favor the retained large SOEs by directing more investments to them. Finally, standard deviations of total assets per employee also show that the disparity of the size of SOEs had widened during this period. This finding reinforces the policy of retaining big and letting go of small SOEs.

Table 2 Total Assets per Employee of All, SOE, and Private Firms, 1995-2001

Ownership		Year						
		1995	1996	1997	1998	1999	2000	2001
All	Mean	4.82	5.27	6.11	9.41	12.34	14.40	18.20
	Stdv.	6.87	5.54	7.27	22.75	30.08	33.20	46.12
	Median	3.51	3.95	4.33	5.07	6.00	6.51	6.61
SOE	Mean	4.83	5.31	6.21	9.77	13.08	15.89	21.07
	Stdv.	6.98	5.62	7.39	23.56	31.54	35.71	50.68
	Median	3.50	3.99	4.37	5.15	6.14	6.82	7.18
Private	Mean	4.56	3.98	3.72	4.73	5.39	5.79	5.69
	Stdv.	2.95	2.27	2.12	3.12	2.77	4.28	4.03
	Median	3.75	3.43	2.77	3.79	4.44	4.87	4.31

Note: All refers to all observations; SOE refers to firms whose majority shares are owned by the state or other SOEs; Private refers to firms whose majority shares are owned by private investor, private firms or foreign entities. Total asset is in unit of 10,000 yuan and adjusted with 1978-1980 price level as base year. Total number of working employees is used as total number of employees in the computation.

From 1995 to 2001, total employment at all firms had continuously decreased, particularly at SOEs. The number of working employees[2] at SOEs had decreased by 47 percent compared to only 34 percent at private firms and 42 percent overall. Private firms on average employed more workers than SOEs, partly due to the fact that most private firms operate in labor intensive industries. In addition, as SOEs consistently shed off working employees, private firms only started labor downsizing after 1998 and maintained a stable workforce before 1998. This decrease in private workforce may be caused by restructuring at private sector after 1997 financial crisis. Table 3 reports these changes.

[2] During the restructuring at Chinese SOEs, reducing excessive employment had been a sensitive and complicated issue. Normally, current employees at a SOE were either retained or let go and became redundant workers. The retained workers would continue to work with full compensation. They are thus named "working employees" in this paper. The redundant workers include workers who chose to take early retirement, whose position were eliminated during the reform but continue to maintain a nominal tie with the company, and who lost their jobs and were no longer affiliated with the company.

Table 3 Working Employees of All, SOE, and Private Firms, 1995-2001

Ownership		Year						
		1995	1996	1997	1998	1999	2000	2001
All	Mean	705	678	628	527	492	443	406
	Stdv.	751	704	657	568	539	511	487
	Total	213,530	218,243	205,307	183,320	180,039	167,893	158,618
SOE	Mean	698	670	619	510	471	409	367
	Stdv.	747	695	640	532	506	471	440
	Total	203,896	208,520	194,467	164,644	155,952	132,184	116,699
Private	Mean	876	884	834	747	688	638	574
	Stdv.	879	949	985	901	767	672	629
	Total	9,634	9,723	10,840	18,676	24,087	35,709	41,919

Note: All refers to all observations; SOE refers to firms whose majority shares are owned by the state or other SOEs; Private refers to firms whose majority shares are owned by private investor, private firms or foreign entities.

2.3 Determinants of privatization and Selection Bias

Causes for privatization in China have been more than a simple matter. The decision to privatize has been highly influenced by government policies. Several determinants have been well observed and documented in previous literature. First, better-performing SOEs are more likely to be privatized because initial success from privatizing these types of SOEs may help the government to attract future private investors and find supports for further reform efforts *(Su and Jefferson (2003))*. Evidence from Table 4 is consistent with this determinant of privatization. On average, the return of assets for firms that have never been privatized is -0.016, which is much lower than 0.019 achieved by privatized SOEs during their pre-privatization period. Privatized SOEs also have lower debt of asset ratio prior to privatization compared to SOEs that have never been privatized. In addition, companies generating higher tax revenues are more favored in the privatization process. As Table 4 shows, the ratio of tax over total asset at privatized SOEs during the pre-privatization period is 0.038 and higher than 0.024 of never-privatized SOEs. Second, to prevent social unrest caused by massive layoff that usually occurs following privatization, Chinese government tries to privatize SOEs with smaller size of employment and assets. Table 4 shows that the average number of employment at privatized SOEs is 720 whereas those remained

Table 4 Summary Statistics of Never-Privatized SOEs and Ever-Privatized Firms before Privatization

	ROA	DAR	Tax	Overdue tax	Total employment	Total assets	Central shares (percent)	Provincial shares (percent)	City shares (percent)	County shares (percent)
Never privatized SOEs	-0.016	0.821	0.024	0.024	847.645	3055.851	0.850	1.590	78.174	12.434
	(0.111)	(0.488)	(0.033)	(0.033)	(877.000)	(3421.338)	(8.890)	(12.512)	(40.765)	(32.627)
Pre-privatization SOEs	0.019	0.776	0.038	0.020	719.592	2135.177	0	0	79.562	11.189
	(0.101)	(0.261)	(0.034)	(0.032)	(485.179)	(1572.254)	---	---	(40.473)	(31.043)

Note: The reported results are means and standard deviations (in parenthesis). Never privatized SOEs are SOEs that have never been privatized in the sample; Pre-privatization SOEs refers to the pre-privatization periods of SOEs that have ever been privatized during the observation period. ROA is return of assets. DAR is debt asset ratio, and Tax is the ratio of total tax and total assets. Total employment includes working employees, retirees, and *Xiagang* employees. Total assets are in unit of Yuan and adjusted for price changes. Central shares, provincial, city and county shares are the percentages of shares owned by the central, provincial, city and county governments, respectively.

SOEs employ 848 workers on average. Moreover, the remained SOEs own 43 percent more assets than their counterparts which are later privatized. Third, firms largely controlled by local governments are more likely to be targets of privatization. *Guo and Yao (2005)* attribute this phenomenon to the financial restraint faced by local governments (city and county levels) after the central government hardened local SOEs' credit lines at state-owned banks. However, in this sample there is no significant difference in shares owned by local governments between privatized SOEs and never-privatized SOEs. The absence of such a difference may reflect how this survey was administrated. It seems that local government controlled SOEs were more likely to be chosen to participate in this survey. Nonetheless, none of the later-on privatized SOEs in the sample has shares from the central or provincial governments. In contrast, firms that remained state-owned do have on average 2.5 percent shares owned by the central and provincial governments.

2.4 Determinants of inefficiency

To understand determinants of Chinese firms' inefficiency, correlations between selected performance indicators and factors that may affect firms' inefficiency are presented in Table 5. The selected performance indicators include value added per employee, revenue per employee, return of asset (ROA), and total factor productivity (TFP). Value added per employee and revenue per employee are derived from dividing total value added and value of gross output over total number of working employees. TFP is the retained residual from estimating a fixed-effects Cobb-Douglas production function. The dependent variable is the value of gross output and independent variables include number of working employees and value of total asset. The determinants of inefficiency include shares owned by the state, shares owned by managers, redundant worker, and government subsidies. To facilitate computation of correlation coefficients, shares of state are chosen as a proxy for ownership and are expected to be negatively correlated with a firm's performance. Manager shares are chosen to capture effects of management incentive and autonomy on firms' performance. Government subsidies are used to measure the extent of soft budget constraint. It is postulated by theory that the availability of subsidies may relieve firms from the pressure of achieving higher efficiency. Figure 5 compares the degree of soft budget constraints at SOEs and private firms. Two interesting observations can

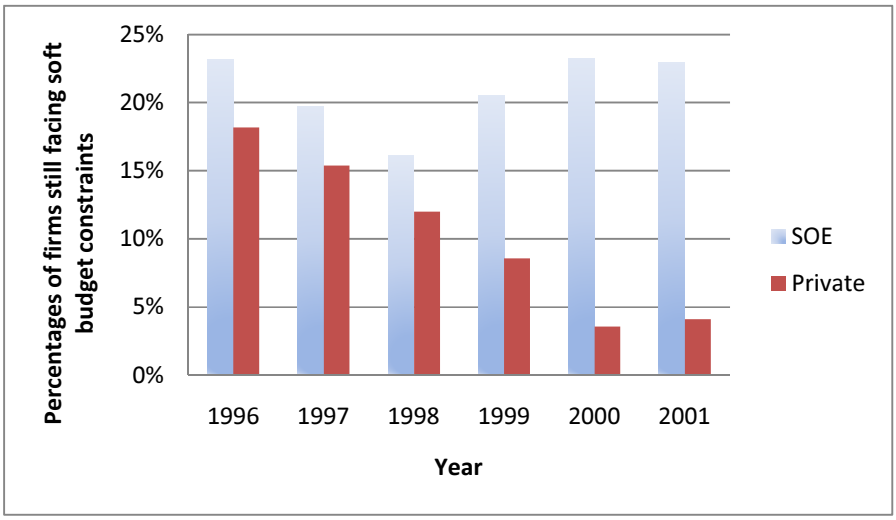
be drawn. First, both the SOEs and reformed SOEs in the sample are still subject to soft budget constraint. Around 20 percent of SOEs reported receiving bank loans while losing money for all years except in 1998. Second, private firms in China also faced soft budget constraint although the percent of such a private firm is smaller and trend is downward. Before 1999, there were over 5 percent of private firms receiving loans while in red. Moreover, Figure 6 shows the percentage of retirees and *xiagang* workers (workers no longer actively working but still receiving minimum benefits from firms) over total number of employees at SOEs and privatized firms. Unlike privatization in other countries, privatized firms in China are continuously obligated to support welfare payments to retirees and *xiagang* workers even after privatization took place. As of 2001, retirees and *xiagang* workers still accounted for on average 40 percent of total employment at privatized firms although this percentage had decreased since 1998. On the contrary, the numbers of redundant workers at SOEs and reformed SOEs had almost doubled from 1995 to 2001.

Table 5 Correlations of Firms' Performance and Efficiency Determinants

Performance Indicators	State shares	Management shares	Redundant workers	Government subsidies
Value Added per Employee	-0.136***	0.041*	-0.077***	0.034
Revenue per employee	-0.058***	0.019	0.283***	-0.003
Return on assets	-0.164***	0.096***	-0.093***	0.047
Total factor productivity	-0.144***	0.073***	-0.052**	-0.114**

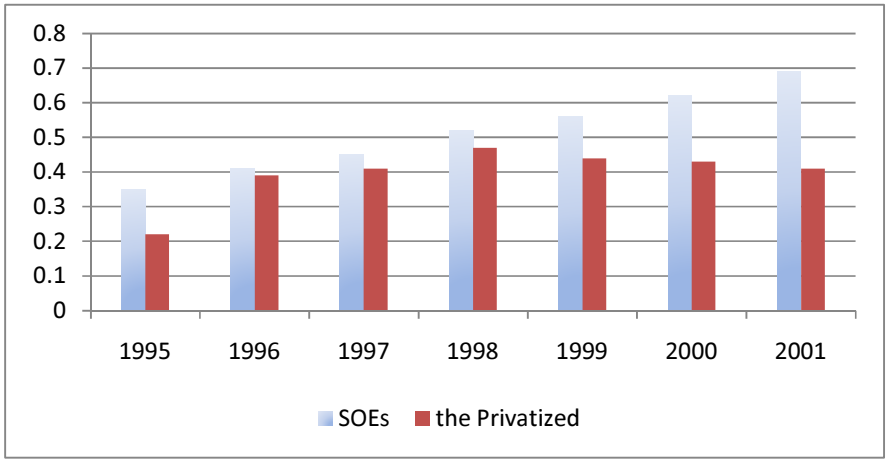
Note: This table reports the correlation between selected performance indicators and efficiency determinants. Total factor productivity (TFP) is derived from a Cobb-Douglas production function regression in which inputs include number of working employees and total assets. *, **, *** indicate the 10%, 5%, and 1% significance levels respectively.

Figure 5 Percentages of SOEs and Private Firms with Soft Budget Constraints, 1995-2001



Note: A firm is indentified as facing a soft budget constraint if it has lost money in the previous year and yet still has outstanding overdue loans by the end of the current year. Data from 1995 are omitted because no firm identified itself as facing a soft budget constraint in 1995.

Figure 6 Percentages of Retired and *Xiagang* Workers at SOEs and Privatized Firms, 1995-2001



Note: This graph shows the ratios of total number of retired and xiagang workers and total number of working employees at SOEs and the privatized from 1995 to 2001. *Xiagang* refers to workers who are no longer working but still receiving minimum benefits from firms.

Table 5 shows that state shares are negatively correlated with all performance indicators with 1 percent significance level. Manager shares are found to be positively correlated with ROA and TFP with 1 percent significance level. Redundant worker is negatively correlated with all performance indicators except revenue per employee. Moreover, government subsidies exhibit no significant correlation with all performance indicators except TFP. TFP is negatively correlated with government subsidies with 5 percent significance level.

Lastly, Table 6 summarizes changes in privatized firms' performance, sizes, employment, and share structures 3 years before and 3 years after privatization. The summary statistics shed some lights on both causes and effects of privatization. ROA had seen a sudden increase in the year before privatization and it picked up quickly after an initial dip in the first year of privatization. Debt asset ratio (DAR) exhibited a rather steady increasing trend prior to privatization. This increase may imply that the governments tried to transfer more debts to private owners before handing over the ownership. After the debt level peaked in the first year after privatization, it started to drop continuously in the following two years. Changes in total assets, numbers of working employees and total employment indicate that the sizes of firms have increased after being privatized. In addition, employment also shows that firms normally shed off labor in the first three years before privatization. Regarding share structure changes during pre and post privatization periods, one can find that city governments tend to sell all of their shares in the privatized SOEs and yet county governments may choose to retain a small percent of ownership in SOEs. To conclude, performance of most firms seemed worsened in the first year after privatization; although the improvements in SOEs' performance after privatization were consistent, their performance most likely just recovered to their pre-privatization level; the sizes of asset value and employment all tended to increase after privatization.

Table 6 Summary Statistics of Performance, Size, and Employment before and after Privatization

Performance Indicators	3-year prior	2-year prior	1-year prior	Privatization	1-year after	2-year after	3-year after
Return of asset	0.026	0.025	0.038		0.020	0.035	0.036
	(0.097)	(0.099)	(0.141)		(0.124)	(0.112)	(0.102)
Debt asset ratio	0.758	0.779	0.821		1.109	0.980	0.794
	(0.247)	(0.248)	(0.309)		(1.444)	(1.210)	(0.389)
Tax	0.043	0.041	0.046		0.044	0.047	0.044
	(0.031)	(0.031)	(0.052)		(0.045)	(0.042)	(0.032)
Overdue tax	0.025	0.028	0.025		0.027	0.031	0.031
	(0.036)	(0.040)	(0.040)		(0.039)	(0.042)	(0.043)
Total asset	2167.290	2244.645	2151.005		2065.233	2272.021	2418.688
	(1652.070)	(1734.625)	(1552.691)		(1557.111)	(1731.757)	(1808.107)
Total employment	738.000	726.000	696.000		674.000	701.000	721.000
	(536.000)	(534.000)	(518.000)		(532.000)	(554.000)	(580.000)
Working employees	615.436	584.691	541.135		507.270	519.018	547.807
	(511.746)	(510.603)	(480.034)		(497.510)	(526.118)	(564.985)
City shares	75.000	76.923	80.000		0	0	0
	(43.667)	(42.544)	(40.584)		---	---	---
County shares	20.549	18.433	13.486		0.162	0.218	0.194
	(39.675)	(38.348)	(33.789)		(0.986)	(1.134)	(1.069)

Note: This table reports summary statistics of privatized firms' performance indicators, size, and employment prior to and after privatization. The reported figures are means and standard deviations (in parenthesis). Return of asset = net profit before tax/total asset; debt asset ratio = total liability/total asset; tax = total tax/total asset; total asset is in unit of 10,000 yuan and adjusted for price change; tax and overdue tax are ratios of total tax and amount of overdue tax over total assets, respectively. Total employment includes working employees, retirees, *xiagang* employees. City and county shares are the shares owned by city and county governments.

3 Two-step Stochastic Frontier Analysis

The endogeneity problem has emerged as a vital empirical issue in various studies on Chinese SOE reforms. An endogeneity problem may arise because the unobserved determinants of privatization may be correlated with independent variables in the production function. The reform of Chinese SOEs has been carefully planned and administrated by the central and local governments (*Lau (1999)*). During this process, the central or local governments may have systematically selected firms to be privatized for a variety of reasons. *Guo and Yao (2005)* find that hardened budget constraints and market liberalization have significant effects on SOEs' privatization decision. *Lau (1999)* also confirms that the privatization policy in China has been primarily targeted at particular sizes and industries of SOEs. Therefore, better performance at the privatized SOEs may not be the direct result of the mere change in ownership, but simply because those SOEs that were doing better in the pre-privatization period tend to be chosen for privatization first. To tackle this endogeneity problem, this paper considers a two-step estimation strategy. The first step involves estimating a random-effects probit model of privatization in which the estimated (predicted) probability of being privatized will be retained and used later on as a proxy for ownership in the second step estimation. The second step will study the impacts of ownership and several other reform measures on firms' efficiency with a random-effects stochastic frontier model.

3.1 Causes of privatization for Chinese SOEs

Numerous studies (*Guo and Yao (2005), Yusuf et al. (2006) and Chun (2008)*) have found that privatization of SOEs in China are very often politically motivated. In particular, the causes of privatization in China have been closely correlated with policies on SOE reforms by various levels of Chinese governments. First, the central government has started to implement a guideline for privatization of SOEs since 1994. The guideline is generally summarized as 'take a firm grip on the large firms in critical industries, let go of the small' (*Lau (1999)*). That means firms with more assets, employees, and in pillar or strategic industries (such as energy, telecommunication, and heavy manufacturing etc.) is more likely to be retained by the central government. Second, local governments (provincial and municipal level) tend to sell profitable SOEs first. By doing so, local governments can recover more before those SOEs become

liabilities. *Su and Jefferson (2003)* find that better performing SOEs are more likely to be privatized first in China. Third, China's market liberalization efforts have significantly accelerated the proceess of privatization. Increased competitions from private and foreign firms caused by deregulations in less critical industries have worsened SOEs' performance. Thus, local governments have more incentive to sell those poor-performing SOEs to the competing private and foreign firms. Fourth, locations of SOEs also influence the likelihood of SOEs' privatization. Firms that are located along the eastern coastal areas should be privatized earlier and faster because of more liberal economic policies and more prospective domestic and foreign bidders. Unlike those in the east, SOEs in the central and western regions normally face more rigid government policies and less competition from domestic and foreign firms. Fifth, SOEs with heavy social welfare obligations are less likely to be granted for privatization bidding in that the government is very sensitive to any social unrest that could be caused by displaced former SOE employees following privatization (Balfour (2009)). Lastly, hardened budget constraint faced by SOEs may more likely lead to their privatization. Soft budget constraint has been considered as one of major factors of inefficiency at SOEs. In the past state-owned banks tend to funnel their resources to distressed SOEs. However, with banking reform during 90s in China deepened, some SOEs became less likely to receive state funding relief due to enormous bad loans already showing on banks' balance sheets. As a result, *Ito (2005)* shows that local governments have incentives to privatize distressed SOEs which failed to secure loans from the State-owned banks.

Consideration of the above causes of privatization leads to the following specification for estimating the propensity of privatization.

(1) $P_{it} = \alpha_0 + \alpha_i + \beta' X_{it} + \beta_j' Location_j + \beta_t' Year_t + \beta_k' Indus_k + \varepsilon_{it}$

Where ε_{it} is assumed to follow a multivariate normal distribution with zero mean and constant variances. P_{it} is the ownership indicator for firm i at time t. $P_{it} = 1$ if 50% or more shares of a firm are owned by private or foreign firms and $P_{it} = 0$ if otherwise. X_{it} is a set of explanatory variables which measures profitability, debt level, worker redundancy, working employees, assets, tax and degree of soft budget constraint. All explanatory variables, except soft-budget

dummies, are constructed as their three-year moving average to avoid possible anticipated-effects bias. Profitability is measured by the returns of asset. Debt level is defined as debt asset ratio. Worker redundancy is the ratio of the number of redundant workers and that of on-duty workers. Working employees and assets are logarithms of the number of on-active duty workers and total assets. Tax is constructed as the ratio between total tax and total assets. Degree of soft budget constraint is proxied with a dummy variable, which takes the value of unity if a firm still has overdue loans at the year end and has been losing money in the last three years.[3] In addition, year dummies, location and industries of firms are also included as controls. Location is defined as *North*, *East* and *West*. *North* includes cities of Harbin, Fushun and Tangshan. *East* represents two cities along the eastern coast (Weifang and Zhenjiang). *West* refers to cities of Xining, Lanzhou, Chengdu, and Guiyang. 45 industries from the dataset have been consolidated to 10 industries in this study.[4]

The straightforward way to estimate this specification of privatization propensity is to estimate a fixed-effects probit model. However, results from fixed-effects probit models are bias since the incidental parameter problem dominates this class of models. Thus, this paper adopts a random-effects probit model to estimate the propensity of privatization. The estimated probability of privatization $E(P_{it} \mid X_{it}, Location, Year, Indus)$ will be retained and introduced as the instrumented ownership variable in the following random-effects stochastic frontier model.

3.2 Random-effects stochastic frontier analysis

The traditional productivity analysis defines technical inefficiency as the deviation of actual output from an optimal value. This optimal value can be estimated with a deterministic production function. Hence, one can examine impacts of external variables on a firm's technical efficiency by regressing the estimated inefficiency on a collection of external variables. However,

[3] Year 1995 has been dropped since it is the first year of observation. The soft budget constraint dummy is constructed for year 1996, using only the profitability of a firm in the previous year. Likewise, only the profitability of the two previous years is used to construct the soft budget constraint dummy of 1997.

[4] In this study, we consider 10 industries. The criteria used to categorize these 10 industries resemble that used by Brown et al (2006), such as, mining and quarrying, food processing, textile industry, timber related industry, petroleum industry, chemical industry, metal product industry, machinery manufacture industry, electric equipment industry, production and supply of electric power industry, and others.

such a practice tends to ignore that the deviation from a firm's ideal production may be also caused by some external factors following a stochastic process, for instance, unexpected machine failures or bad weather. In a traditional approach, these random uncertainties of production may be simply explained as inefficiency. Aigner et al. (1977) and Meeusen and Broeck (1977) propose a stochastic production frontier to incorporate these random variables into efficiency analysis. Their models show that a firm's production is bounded within its own production frontier and that this frontier should be collectively determined by a deterministic production function and a stochastic term. However, the early attempt to apply stochastic frontier under a panel framework was unsatisfactory because inefficiency was normally assumed to be firm-specific and time-invariant. This assumption may be unwarranted if inefficiency does change over time. Battese and Coelli (1995) address this shortcoming and demonstrate how to incorporate time decaying effects into inefficiency estimation. However, their original model cannot consider any time-varying factors but only time trend as the cause of inefficiency.

A generalized form of Battese and Coelli's model is developed to allow both time-variant and time-invariant inefficiency determinants to enter the model. In this specification, the inefficiency term is modeled as a multiplication of a truncated normal distribution and a function of time-variant variables. All time-varying variables, such as privatization and soft-budget, will influence firm efficiency by entering a scaling-effect term. That is, changes of these variables may only alter the magnitudes but not the distributions of firm efficiency over time. Time-invariant variables, such as industry and location, may alter the means of inefficiency's distributions. The only panel-specific effect of this model is the random inefficiency term. In addition, the estimated probability of privatization from Equation (1) will appear as the ownership variable in the scaling effect term. By doing so, the endogeneity problem can be addressed and controlled. Following this generalized model, the following stochastic frontier specification is considered.

(2) $y_{it} = \alpha_0 + \beta' x_{it} + v_{it} - u_{it}$

$$
\begin{aligned}
&v_{it} \sim N(0, \delta_v^{\,2}) \\
&u_{it} = h_{it} u_i *, \\
&h_{it} = \exp(\eta' z_{it}), \\
&u_i * \sim N^{+}(\gamma' D_i, \delta_u^{\,2}), \\
&t = 1,...T, n = 1,..., N
\end{aligned}
$$

where y_{it} is a measure of firm performance, namely the gross value of output. α_0 is the coefficient of a constant term, and x_{it} includes a collection of input variables. u_{it} is a stochastic term reflecting a firm's technical inefficiency and is modeled as a product of a time-varying scaling effect h_{it} and time-invariant individual effect u_i * . The magnitudes of firm *i*'s inefficiency at time *t* are determined by a set of time-varying variables z_{it} which includes the ownership variable. The distribution of firm *i*'s inefficiency is considered to be truncated-normal. The underlying mean is allowed to be heterogeneous and depends on firm-specific characteristics D_i . v_{it} is an error term following a normal distribution with mean zero and variance $\delta_v^{\,2}$. Random variables v_{it} and u_{it} are assumed to be independently distributed. The primary interest of this study centers on the coefficients of time-varying and time-invariant inefficiency determinants η and γ' .

A Cobb-Douglas specification is considered for Equation (2) and the production covariates x_{it} include time trend, value of total assets, total number of working employees, industry and year dummies. Time trend and industry dummies are included to account for technological changes and industry-specific effects, respectively. Year dummies are used to control for production shocks caused by changes of overall macroeconomic policies and conditions. Based on the analysis of data from the previous section, a decline of output for all firms should be expected in 1997 and 1998 because of the contractionary fiscal policies and Asian financial crisis.

Time-variant determinants of inefficiency h_{it} include time decay effect, shares owned by managers, ratio of retired and *xiagang* workers over total employment, a dummy variable of soft-

budget, debt asset ratio (DAR) and the retained probability of privatization from Equation (1). Efficiency of Chinese manufacturing is expected to be improved over time because of reforms deepening and increased competition. More shares owned by managers should imply that more incentives and autonomy are given to the management. Hence, shares owned by managers should be positively correlated with firms' efficiency. Likewise, a lower percent of total number of employees depending on companies' welfare payments may also allow firms to be more efficient. In China, privatized firms are often required to keep redundant workers for a period of time after privatization because local governments are afraid of any social unrest that may occur as result of immediate layoffs. Thus, privatized firms may continue to carry social burdens even after privatization takes place. In addition, firms with soft-budget constraint or facing higher DAR may be less efficient. The data also suggest that soft-budget is not an exclusive phenomenon for SOEs in China. To attract private investors, local governments may force local branches of state-owned banks to offer loans without adequate dual diligence and proper assessment. At last, privatized firms should perform better and the coefficient of privatization is the primary interest of this paper. With control of these reform factors, the effect of privatization on firms' efficiency in this paper is expected to be smaller than that in previous literature without proper specification.

3 Empirical Results

3.1 Endogeneity test

A Heckman endogeneity test is first conducted to examine whether or not simply including an ownership dummy in the efficiency analysis may introduce an endogeneity problem. In the context of China's privatization, a better-performing privatized firm may perform better even prior its privatization because the government may intentionally select it to privatize first in order to maintain the momentum for reform. The preliminary data analysis earlier (in Section 2) supports this notion. This Heckman test involves two steps; first, Equation (1) is estimated and the residual is retained; second, both the retained residual and the ownership dummy are included in a linear production function regression. This linear production function includes time trend, production factors, industry and time dummies and causes of inefficiency. The model is specified as

(3)

$$output_{it} = \alpha_0 + \beta_1 trend_{it} + \beta_2 workingemployee_{it} + \beta_3 asset_{it} + \sum_{k=1}^{9} \theta_k indus_{ik} + \sum_{k=1}^{6} \phi_k year_{ik} + \omega_1 priv_{it} + \omega_2 priv\_res_{it} + \omega_3 manager\_shr_{it} + \omega_4 social\_burden_{it} + \omega_5 soft\_budget_{it} + \omega_6 DAR_{it} + \varepsilon_{it}$$

If the privatization residuals exhibit significant effects on firms' performance, then the existence of endogeneity problem is detected. The estimated coefficients from Equation (3) are reported in Table 7. In Table 7, the results from a pooled OLS model are presented along with those from a fixed-effects as well as a random-effects model. In the pooled model, both coefficients of the ownership dummy and the retained privatization residual are significant with 5 percent significance level. Therefore, the two-step approach considered in this paper is indeed necessary since these results are, to a great extent, in support of the existence of selection bias caused by the privatization policies in China.

Further, several preliminary observations on causes of Chinese firms' performance can be drawn when results from the fixed and the random-effects models are compared to the pooled model. The significance of privatization and privatization residuals on firms' performance disappear in both the fixed and the random-effects models. This may suggest that panel approaches can ease the concern of the endogeneity problem. In addition, all three models further confirm the decline of Chinese firms' output in year 1997 and 1998. During these two years, an average Chinese firm's output dropped by 10 percent. Social burden poses as a significant factor that undermines a firm's efficiency in all three models. However, the effects of soft-budget constraint are only significant in the pooled and the random-effects model. In both fixed and random-effects models, the negative effects of social burden is smaller than that in the pooled model after individual effects are controlled. None of the effects of manager shares and debt asset ratio on firms' performance appear to be significant.

Table 7 OLS, Fixed, and Random-Effect Production Function Regression Results

	OLS (Pooled)	Fixed-Effects	Random-Effects
Constant	-0.313	0.105	-0.311
	(0.208)	(0.866)	(0.357)
Time trend	0.023	0.014	0.022*
	(0.019)	(0.014)	(0.013)
Working Employee	0.538***	0.567***	0.573***
	(0.042)	(0.067)	(0.052)
Asset	0.547***	0.416***	0.495***
	(0.038)	(0.108)	(0.053)
Year 1997	-0.142*	-0.089*	-0.101**
	(0.080)	(0.048)	(0.048)
Year 1998	-0.137*	-0.114***	-0.118***
	(0.074)	(0.045)	(0.045)
Year 1999	-0.047	-0.029	-0.027
	(0.071)	(0.044)	(0.043)
Year 2000	-0.048	-0.030	-0.030
	(0.074)	(0.044)	(0.044)
Privatization	0.316**	0.001	0.198
	(0.131)	(0.196)	(0.156)
Privatization residual	0.294**	0.012	0.116
	(0.140)	(0.146)	(0.130)
Managers' shares	-0.001	0.001	0.000
	(0.003)	(0.003)	(0.003)
Social burden	-0.727***	-0.321**	-0.541***
	(0.095)	(0.163)	(0.123)
Soft budget constraint	-0.602***	-0.085	-0.256***
	(0.065)	(0.080)	(0.070)
debt asset ratio	0.051	0.029	0.036
	(0.055)	(0.052)	(0.046)
obs	1064	1064	1064
Adj. R-square	0.751		
R-square (within)		0.208	0.203
R-square (between)		0.724	0.772

Note: this table reports the estimated coefficients of OLS, fixed effect and random effect models with a Cobb-Douglas production function. Probability of privatization is derived from the first step random effect probit model, layoff is the ratio of number of fired over working workers, soft budget constraint is a dummy variable here and manager's shares are the percent a firm's shares owned by its managers. Standard deviations are in parenthesis. *, **, *** indicate the 10%, 5%, and 1% significance levels respectively.

4.2 Panel specification test

A Hausman test comparing Fixed and Random-effects models is implemented after controlling the endogeneity problem with the first-step estimation. The results from this test will determine the specification of the stochastic frontier panel model in the efficiency analysis. Specification in Equation (3) is used as the baseline model for this test. The only modification is to add a firms' individual-effects term α_i. The chi-square statistics of the test are shown in Table 8. The null hypothesis of the test is that coefficients from fixed and random-effects models are not systematically different. The P-value 0.8986 fails to reject the null hypothesis. This finding suggests that a random-effects model can perform as well as a fixed-effects model once the production function is properly specified and the endogeneity problem is controlled. To further examine the presence of random effects in this case, a Breusch and Pagan Lagrangian multiplier test is conducted. The results are reported in Table 9. Firms' individual random effects and the idiosyncratic errors of the regression explain 24 percent and 9 percent of the total variations of firms' output, respectively. The factors of production, technological changes, industry and time dummies, and causes of inefficiency collectively contribute to the rest of production variations. Table 9 also shows that the variances of firms' individual random effects are significantly different from zero. These results further suggest adoption of a random-effects model in the second-step stochastic frontier estimation.

Table 8: Hausman Specification Test for Fixed and Random Effects

Null hypothesis: Coefficients from Fixed and Random effects models are not systematically different			
Chi square statistic:	4.19	P-value:	0.8986

Note: This table reports results from a Hausman specification test. The fixed and random-effects models follow the same specification in Equation (3).

Table 9: Breusch and Pagan Lagrangian Multiplier Test for Random Effects

	Variance	Standard deviation
Output	2.450	1.565
ε_{it}	0.211	0.460
α_i	0.577	0.760
Test: null hypothesis var(α_i) = 0		
chi square statistics: 880.87	P-value: 0.000	

Note: This test examines the existence of random effects. The model considered here follows the same specification in Equation (3). Output is the value of gross output and serves as the dependent variable in the model. eit is the estimated idiosyncratic random variable and ait is the estimated random effects.

4.3 Measuring firms' inefficiency

The application of stochastic frontier models is based on the assumption that the inefficiency term follows a non-negative distribution. Hence, to justify the use of stochastic frontier models in this particular study, the distribution of inefficiency from consistent random-effects production estimation on the dataset is examined. The distribution should show signs of left-skewness if the positively truncated normal distribution assumption on the inefficiency term is appropriate. The estimated proxy for inefficiency is computed from Equation (4) below.

$$(4)\ \hat{w}_{it} = -(y_{it} - \hat{\alpha}_0 - \hat{\alpha}_i - \hat{\beta}' X_{it} - e_{it})$$

where $\hat{w}_{it}$ is the estimated proxy for firms' inefficiency from a linear random-effects production function; $\hat{\alpha}_0$ and $\hat{\alpha}_i$ are the estimated constant term and firm-specific random-effects from Equation (3) with random effects; production covariates X_{it} include time trend, number of working employees, total value of assets, industry and year dummies and all the coefficients of X_{it} and the estimated overall residual e_{it} are also retained from estimating Equation (3) with random effects.

The summary statistics of $\hat{w}_{it}$ are provided in Table 10. The mean, skewness, and kurtosis of $\hat{w}_{it}$ are examined over time. The results indicate that the distributions of firms' inefficiency are significantly left-skewed during years of 1997, 1998 and 2001, and values of Kurtosis of these three years also suggest that modeling inefficiency with a normality assumption

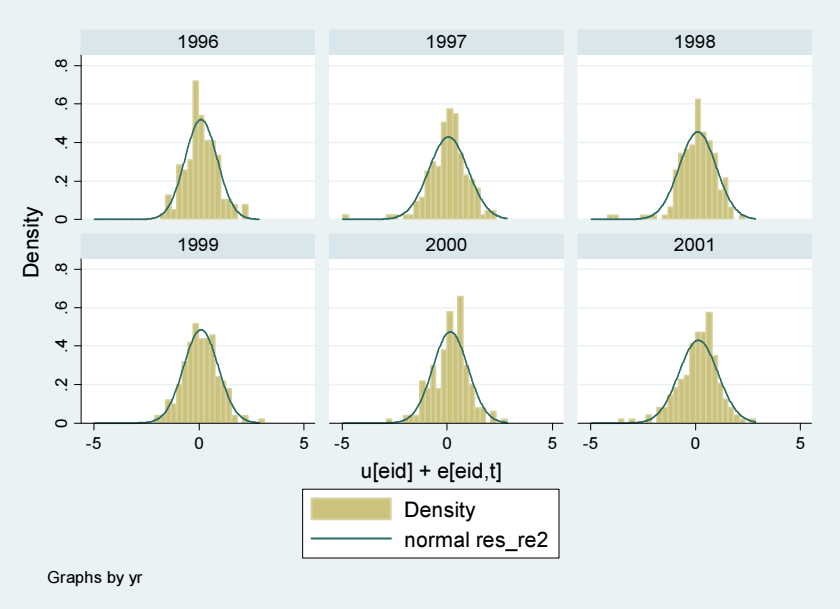
may not be very ideal. In addition, although the values of skewness for years of 1996 and 1999 are positive, one cannot conclude that the inefficiency distributions of these two years are right-skewed because these values are insignificant. Thus, in general, the distributions of firms' inefficiency appear to be non-negative and this finding further validates the assumption of positively truncated-normal distribution on firms' efficiency in Equation (2). For the purpose of visual examination of $\hat{w}_{it}$'s truncated normality, the histograms of $\hat{w}_{it}$'s distribution are plotted against normal distributions in Figure 7 and a similar pattern can be observed.

Table 10: Summary Statistics and Skewness/Kurtosis Tests of Random-Effects Residuals

Year	Mean	Stdv.	Median	Skewness	Kurtosis
1996	0.102	0.767	0.102	0.155	3.109
1997	0.058	0.931	0.058	-1.036***	7.606***
1998	0.100	0.878	0.100	-1.099***	6.859***
1999	0.095	0.821	0.095	0.077	3.212
2000	0.148	0.840	0.148	-0.212	3.541
2001	0.133	0.927	0.133	-0.639***	4.378***
Total	0.107	0.862	0.107	-0.544	5.185

Note: The summary of skewness and kurtosis examines the normality of estimated residuals obtained from Equation (4). The distributions of the residuals are compared to normal distributions with the same means and standard deviations. *, **, *** indicate the 10%, 5%, and 1% significance levels respectively.

Figure 7: Histograms of Random-Effects Residuals Compared to Normal Distributions



Note: This figure helps visually examine the normality of retained estimated residuals from the random-effects estimation of Equation (4), namely $\hat{w}_{it} + e_{it}$. The bars represent densities of the estimated residuals and the solid lines show densities of normal distributions with the same means and standard deviations. The histograms of the retained residuals are plotted by years.

Moreover, it is also critical to test how the distributions of inefficiency vary over time. With a rather restrictive setup, Equation (2) models the heterogeneity of firms' inefficiency with time-invariant mean and a constant variance. It may not be appropriate to do so if the dataset suggests otherwise. Table 11 reports results from testing whether the means and variances of $\hat{w}_{it}$ are time-invariant. The between-groups F-test statistics fails to reject the null hypothesis that the means of $\hat{w}_{it}$ are not systematically different over time. Bartlett's test for equal variance suggests a time-invariant variance for $\hat{w}_{it}$ with P-value 0.106. On the empirical front, these results may simply indicate that the distribution of a firm's inefficiency can be modeled with a time-invariant mean and a constant variance in the context of this study.

Table 11: Tests for Time-invariant Means and Constant Variances of Random-Effect Residuals

	SS	degree of freedom	MS	F-test	P-value
Across time (between groups)	0.882	5	0.176	0.24	0.947
Bartlett's test for equal variance Chi square = 9.800 P-value = 0.106					

Note: This table examines whether means or variances of the retained residuals from the linear random-effects model (Equation (4)) change over time. Two tests are used. First, a standard F-test evaluates if the means of residuals' distributions from different years are significantly different. Second, a Bartlett's test is considered to evaluate if the variances of residuals' distributions are significantly different.

4.4 The random-effects probit model on causes of privatization

To study the causes of inefficiency, a random-effects probit model (Equation (1)) is chosen as the baseline model. The ownership dummy is used as the dependent variable and the determinants of privatization discussed in Section 3.1 are selected as independent variables. The purpose of this estimation is two-fold. First, it helps one to understand what drives the current privatization in China. In particular, how economic reform policies and the governments from different jurisdictions decide which SOE to be privatized and which to be retained. Second, this first step estimation would also generate a new ownership variable (privatization propensity), which will later address the endogeneity problem in the stochastic frontier estimation. This baseline estimation includes variables of performance (ROA and tax), labor redundancy (Redundancy), size (Total employment and Asset), share distribution (Central and provincial, City, and County shares), year (from year 1997 to 2001), location (North, East and West) and industry dummies (industries 1-9). The marginal effects of independent variables are presented in the second column of Table 12. In addition, a standard random-effects model is also conducted as the robustness test with the same independent variables, but with the percentage of private shares replacing ownership dummy as the dependent variable. The resulting marginal effects are shown in the fourth column of Table 12.

The coefficients of performance variables from both models confirm that SOEs with better profit margin are more likely to be privatized or to accept private shares with 5 percent significance level. However, in contrast to the insignificant effect of tax on privatization decision in the probit model, the random-effects model shows that firms generating more tax revenues on average have 47 percent fewer shares from private investors. Such result may reflect that the governments are inclined to retain SOEs critical to their budgets. This finding is also consistent

with the policy orientation of privatization in China. In general, the Chinese government's stance is to undertake gradual rather than drastic reforms. Keeping control of firms with more tax revenues provides more financial means for the governments to proceed with gradual reforms. In line with this result, firms with more redundant workers are less likely (with 0.823 percentage points) to be privatized in the baseline model. Interestingly, the size of firms seems to pose no impact during privatization decision-making process. Both the assets and the total employment coefficients are insignificant. One explanation is that the size effects may be absorbed by the coefficient of government shares. In other words, governments may be inclined to control and keep majority stakes in large firms. Indeed, probabilities of privatization decrease by 0.035 and

Table 12 Causes of Privatization

Dependent variables	Ownership dummy		Private shares	
Models	Probit RE	Logit FE	RE	FE
Independent variables				
ROA	6.332**	107.761**	14.499**	14.342*
	(2.979)	(49.840)	(6.860)	(7.686)
Tax	-5.742	-241.101**	-47.781**	-44.044
	(6.958)	(122.257)	(23.509)	(28.256)
Total employment	-0.078	-30.970	0.717	8.796*
	(0.356)	(27.533)	(1.767)	(5.256)
Redundancy	-0.823***	-25.797**	-0.453	-0.339
	(0.334)	(12.101)	(0.318)	(0.410)
Asset	-0.085	-2.478	-0.931	1.504
	(0.273)	(5.674)	(1.329)	(2.251)
Central and provincial Shares	-0.245		-0.242***	-0.037
	(230.704)		(0.068)	(0.150)
City shares	-0.035***		-0.223***	-0.069**
	(0.005)		(0.024)	(0.034)
County shares	-0.039***	-5.160	-0.219***	-0.134
	(0.007)	(52.830)	(0.033)	(0.045)
Year 1997	0.609	3.318	0.248	0.007
	(0.676)	(4.578)	(1.021)	(1.011)
Year 1998	1.713***	13.884*	1.304	1.150
	(0.637)	(7.611)	(1.015)	(1.012)

Table 12 Causes of Privatization (Continued)

	Ownership dummy		Private shares	
Independent variables	Probit RE	Logit FE	RE	FE

Year 1999	1.862***	18.814**		2.263**	2.216**
	(0.640)	(8.953)		(1.032)	(1.054)
Year 2000	2.169***	22.479**		2.021*	2.394**
	(0.645)	(10.304)		(1.072)	(1.125)
Year 2001	2.545***	26.872**		3.507***	4.511***
	(0.647)	(11.772)		(1.120)	(1.212)
North	0.787			2.264	
	(0.526)			(2.827)	
East	1.055**			-2.614	
	(0.544)			(3.160)	
West	0.512			0.969	
	(0.502)			(2.975)	
Constant	-0.591			23.606***	
	(1.613)			(8.263)	
Log likelihood	-153	-4.092	R-square	0.365	0.018
Obs.	1222	1222		1192	1192
Var(α_i)	2.390			8.995	
Rh_0	0.705			0.760	

Note: This table reports estimation results from four models in attempt to examine the determinants of privatization. The specifications of these four models are based on Equation (1). In the probit random-effects and the logit fixed-effects models, an ownership dummy is used as the proxy for firms' ownership. It takes value of unity if private shares in a firm exceed 50 percent. As a robustness test, the percentage of private shares in a firm is used as a proxy for ownership variable in the random-effects and fixed-effects models. R-square reported here is between R-square. The variances of random-effects are shown as var(α_i) and Rh_0 represents the proportion of the total variance contributed by the random-effects variances. Standard deviations are shown in the parenthesis. *, **, *** indicate the 10%, 5%, and 1% significance levels respectively.

0.039 percentage points respectively if city and county shares increase by one percentage point. Moreover, the propensity of privatization also increases significantly over time. The chance of being privatized in 1998 was only 1.713 percent, whereas the probability had increased to 2.545 percent in 2001. Such strong and persistent time effects reveal several additional driving forces of privatization in China. First, there is a more mature equity market to finance privatization over time. With the influx of foreign investors and growing strength of domestic investors after two decades of reform, alternative financing sources become increasingly available to SOEs and local governments, thereby facilitating privatization process. Second, the increased competition caused by further removal of market entry barriers to most sectors of the economy may have dramatically worsened the financial situations at the less competitive SOEs. As a result, local governments may feel the urge to pursue a more rapid approach towards privatization. Third, the time effects also reflect the shift of governments' attitudes toward privatization over time.

Recognizing privatization as an important alternative approach to unload money-losing SOEs, the reformists' views on privatization had started to dominate in the local governments. This shift is found to be particularly prevalent in the cities located in the eastern region. SOEs from the east region are 1.055 percent more likely to be privatized than those from other regions in the sample. Lastly, not shown in the table, firms in equipment manufacturing are found more likely to be privatized.

To examine the robustness of these results, a logit fixed-effects model and a standard fixed-effects model with the percentage of private shares as dependent variable are also estimated. The results are presented in the third and the last columns of Table 12 respectively. Results from these alternative estimations may differ in magnitudes, but largely reinforce findings in the baseline model.

4.5 Random-effects stochastic frontier model

The panel stochastic frontier estimation results shown in Table 13 provide information on factors that may affect firms' inefficiency. Among the five different specifications considered in Table 13, our primary interest rests on the generalized Battesse and Coelli model with normal-truncated normal distribution (Model 5) and its estimation results are reported in the last column. Results from the other four alternative stochastic frontier models are also presented in Table 13 for comparison purpose. These four models include the Cornwell, Schmidt, and Sickles' fixed-effects (Model 1), Pitt and Lee time-invariant with normal-half normal distribution (Model 2), Battesse and Coelli (Model 3), and a generalized Battesse and Coelli model with normal-half normal distribution (Model 4). In this section, effects of time-varying and time-invariant variables on inefficiency are interpreted based on the Model 5 normal-truncated model. Furthermore, implications from the other four aforementioned models are examined and compared against the chosen specification. Finally, the patterns of Chinese firms' efficiency are studied across time and ownerships.

Table 13 Fixed and Random-Effects Stochastic Frontier Results

	Cornwell, Schmidt, and Sickles fixed effects model (Model 1)	Pitt and Lee time-invarying model (normal-half normal) (Model 2)	Battesse and Coelli baseline model (normal-half normal) (Model 3)	Time-varying model with scaling effect (normal-half normal) (Model 4)	Time-varying model with scaling effect (normal-truncated normal) (Model 5)
			Production function		
Constant		0.455	0.429	0.655*	2.019***
		(0.419)	(0.380)	(0.390)	(0.664)
Time trend	0.012	0.153	0.074***	0.068***	0.129***
	(0.012)	(0.012)	(0.018)	(0.019)	(0.032)
Working Employee	0.646***	0.667***	0.624***	0.525***	0.540***
	(0.057)	(0.029)	(0.032)	(0.042)	(0.045)
Asset	0.400***	0.489***	0.480***	0.538***	0.496***
	(0.095)	(0.070)	(0.066)	(0.067)	(0.055)
Year 1997	-0.085*	-0.096	-0.100	-0.095	-0.107
	(0.048)	(0.069)	(0.069)	(0.084)	(0.085)
Year 1998	-0.114***	-0.119**	-0.124**	-0.119*	-0.131*
	(0.045)	(0.054)	(0.057)	(0.067)	(0.070)
Year 1999	-0.031	-0.033	-0.040	-0.038	-0.043
	(0.043)	(0.060)	(0.059)	(0.060)	(0.058)
Year 2000	-0.031	-0.035	-0.043	-0.041	-0.044
	(0.044)	(0.058)	(0.059)	(0.058)	(0.059)
			Coefficients of variables determining the mean of inefficiency γ		
Constant					2.869***
					(0.681)
Northern region					-0.092
					(0.157)
Eastern region					-0.153
					(0.186)

Table 13 (continued)

Western region					-0.485***
					(0.135)
Coefficients of variables determining the scaling factor η					
Time decay			-0.059***	-0.054***	-0.054***
			(0.009)	(0.011)	(0.010)
Privatization				-0.258	-0.146*
				(0.164)	(0.080)
Managers' shares				0.000	0.001
				(0.003)	(0.001)
Social burden				0.261***	0.183***
				(0.064)	(0.049)
Soft budget constraint				-0.010	0.058**
				(0.030)	(0.025)
Debt asset ratio				-0.040	-0.005
				(0.058)	(0.033)
Composed error $v_{it} - u_{it}$					
Lambda		3.149***	3.446***	2.988***	1.438***
		(0.471)	(0.024)	(0.035)	(0.040)
Sigma (u_{it})		1.476***	1.608***	1.387***	0.651***
		(0.116)	(0.373)	(0.322)	(0.032)
obs.	1064	1064	1064	1064	1064
Log likelihood		-1000	-1327	-985	-931

Note: this table reports the results from all random stochastic frontier models considered in this study. Model 1 is a standard fixed-effects model based on Cornwell et al. (1990), in which the individual effects are considered as inefficiencies. Model 2 is a standard random -effects model based on Pitt and Lee (1982), in which individual effects are estimated as inefficiencies. Model 3 is a standard Battese and Coelli (1995)'s time-decaying random effect stochastic model. Time has scaling effects on the values of inefficiencies. A normal-half normal composed error term is assumed in both Model 2 and Model 3. Model 4 is a random effect stochastic frontier model in which the mean of individual effects depends on ownership, redundant workers, social burdens, soft-budget constraint, and managers' shares. Time is assumed to have no impact on changes of firms' inefficiencies. Model 5 is a combination of Models 3 and 4. In Model 5, the values of firms' inefficiency are determined by a time-varying scaling effect and time-invariant individual effects. The time-varying scaling effect depends on ownership, redundancy, soft-budget constraint, social burdens and managers' shares. The means of the time-invariant effects' distributions depend on time-invariant variables, such as location. Normal-half normal and Normal-truncated normal distributions are assumed for the composed error terms in Models 3 and 4, respectively. Standard errors are shown in parenthesis and *, **, *** indicate the 10%, 5%, and 1% significance levels respectively.

4.5.1 Effects of privatization on firms' technical efficiency

It may seem surprising that the included time trend variable indicates a continuously deteriorating trend in firms' efficiency over time in the overall sample. This finding seems counterintuitive at first glance because efficiencies at Chinese firms are normally expected to improve over years. However, further examination on efficiencies at different ownerships can help understand this unusual phenomenon. The estimated coefficient on privatization shows that efficiency at privatized firms is 15 percent higher than those at SOEs on average. In addition, social burden and soft-budget constraint decrease efficiency by another 18 percent and 6 percent, respectively. Variance from the inefficiency term is attributed to almost 60 percent of the production variance whereas the overall disturbance error only account for 40 percent of production variance. Lastly, shares owned by managers and debt ratio of a firm exhibit no significant impact on firms' efficiency. Similarly, results from Models 3 and 4 also indicate a decrease in firms' efficiency over time. Nonetheless, only social burden shows positive effect on firms' inefficiency at 1 percent significant level. Privatization effect appears not significant in the Model 4. For effects of time-invariant variables on the means of efficiency's distributions, only the western region dummy is significant. This associated coefficient of western region dummy implies that firms selected from the western region are on average more productive than those from other regions by 48.5 percent. This difference is significant at 1 percent significance level.

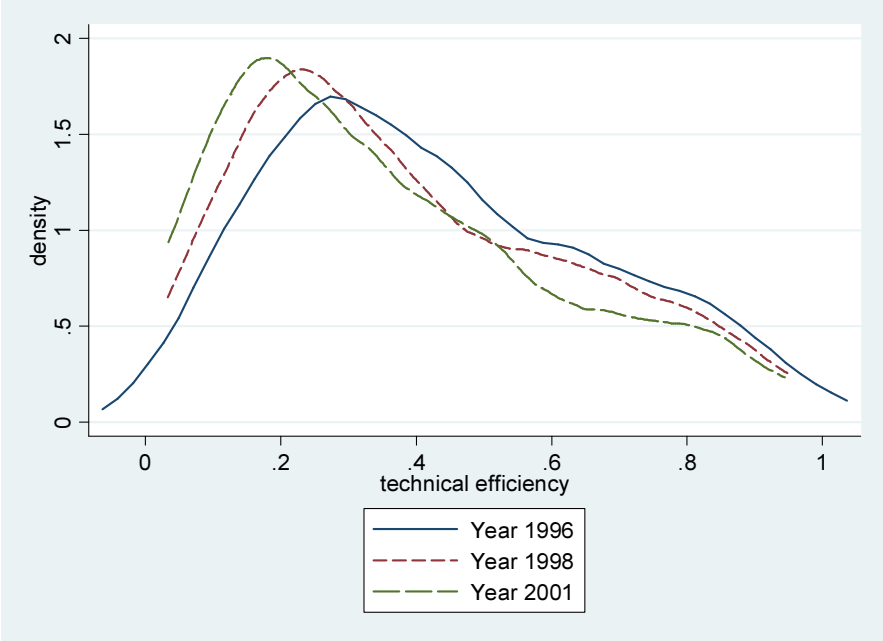
For production factors, all specifications reveal a drop of production in 1998 at all firms. The decrease ranges from 11 percent in the Model 1 to 13 percent in the Model 5. This sudden contraction in output may be largely caused by more restrictive lending rules and shocks from the unexpected Asian financial crisis. The estimated marginal effects on production of labor and capital in the Model 5 are 0.54 and 0.50 respectively. Likewise, similar results can be found in the other four alternative estimation models. All models except the Models 1 and 2 show positive and significant effects of time trend on firms' output. In particular, time trend has the most impact on output in the Model 5 and its marginal effect is 0.13.

4.5.2 Dynamics of efficiency changes and economic growth in China

To investigate how Chinese firms' efficiency has changed over time, the overall efficiencies of all firms from 1996 to 2001 are estimated with the Model 5 following Equation

(2)'s specification. The resulting kernel densities of the estimated efficiencies from year 1996, 1998 and 2001 are shown in Figure 8. Taking a snapshot of the dynamics of firms' efficiency in Figure 8, two questions can be raised regarding the changes of efficiency at Chinese manufacturing firms and their impacts on Chinese economic growth. First, even after a decade of enterprise reform aimed at improving SOEs efficiency, it seems that efficiency at Chinese firms, overall, instead of improving, has declined consistently from 1996 to 2001. Second, given that the overall performance of firms has worsened, improved efficiency at enterprises apparently cannot sufficiently explain the last two decades of impressive economic growth in China.

Figure 8: Estimated Overall Efficiency for All Firms with Chosen Years: 1996, 1998, and 2001



Note: This figure shows the kernel densities of estimated efficiencies for all firms during three chosen periods, 1996, 1998 and 2001. The efficiencies are estimated from Model 5 with Equation (2)'s specification.

To examine the first question further, statistics of the estimated efficiencies at different ownerships are summarized and compared in Table 14. It is found that the overall decrease of efficiency at Chinese manufacturing firms may be largely the result of increased inefficiency at SOEs, which make up the majority of samples surveyed in our dataset. Efficiency at SOEs has on average decreased from 0.43 in 1996 to 0.33 in 2001 even after most of SOEs have undergone a series of reforms on corporate governance. Clearly, this finding casts doubts on the

effectiveness of Chinese governments' efforts to improve firms' technical efficiency without restructuring their ownerships. The gradualism of Chinese overall economic reform may attribute to this receding efficiency at reformed SOEs in the following ways. First, reformed Chinese SOEs are still subject to soft-budget constraints because of the intimate relationship between local banks and provincial and local government officials. *Yusuf, Nabeshima, and Perkins (2006)* report that SOEs were still favored in bank lending even after the central government tightened banks' credit lending practice. Second, diversifying state ownership at reformed SOEs does not fundamentally improve their corporate governance. Normally, smaller SOEs were converted to limited liability companies (LLC) and larger SOEs were restructured to limited liability shareholding corporations (LLSC) during the waves SOE reform in the 1990s. The purpose of corporatizing SOEs is to grant them with independent legal entity status and subsequently the governments may be relieved from taking responsibility for firms' poor performance. However, in a sample of 1,105 Chinese reformed SOEs, *Liu and Sun (2003)* find that 84 percent of them are still controlled by the state (as a majority shareholder) in 2001 although private ownerships are introduced to these reformed SOEs. Thus, as minority shareholders, private investors very often do not have voice in business operations and personnel appointments. Even worse, reform processes at SOEs are regularly influenced by local politicians. Therefore, it is not surprising that most of reformed SOEs still behave as pre-reformed SOEs and still face various social obligations. These factors may jointly undermine efficiency of SOEs and reformed SOEs in China.

In contrast, estimated efficiency at privatized firms has been consistently higher than that at SOEs and is on the rise since 1999. Table 14 summarizes the means and standard deviations of these estimated efficiencies. Furthermore, tests results on whether the means of the estimated efficiencies at SOEs and those at the privatized firms are statistically equal from 1996 to 2001 are also shown in Table 14. In despite of insignificant difference in the early years, efficiency at private firms has been significantly different from and higher than that at SOEs after 1999. As of 2001, private firms were on average 50 percent more efficient than their SOE counterparts. More interestingly, the standard deviations of private firms' efficiency have continuously decreased from 0.17 in 1996 to 0.04 in 2001. This may reflect the fact that efficiencies at firms primarily owned by private investors have converged over time. The primary cause of this convergence

could be post-privatization effects, increased market competition or simply improved management skills. Conversely, the standard deviations of SOEs' estimated efficiency are roughly the same from 1996 to 2001. The kernel densities of the estimated technical efficiency of private firms and SOEs in Figure 9 also confirm this pattern of changes in efficiency at the private firms and SOEs.

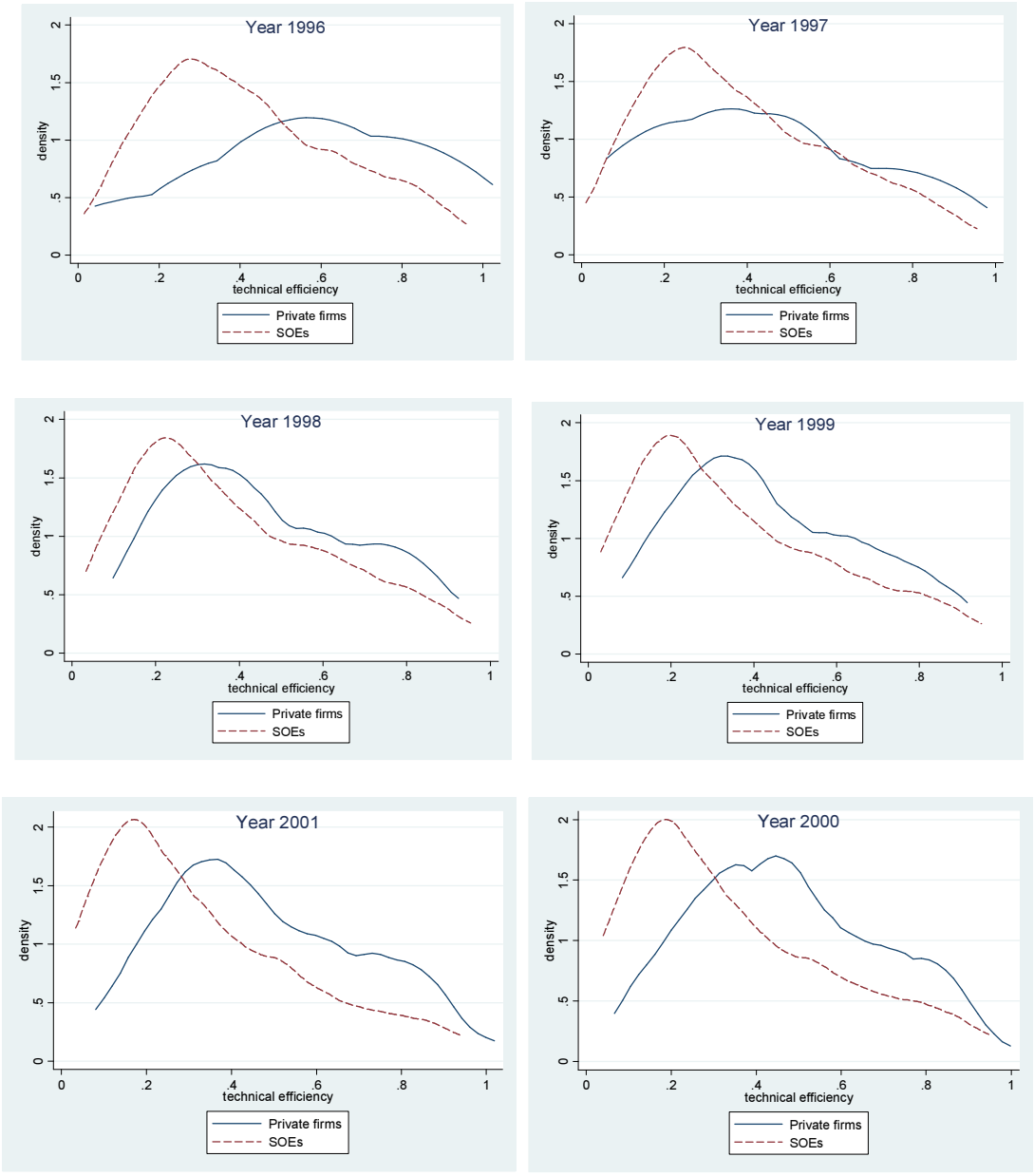
Table 14: Tests for Equal Means of Efficiency at the Privatized and SOEs, from 1996 to 2001

	1996	1997	1998	1999	2000	2001
SOE	0.427	0.397	0.391	0.370	0.351	0.329
	(0.019)	(0.018)	(0.019)	(0.019)	(0.019)	(0.019)
Private	0.571	0.449	0.465	0.449	0.477	0.482
	(0.167)	(0.117)	(0.067)	(0.053)	(0.040)	(0.037)
Difference = mean (SOEs) - mean (Private)						
Difference	-0.143	-0.052	-0.073	-0.079*	-0.127***	-0.152***

Note: All efficiencies are estimated based on Model 5 with Equation (1)'s specification. Standard errors are shown in parenthesis and *, **, *** indicate the 10%, 5%, and 1% significance levels respectively.

To shed lights on the second question regarding the seeming paradoxical relationship between rapid economic growth and declining enterprise efficiency in China, two conjectures are worth of exploring. First, *Yusuf, Nabeshima, and Perkins (2006)* conclude that most of China's economic growth is attributable not to improvement of firms' efficiency, but to intersectoral resources transfer caused by structural reform and to technological advances as a direct result of heavy investment in industries and infrastructure. They found that the average growth rate of GDP has diminished as capital-output-ratio has increased from 3.96 in 1980-4 to 5.40 to 2000-2 (Yusuf, Nabeshima, and Perkins (2006) pp.7). As they speculate, this may largely represent "a systematic misallocation of resources at Chinese firms and lack of enforcement on organizational restructuring at firms". Thus, decreased efficiencies at SOEs and reformed SOEs are not contradictory to the economic growth in China during the studied period. Furthermore, compared to the weaker performance at SOEs, efficiency gains from private firms may also tend to explain a portion of economic growth in China. Our study also illustrates the same phenomenon of growing importance of private sector in Chinese economy since 1997-8 in that the weight of gross output produced by private firms has increased from 4 percent in 1995 to 23 percent in 2001 in our sample.

Figure 9: Kernel Densities of Technical Efficiency of the Private Firms and SOEs, from 1996-2000



Note: This figure compares the kernel densities of the estimated efficiencies at SOEs and private enterprises from 1996 to 2001. The efficiencies at SOEs and private enterprises are estimated based on Model 5 with Equation (2)'s specification.

5 Conclusions

This paper uses a panel data of 863 Chinese firms in 11 cities to estimate and compare impacts of privatization and various reform attempts on Chinese SOEs' technical efficiency from 1995 to 2001. This time period is particularly interesting because privatization has started to gain its momentum in China after a decade of policy debates and experiments. To address the endogeneity problem commonly faced by studies on Chinese privatization, a two-step Heckman-type estimation strategy is adopted. The endogeneity problem is present due to the gradual nature of Chinese SOE reform. In particular, some better-performing SOEs are chosen first for privatization since the local governments may do that deliberately to attract more private investors or rally support to retain momentum for privatization. A Heckman endogeneity test confirms the presence of the endogeneity problem and a panel probit estimation subsequently is considered to study the causes of privatization. The panel probit estimation results further confirm that the likelihood of a better-performing SOE being privatized is significantly higher than their peers. To appraise the impact of privatization and of other reform measures without relinquishing the state control, a panel stochastic frontier model is estimated in the second step. The results show that privatization has significantly improved a firm's efficiency by 15 percent on average and that hardening budget constraint and relaxing firms' obligations to retirees and *xiagang* workers have also significantly improved a firm's efficiency by 6 and 18 percents, respectively. Further estimations on the dynamics of firms' efficiency in 1996-2001 suggest that efficiency of SOEs has continued to deteriorate during this period and in contrast, efficiency of private firms in China has exhibited a rather robust improvement after 1998.

In summary, this study adds insights on the effectiveness of Chinese SOE reform and privatization policies. It shows that any attempts aimed at reviving Chinese SOEs' technical efficiency without seriously challenging the state control may be insufficient to improve efficiency and that their effectiveness, if any, is at most modest. After decades of SOE reform in China, as of 2001, most of the reformed SOEs are still subject to soft-budget constraint and social obligations and consequently the efficiency outcomes of these reforms have been largely undermined.

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