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Firm Dynamics and SOE Transformation During China's Economic Reform*

Shijun Gu[†] Chengcheng Jia[‡]

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Abstract

We study the reform of China's state-owned enterprises (SOE) with a focus on the corporatization of SOEs. We first document the empirical patterns of the *"grasp the large and let go of the small"* policy. To quantify the implications of the reform for aggregate output and TFP, we build a three-sector firm dynamics model featuring financial frictions and endogenous firm-type choices. Our calibrated model shows that the SOE reform can increase long-run TFP by encouraging the exit of the least efficient firms in the state sector, but the magnitude of TFP growth also depends on the efficiency in capital reallocation. In the short run, corporatization increases aggregate output and TFP because it allows the most productive SOEs to have a higher borrowing capacity than they would under privatization.

Keywords: firm dynamics, economic reform, Chinese economy
JEL classification: E23, E44, O16, O41, O43, O53

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[†]Central University of Finance and Economics. Email: shijungu@cufe.edu.cn
[‡]Federal Reserve Bank of Cleveland. Email: Chengcheng.Jia@clev.frb.org

1 Introduction

A large body of literature (e.g, Hsieh and Klenow (2009), Song, Storesletten, and Zilibotti (2011)) argues that China's economic growth since the Economic Reform is mainly driven by the reallocation of resources from the less efficient state sector[1] to the more efficient private sector. However, most existing papers ignore the heterogeneous performance of firms in the state sector and the impact of corporatization of state-owned enterprises (SOEs) on economic transition. In the data, although the output share of the state sector in the aggregate economy declines, individual firms in the state sector become larger and more profitable on average. Our paper fills this gap by studying SOE transformation with a special focus on the corporatization of SOEs after the Economic Reform.

We first empirically document that small SOEs are more likely to exit or become privatized, whereas large SOEs are more likely to become corporatized while remaining state-owned. In addition, the increase in TFP following the SOE reform comes from both the improvement in average firm productivity and the increase in allocative efficiency. To quantify the effects of the SOE reform on the aggregate economy, we build a three-sector firm dynamics model featuring financial frictions and endogenous firm-type choices. The parameterized version of our model shows that the SOE reform can increase long-run TFP by encouraging the exit of the least efficient firms in the state sector, but the magnitude of TFP growth also depends on the efficiency in capital reallocation. In the short run, the corporatization of SOEs increases aggregate output and TFP, because it allows the most productive SOEs to have a higher borrowing capacity than they would under privatization.

We start the analysis by empirically documenting the SOE reform using firm-level data from the Annual Survey of Industries. We show the important trend of corporatization of SOEs: since the late 1990s, an increasing number of firms are owned by the state but are registered as non-SOE corporations. We name this type of firm corporatized state-owned enterprises (CSOEs) to distinguish them from the traditional SOEs.

To study the impact of SOE reform, we first show that at the aggregate level, the output share of the state sector significantly declined. However, the average size of firms in the state sector increased relative to that in the private sector. We further find that this change is consistent with the *"grasp the large and let go of the small"* policy, which was implemented in the SOE reform starting in 1999. That is, small SOEs either exit or become privatized, whereas large SOEs are corporatized and remain state controlled.

Next, we apply the TFP accounting framework similar to that in Hsieh and Klenow

[1] In the literature, state-owned vs. private firms can be defined by either registration type or the controlling share of equity. In our paper, the state sector contains all firms of which the state government has controlling shares of equity, including those that are corporatized. Details of our definition are provided in Section 2.2.

(2009) and Midrigan and Xu (2014) and document strong TFP growth between 1998 and 2007, explained by a 60 percent increase in efficient TFP and a 25 percent decline in TFP loss. We also find that on average, the exited SOEs have lower firm productivity and lower returns to capital, which implies that the SOE reform contributes to the increase in average firm productivity and the reduction in capital misallocation observed in data.

To explain these empirical patterns and quantify the aggregate effects of the SOE reform, we build a heterogeneous-firms model with endogenous entry and exit based on Jovanovic (1982) and Hopenhayn (1992). To capture the firm dynamics specific to China's Economic Reform, we augment the model in three dimensions. First, we assume that firms are subject to collateral constraints, similar to Evans and Jovanovic (1989), Buera and Shin (2013), and Gavazza, Mongey, and Violante (2018). Second, we model a three-sector economy (SOE, POE, and CSOE sectors) and discipline sector-specific characteristics using firm-level data. Third, we model SOE reform as allowing incumbent SOEs to optimally choose between corporatization, privatization, or exiting the market. In this way, our model generates endogenous firm measures, firm sizes, and market shares in different sectors.

In our model, SOEs, CSOEs, and POEs operate under the same decreasing returns to scale technology, but are different in borrowing constraints, borrowing costs, fixed costs of operation, production efficiency, and discount rates. Prior to the SOE reform, all firms make endogenous entry and exit decisions, and the life-cycle decisions of firms are identical across all sectors. Once the SOE reform starts, a fraction of SOEs receive a reform shock in each period. If hit by the shock, an SOE has the opportunity to transform to a CSOE or a POE and continue its operation, in addition to its exit option.

We discipline our model parameters to match the firm-level empirical moments in the pre-reform period. Our calibration suggests that SOEs' production efficiency is 23 percent lower than that of POEs, but their borrowing capacity is substantially higher and their exit criteria are significantly lower. This explains two important features of the SOE sector in the pre-reform period. First, the data exhibit the coexistence of a small average output and a large share of capital used in the SOE sector. Second, SOEs are less efficient but rarely exit the market before the SOE reform.

With these estimated parameters, we quantitatively assess the impact of the SOE reform on the aggregate economy. We first study the long-run effects of the reform by comparing the initial steady state that we calibrated to the Chinese economy in 1998 and the final steady state in which the SOE sector is completely closed. Under our calibration, the SOE sector has the lowest sectoral TFP compared to the other two sectors in the pre-reform period. We find that this is mainly driven by two factors: the low production efficiency that affects all SOEs and the low exit value that prevents the least productive SOEs from exiting the market. In the final steady state, we find that the SOE reform leads to aggregate TFP improvement due to its role in facilitating resource reallocation, but the magnitude of growth depends on the reallocative efficiency. Without the relaxation of financial constraints in the CSOE and POE sectors, the extent of TFP improvement after the closure of the SOE sector is significantly limited.

Last, we study the short-run effects of the SOE reform by simulating the transition dynamics in which entry into the SOE sector is gradually closed and the incumbent SOEs are given a transformation choice. Our model predicts that, when given the transformation option, incumbent SOEs with a high technology level choose corporatization, whereas those with a low technology level choose to be privatized or exit the market. The intuition is that an incumbent SOE weighs the benefits of corporatization - a higher borrowing capacity - against the cost of corporatization - a lower gain in production efficiency. When the incumbent SOE is very productive, the benefits of corporatization outweigh the cost. Under this decision rule, the SOEs that are corporatized are larger than those that are privatized or that exit. Therefore, our model predicts that the exit ratio decreases with firm size and the corporatization ratio increases with firm size, consistent with the empirical findings of the "grasp the large and let go of the small" policy.

Regarding the aggregate effect along the transition path, we find that the SOE reform leads to 15.6 percent growth in measured TFP from 1998 to 2007, which comes from both the improvement in efficient TFP and the reduction in TFP loss. To quantify the importance of the corporatization option, we conduct a counterfactual analysis where SOEs are only given two options: privatization or exiting the market. We find that without the corporatization option, the gains from the SOE reform would be substantially reduced. The reason is that under the no-corporatization reform, high productivity SOEs would have to turn into POEs instead of CSOEs and thus face tighter borrowing constraints. The tighter constraints would exacerbate capital misallocation, leading to lower aggregate output and lower aggregate TFP.

Related Literature

Our paper builds on the large body of literature studying economic growth in China. Earlier work focuses on identifying the sources of China's economic growth. Evidence has shown that both TFP improvement and capital deepening have contributed to the sustained output growth in China. (See Young (2003), Bosworth and Collins (2008), and Brandt and Zhu (2010), among others.) The recent literature focuses on modeling the source of TFP improvement as resource reallocation, either between the state and the private sector (Song, Storesletten, and Zilibotti (2011), Brandt, Tombe, and Zhu (2013), Curtis (2016), and Zhu

(2012)) or between the heavy-industry and the light-industry sector (Chang et al. (2016)).

Different from all of the above-mentioned papers, our paper models a three-sector economy and focuses on the corporatization of SOEs. Our paper is most closely related to Hsieh and Song (2015) and Peng (2019), both of which focus on China's SOE reform. Hsieh and Song (2015) are the first to empirically document that the Economic Reform in China has had heterogeneous effects on state-owned enterprises, which can be summarized as *"grasp the large and let go of the small."* Peng (2019) theoretically models the endogenous exit of SOEs by adding non-negative equity constraints to all SOEs after the reform. The main novelty of our paper is that we model the optimal transformation decision of SOEs between corporatization, privatization, and exiting the market.

More generally, our paper contributes to the literature on misallocation pioneered by Restuccia and Rogerson (2008) and Hsieh and Klenow (2009). Our model builds on the recent literature that focuses on the role of financial market imperfection in driving the reallocation dynamics after economic reforms (Jeong and Townsend (2007), Caballero, Farhi, and Gourinchas (2008), Buera, Kaboski, and Shin (2011), Buera and Shin (2013), Moll (2014), Midrigan and Xu (2014), and Buera and Shin (2017)). Specific to the Chinese economy, Bai, Lu, and Tian (2018) find that endogenous borrowing constraints can explain one-third of the TFP loss measured in Hsieh and Klenow (2009). David and Venkateswaran (2019) find that firm-specific factors, especially size-dependent government policies and distortions caused by financial market imperfections, account for around 40 percent of TFP loss. Our main contribution is to use China's SOE transformation as a special case to study the impacts of financial frictions on resource reallocation and TPF growth during post-reform economic transition.

2 Empirical Evidence

We begin this section by providing an overview of the institutional background of China's Economic Reform, which also sheds light on our definition of traditional vs. corporatized SOEs. We then present a set of empirical findings based on firm-level data from the *Annual Survey of Industries (ASI)* conducted by China's National Bureau of Statistics.[2] This data set contains all state-owned firms and private firms in the industrial sector whose annual revenue equals or exceeds 5 million RMB. Our sample period is from 1998 to 2007, which covers the pre-reform period and the post-reform transition period.[3] We restrict our sample

[2] The aggregate data on Chinese industrial firms are available at http://www.stats.gov.cn/tjsj/. The firm-level data are not publicly available.

[3] Another reason we use data only through 2007 is that some variables are no longer reported for the full set of firms after 2007.

to firms under operation with positive value-added, positive capital, positive labor, and positive total assets. A detailed description of our data-cleaning procedure is provided in Appendix A.

2.1 Institutional Background

China's Economic Reform started in 1978, setting off China's transition from a planned economy to a market economy. The Economic Reform has gone through several phases. In the first phase leading up to the late 1980s, the reform focused on agriculture in rural areas. For the manufacturing and service sectors, most market-oriented economic policies were only effective in the "special economic zones" such as Shenzhen and Zhuhai. After Deng Xiaoping's 1992 southern tour, the reform was resumed and was extended to the whole country. In this second phase, a set of policies were established to encourage the entry of private firms, including the first Corporation Law, which was enacted in 1993.

This paper focuses on the third phase of the reform, which started in 1998 and was led by the then premier, Zhu Rongji. Before 1998, the manufacturing sector was dominated by SOEs, and many of them were thought to be inefficient. In 1995 and 1996, around 50 percent of the SOEs reported losses (Meng (2003)), but very few SOEs ever went bankrupt. To improve efficiency and to stem the losses of SOEs, the Chinese government announced the SOE reform at the Fifteenth Communist Party Congress in September 1997, and more implementation details were laid out in Zhu Rongji's 1999 state council government report. According to the report, the goal of the SOE reform was summarized as "grasp the large and let go of the small."

To achieve this goal, small SOEs were either sold to private owners or liquidated. Large SOEs were incorporated as limited liability or share-holding companies. The state government does not directly operate these corporatized SOEs. Instead, the state government established industrial conglomerates to serve as parent companies that hold shares of these corporatized SOEs. In the rest of this section, we provide firm-level evidence on both the ex-ante characteristics of SOEs that made different transformation decisions (exit, privatization, and corporatization) and the ex-post performance of the SOEs after the transformation.

2.2 Definition of State Ownership

Since the onset of the SOE reform, the definition of state ownership has become less clear-cut. Our data provide two types of information on state ownership. The first type of information is the firm's registration type, which has six categories: (1) state-owned, (2) collectively owned (including state jointly owned), (3) privately owned, (4) limited liability corporations, (5) share-holding firms (including publicly traded), and (6) Hong Kong, Macao, Taiwan, or foreign owned. The second type of information is the controlling share of a firm, which shows whether the state has (1) an absolute controlling share, (2) a relative controlling share, or (3) no controlling share of the firm.[4]

The existing literature uses either firm registration type (for example, Bai, Lu, and Tian (2018)) or the controlling share of a firm (for example, Hsieh and Song (2015))[5] to categorize state owned versus privately owned. However, these two definitions of ownership do not always overlap. We use the Sinopec Beijing Yanshan Petrochemical Company as an example to illustrate this point. In 2002, this firm's registration type changed from state owned to a limited liability corporation, but the state government continues to have absolute controlling share of this company. The company's registered capital is 100 percent owned by its parent holding company, China Petrochemical Corporation, a state-owned conglomerate administered by SASAC (State-owned Assets Supervision and Administration Commission).[6] Since 2002, the Sinopec Beijing Yanshan Petrochemical Company has become a private firm by registration type, but still a state-owned company by controlling share of equity. This example illustrates how some state-owned enterprises have changed during the SOE reform: they have become modern corporations while continuing to be owned by the state government.

Instead of defining state-owned enterprises by either registration type or controlling share, we make use of both types of information and define three types of firms. Specifically, we define traditional state-owned enterprises (SOEs) as firms that are state owned under both definitions. We define corporatized state-owned enterprises (CSOEs) as firms that are state owned under controlling share of equity but registered as private corporations. We define privately owned enterprises (POEs) as firms that are not owned by the state government and are private by registration type. A summary of statistics of SOEs, CSOEs, and POEs under our definition is provided in Appendix A.

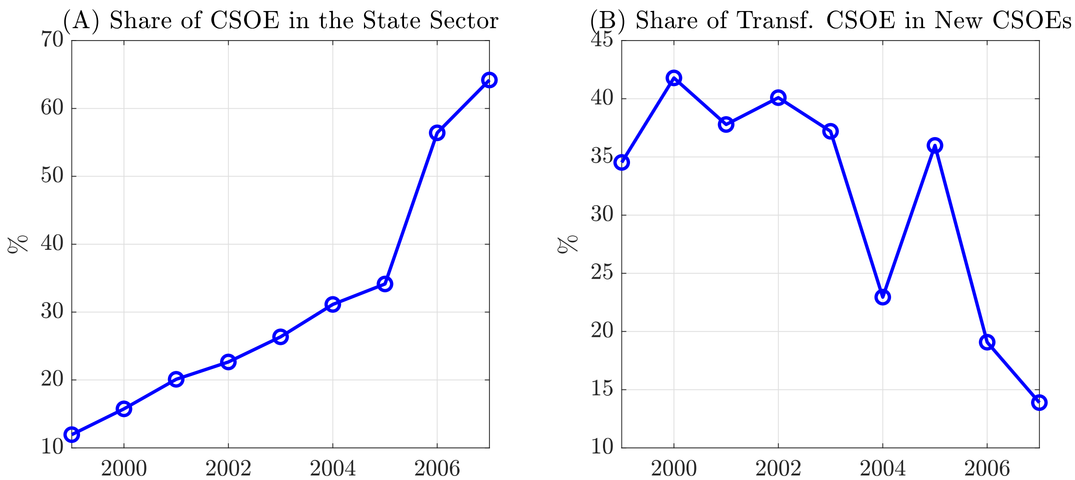
After the onset of the SOE reform, the share of CSOEs in the state sector (including both SOEs and CSOEs) increased from around 10 percent in 1998 to over 60 percent in 2007, as shown in Figure 1 (A). Three factors contributed to this change: (1) the exit of SOEs, (2)

[4] The data also provide another type of information that helps define firm ownership type, which is the shares of the registered capital that are owned by the state, by a collective, by private persons, by foreigners, and by a legal person. However, we do not have additional information on whether the legal person of a firm represents a private person, a private firm, or a state-owned parent holding company. Therefore, we do not use shares of registered capital to define state ownership.

[5] Hsieh and Song (2015) use the combination of the controlling share of the firm and the shares of the registered capital to define state ownership.

[6] Ownership information for the Sinopec Beijing Yanshan Petrochemical Company is available at https://aiqicha.baidu.com.

Figure 1: Share of CSOEs and Transformed CSOEs



Source: Authors' calculations based on ASI.
Notes: The state sector includes both the SOE sector and the CSOE sector.

the corporatization of existing SOEs, and (3) the entry of new CSOEs. Figure 1 (B) shows that the transformed CSOEs account for about 30 percent of new CSOEs, suggesting the importance of the corporatization of SOEs in explaining the rising share of CSOEs in the state sector.

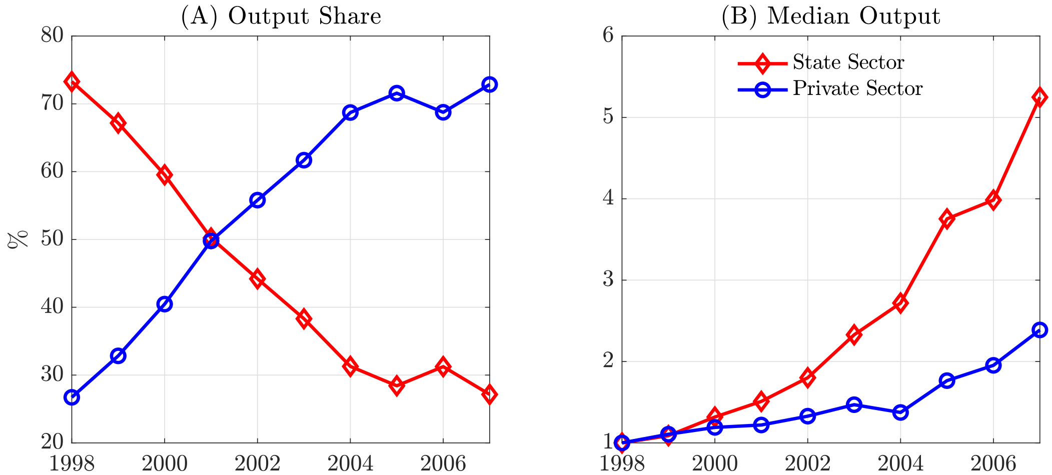
2.3 Grasp the Large and Let Go of the Small

The SOE reform resulted in significant changes in the state sector. The exit ratio among SOEs surged during the transition period. Among the SOEs that were in operation in 1998, around 70 percent of them had exited by 2007.[7] This is in stark contrast to the pre-reform period, during which time very few SOEs ever went out of business.[8] In this section, we investigate whether the empirical patterns during the reform period are consistent with the official slogan of the SOE reform: "grasp the large and let go of the small."

We first plot the state sector's share of output in the aggregate economy and the median output of the state sector in Figure 2. To control for industry effect, we normalize each firm's output by the mean within each industry.[9] Although the state sector's share of output in the economy decreases, it increases in terms of firm size on average, and the increase is significantly higher than that of the private sector. This indicates that small SOEs either exited the market or changed to POEs. Larger SOEs, on the other hand, changed to CSOEs

[7]Additional information on the number of exited and transformed SOEs is provided in Appendix A1.
[8]The average annual exit rate for SOEs during 1991-1995 is 0.9 percent (Hsieh and Song (2015)).
[9]We define industry at the 2-digit level.

Figure 2: Output Share and Firm Size in the State and the Private Sector



Source: Authors' calculations based on ASI.
Notes: Output is defined by value-added. Each firm's output is normalized by the mean within each industry. In panel (B), we normalize median output in both sectors by their 1998 values. The state sector includes both the SOE sector and the CSOE sector.

and stayed in the state sector.

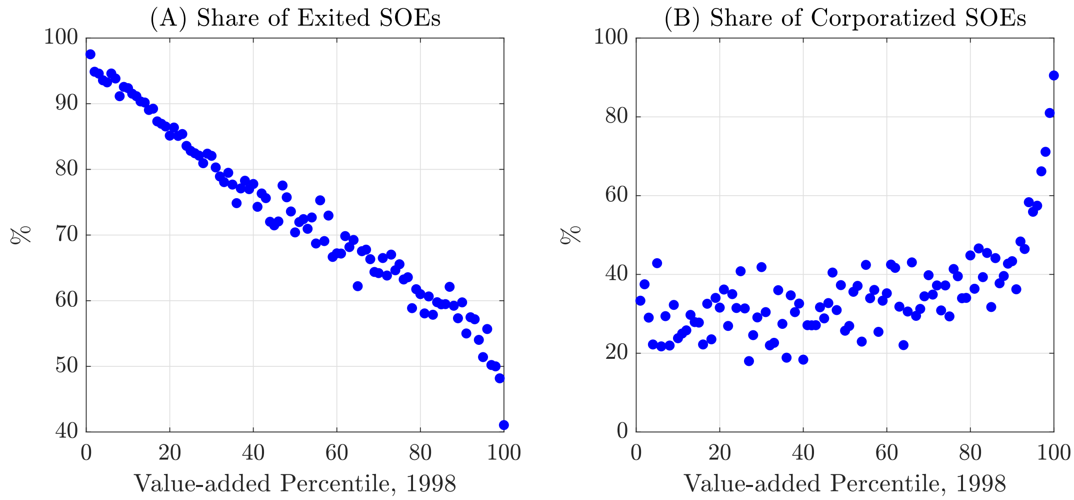
To further examine the relationship between the transformation decision and output size, in Figure 3 we plot the fraction of exited SOEs among all SOEs and the fraction of corporatized SOEs among all transformed SOEs (either privatized or corporatized) on each size bin defined by their value-added in 1998. It shows that the exit ratio significantly decreases with the size of value-added of the SOEs. For the transformed SOEs, larger SOEs are more likely to become corporatized than privatized. These patterns are generally consistent with the official slogan of the SOE reform, "grasp the large and let go of the small," although there are also some small SOEs that become CSOEs rather than POEs.

2.4 Accounting for Post-Reform TFP Growth

The SOE reform improves TFP in the aggregate economy via two channels: by increasing the average firm productivity and by facilitating resource reallocation. To measure the contribution of these two channels, we follow Hsieh and Klenow (2009) and Midrigan and Xu (2014) to decompose the changes in TFP. Specifically, with homogeneous goods and a decreasing returns to scale production function, TFP can be written as

$$logTFP = \underbrace{\mu_z + \frac{1}{2}\frac{1}{1-\gamma}\sigma_z^2}_{\text{Efficient TFP}} - \underbrace{\frac{1}{2}\frac{\alpha\gamma(1-(1-\alpha)\gamma)}{1-\gamma}\sigma_\epsilon^2}_{\text{TFP Loss}} \tag{1}$$

Figure 3: Exit and Corporatization Ratio by Output Size



Notes: Panel (A) calculates the percentage of SOEs that exited the market by 2007 for each size bin defined by percentiles of the firms' value-added in 1998. Panel (B) calculates the ratio of corporatized SOEs over transformed SOEs (including both privatized and corporatized) for each size bin under the same definition for the balanced panel between 1998 and 2007. Each firm's output is normalized by the mean within each industry.

where z is firm-level productivity in logs, ϵ is the log of the gross deviation of firm's marginal product of capital from the industry average, γ is the span-of-control parameter, and α is the capital share in the production function.[10] The parameters are chosen to be consistent with our model and calibrated to match the Chinese economy. (See our calibration method in Section 4.)

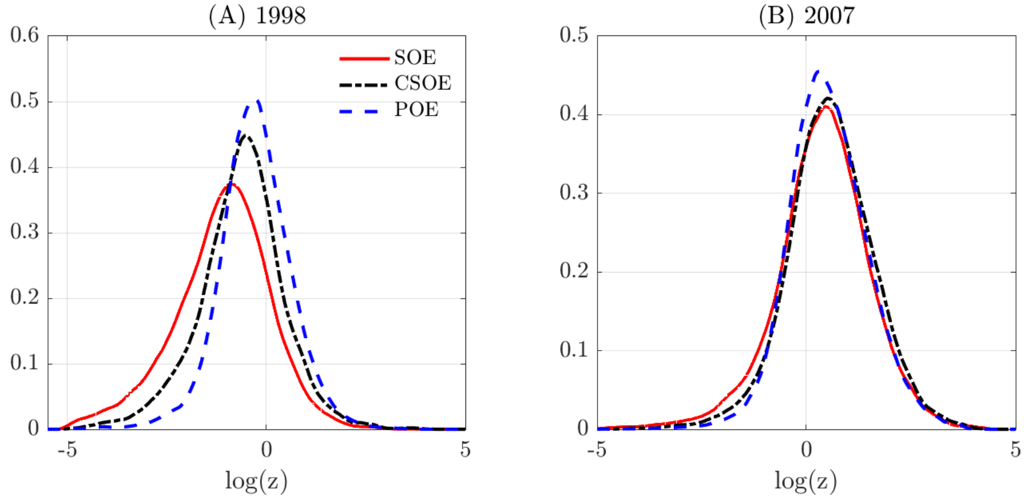
The first channel of changing the average firm productivity is reflected in the first two components in equation (1), which is defined as efficient TFP. The second channel of resource reallocation is captured by a reduction in the TFP loss due to market distortions, reflected in the last component in equation (1).[11] A reduction in the dispersion of the marginal products of capital across firms reduces TFP loss and thus increases aggregate TFP.

Figure 4 plots the changes in firm productivity from 1998 to 2007 in all three sectors. In 1998, SOEs are much less productive than POEs or CSOEs on average, as the distribution of firm productivity of SOEs lies largely to the left of POEs and CSOEs. In 2007, however, the distributions of firm productivity between the three sectors become very similar. This

[10]See the online appendix for additional details.

[11]The first channel is often referred to as the increase in TFPQ, and the second channel is commonly referred as the dispersion in TFPR. The dispersion in TFPR may come from a various of reasons, such as taxes or markups at the product level. Following Midrigan and Xu (2014), we consider distortions in the capital market as the only source of distortions, and therefore, may overstate the TFP losses from capital market imperfections.

Figure 4: Changes in Firm Productivity by Sectors



Notes: Firm-level productivity is calculated by the Solow residual method. Parameters regarding the production function are calibrated to the Chinese economy as explained in Section 4. Firm output is measured by value-added and capital is measured in book value. We also normalize each firm's productivity by the industrial average.
Source: Authors' calculations based on ASI.

suggests that aggregate TFP increases as the exit of small SOEs shifts the productivity distribution in the SOE sector to the right.

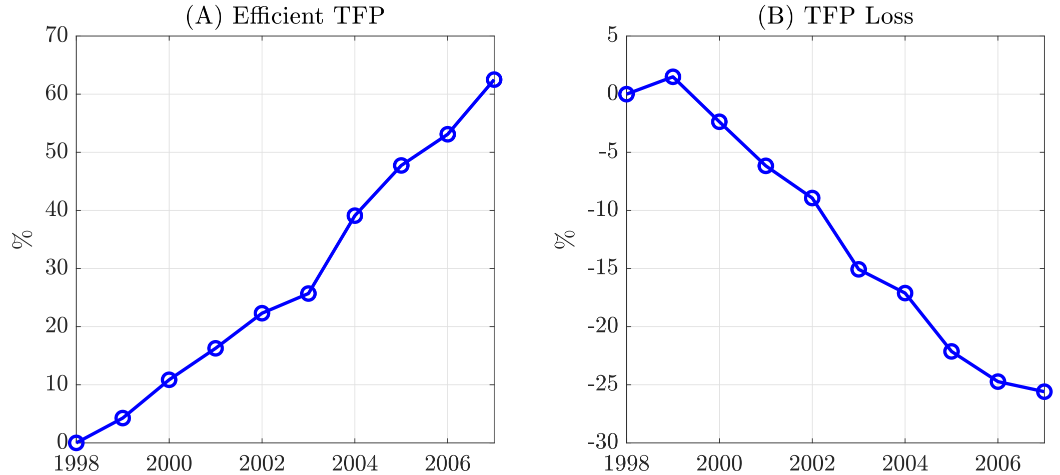
As a result, efficient TFP increases after the SOE reform. Specifically, as shown in Figure 5(A), efficient TFP increases by over 60 percent following the 1998 SOE reform. In addition, Figure 5(B) also shows that TFP loss is reduced by roughly 25 percent in the same period. We further investigate the role of the SOE reform in the next section.

2.5 SOE Transformation and TFP Growth

In this section, we empirically study how the SOE reform contributes to each of the two channels discussed in Section 2.4. We do that by first documenting the composition effect of the exit and entry channel of the SOE reform, which changes the average firm productivity in the economy. Second, we examine the post-reform performance for corporatized and privatized SOEs, which shows how the transformation channel may increase aggregate TFP.

Table 1 compares the pre-reform characteristics of firms that exited before 2007 (exiters) and firms that survived through 2007 (non-exiters) in all three sectors. The average of log productivity ($log(z)$) of exiters in the SOE sector is much lower than that of non-exiters (including both survived and transformed SOEs) in the same sector. This suggests that the exit channel forces the less productive SOEs to exit the market. Regarding capital

Figure 5: TFP Decomposition



Notes: Efficient TFP and TFP loss are defined in equation (1). Parameters regarding the production function are calibrated to the Chinese economy as explained in Section 4. We normalize firm productivity and capital productivity by their industrial average.
Source: Authors' calculations based on ASI.

Table 1: Effects of the Exit Channel

	Mean $\log(z)$			Mean $\log(y/k)$		
	SOE	CSOE	POE	SOE	CSOE	POE
Non-exiters	-1.06	-0.59	-0.28	-0.95	-0.90	-0.11
Exiters	-1.62	-1.08	-0.38	-1.28	-1.13	-0.13

Source: Authors' calculations based on ASI.
Notes: Firms are categorized by their sectors in 1998. All values are measured in 1999 terms.

productivity ($log(y/k)$), the SOE and CSOE sectors have lower average capital productivity than the POE sector, suggesting that the state sector enjoys preferential treatments in capital markets. In addition, the exited SOEs have the lowest capital productivity on average, which implies that the exit channel decreases the dispersion in capital productivity across sectors.

The SOE reform also affects entrants in the state sector. Table 2 compares the average firm productivity and capital productivity for entrants and incumbent firms in 1999 in all three sectors.[12] Regarding both average firm productivity ($log(z)$) and average capital

[12] Because ASI has a size cutoff for firms in the POE sector, a firm that enters the data in 1999 might be established prior to 1999 but its size exceeded the cutoff in 1999. This limitation particularly affects the comparison between entrants and incumbents in the POE sector, and thus the data provide limited insights into how the Economic Reform encourages the entry of private firms. Our focus is the reform in the state sector.

Table 2: Effects of New Entrants

	Mean log(z)			Mean log(y/k)		
	SOE	CSOE	POE	SOE	CSOE	POE
Incumbents	−1.06	−0.51	−0.25	−0.98	−0.88	−0.12
Entrants	−1.33	−0.64	−0.25	−1.18	−0.88	−0.03

Source: Authors' calculations based on ASI.
Notes: Firms are categorized by their sectors in 1999. All values are measured in 1999 terms.

productivity ($log(y/k)$), entrants in the state sector are slightly less productive than incumbents. The comparison between Table 1 and Table 2 shows that the exit channel is more important than the entry channel in driving TFP improvement following the SOE reform. This result appears to contradict Hsieh and Song (2015), who argue that entry in the state sector contributes to the increase in productivity in the state sector. However, the state firms in Hsieh and Klenow (2009) include both SOEs and CSOEs under our definition. In addition, as shown in Table 2, the difference between the SOE and the CSOE sector is more important than the difference within the sector. Therefore, the importance of entrants in the state sector found in Hsieh and Song (2015) is consistent with the composition effect of the rising share of CSOEs in the state sector.

To investigate how the transformation channel contributes to the improvement in TFP growth, we regress variables of interest on firms' type (SOE, CSOE, POE) with interaction terms that indicate the time of the transformation. Table 3 reports the regression results.

We find that POEs and CSOEs have higher firm productivity than SOEs. The coefficients on transformation terms show that when an SOE transforms to a POE or a CSOE, its firm productivity increases gradually.

In addition, the regression of capital productivity suggests that SOEs enjoy the highest privilege in the capital market, followed by CSOEs and POEs. For leverage, both POEs and CSOEs borrow less than SOEs. After an SOE transforms to a POE or CSOE, it starts to gradually de-leverage. The output growth of POEs is the fastest, followed by CSOEs and SOEs. When an SOE transforms to a POE or CSOE, its growth rate increases immediately. In addition, a transformed CSOE grows faster in the year of transformation than the average growth rate of all CSOEs.

In conclusion, the SOE reform encourages the exit of less productive SOEs, which increases average firm productivity and facilitates capital reallocation. In addition, the transformation channel (both corporatization and privatization) also increases aggregate TFP.

Table 3: The Effects of SOE Transformation

Variables	$\log(z)$	$\log(y/k)$	Leverage	y growth
POE	0.782***	0.865***	−0.162***	0.189***
	(0.004)	(0.005)	(0.001)	(0.005)
CSOE	0.612***	0.547***	−0.117***	0.047***
	(0.005)	(0.007)	(0.002)	(0.008)
POE Transf. at t	−0.429***	−0.462***	0.111***	−0.021
	(0.009)	(0.012)	(0.003)	(0.016)
POE Transf. at $t-1$	−0.300***	−0.336***	0.089***	−0.049*
	(0.016)	(0.013)	(0.003)	(0.018)
CSOE Transf. at t	−0.281***	−0.282***	0.063***	0.062***
	(0.010)	(0.013)	(0.003)	(0.018)
CSOE Transf. at $t-1$	−0.244***	−0.255***	0.056***	−0.023
	(0.012)	(0.015)	(0.004)	(0.021)
Observations	1,382,668	1,382,668	1,382,668	951,647
R-Squared	0.189	0.265	0.040	0.015
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes

Notes: Leverage is defined as total debt over total assets. Output is defined by value-added in nominal value. Transf. at t means the firm is an SOE in year $t-1$ and a POE or CSOE in year t. For the regression of output growth reported in column (5), we dropped observations whose output growth rate is greater than 1000 percent, as such output changes are more likely due to mergers and acquisitions instead of business operations. All regressions control for the industry effect and year fixed effect.

3 Model

We build a firm dynamics model based on Hopenhayn (1992), in which firms with different productivity make endogenous entry and exit decisions. To capture the specific features of the Chinese economy, we impose a borrowing constraint and allow the tightness of the constraint to vary by sectors. In addition, we allow SOEs to endogenously transform to other sectors in the post-reform period. In the rest of the section, we first specify assumptions of the model setup (Section 3.1) and then explain the firms' decisions in the pre-reform (Section 3.2) and the post-reform (Section 3.3) period.

3.1 Model Setup

Time is discrete and the horizon is infinite. The economy has three sectors: an SOE sector (S), a CSOE sector (C), and a POE sector (P). In what follows, we use $i \in \{S,C,P\}$ to index firms in different sectors. Each sector is populated by a continuum of firms that are heterogeneous in productivity z and assets a.

Prior to the SOE reform, the life-cycle of firms is identical across sectors. Specifically, an exogenous measure M^i of potential entrants in sector i decides whether to enter the market in every period. Upon entering the market, the potential entrant becomes an incumbent firm. In each following period, incumbent firms choose whether to exit the market.

All incumbent firms in this economy solve a two-stage optimization problem after they make the entry decision. In the first stage, conditional on their productivity and assets, they choose optimal capital and labor inputs to maximize their profits. In the second stage, conditional on their available resources, including after-tax profits and interest on corporate savings, incumbent firms choose their dividend payout d, and savings for the next period, a'.

Since the start of the SOE reform, a fixed fraction, θ, of incumbent SOEs receive a transformation shock in each period. If hit by this shock, an SOE can choose to become either a CSOE or a POE after paying a transformation cost. All incumbent SOEs, whether hit by the transformation shock or not, continue to make endogenous exit decisions. CSOEs and POEs after the reform solve the same problem as before.

Productivity There is no aggregate uncertainty in the model. Productivity is firm-specific. A firm's productivity is the combination of a time-varying, idiosyncratic component and a constant, sector-specific component. Specifically, the productivity of a firm in sector i is given by $(1-\eta^i)z$. The idiosyncratic component, z, follows an AR(1) process in logs, given by

$$\log(z') = \rho \log(z) + \epsilon, \quad \epsilon \sim \mathrm{N}(0,\sigma^2), \tag{2}$$

where ϵ is an *i.i.d.* shock. We use η^i to denote the sector-specific parameter that captures the production inefficiency of the SOE or the CSOE sector relative to that of the POE sector. We also assume that the idiosyncratic productivity process, z, is independent of the sectoral production inefficiency, η.

Firms are perfectly competitive and produce a single homogeneous good. They operate with a decreasing-returns-to-scale (DRS) production technology that uses two inputs: labor l and capital k. Firms' production function is

$$y^i(z,k,l) = (1-\eta^i)z(k^{\alpha}l^{1-\alpha})^{\gamma}, \tag{3}$$

where $\gamma < 1$ is the span-of-control parameter. A share γ of output goes to factor inputs. Out of this, a fraction of α goes to capital and $1-\alpha$ goes to labor.

Financial Market Firms deposit savings in financial intermediaries (banks) at the deposit rate, r. Firms need to finance the up-front capital rental costs with intra-period loans. The financial market is imperfect in two respects. First, we allow the rental costs of capital, r^i, to be greater than or equal to the deposit rate and to vary across sectors. Since capital depreciates at rate δ in production, the rental price of capital that banks charge firms is $r^i + \delta$. Second, firms in all sectors face collateral constraints that limit their demand for capital, given by[13]

$$k \leq \lambda^i a, \tag{4}$$

The degree of financial constraints, measured by the maximum ratio of capital to asset, λ^i, is also sector-specific.

These two aspects of financial market imperfection allow our model to capture the general financial frictions in China, as well as the fact that firms in the state sector enjoy preferential access to bank loans.

Profit Maximization Problem Conditional on the current period's productivity and assets, all incumbent firms solve the profit maximization problem by choosing the optimal capital and labor:

$$\pi^i(a,z) = \max_{k,l} \left\{ y^i(z,k,l) - wl - (r^i+\delta)k - \chi^i z \right\}, \tag{5}$$

given the wage rate, w and the borrowing interest rate, r^i, and subject to the collateral constraint given by equation (4). Moreover, incumbent firms pay a fixed operation cost, $\chi^i z$, in each period. We assume that the fixed operation cost has a sector-specific component, captured by χ^i, and is proportional to firm productivity, by which we allow the operation cost to correlate with firm size.

3.2 Firm Dynamics in the Pre-Reform Period

In this section, we describe firm dynamics in the pre-reform period. We start by defining firms' entry and exit conditions and then characterize the dynamic optimization problem for incumbent firms.

[13]This setup of financial frictions due to imperfect contractual enforcement is based on Evans and Jovanovic (1989). For more quantitative applications of this type of collateral constraint, see Buera and Shin (2013), Moll (2014), Midrigan and Xu (2014), and Gavazza, Mongey, and Violante (2018).

Entry A potential entrant in sector $i \in \{S, C, P\}$ with initial asset a_0^i draws its initial productivity from a stationary distribution, $\mu^*(z)$. Conditional on this draw, the firm decides whether to enter and become an incumbent after paying an entry cost κ_e^i. The discrete entry decision is characterized by the following entry condition:

$$max\left\{v^i(a_0^i, z) - \kappa_e^i, \bar{v}_e^i\right\}, \tag{6}$$

where v^i is the value function for incumbent firms in sector i. A potential entrant chooses to enter if the value of operation under initial conditions, $v^i(a_0^i, z)$, net of the entry cost, κ_e^i, is greater than the sector-specific exit value, $\bar{v}_e^i$

We use $\xi_e^i(a_0^i, z) \in \{0, 1\}$ to denote the entry decision, which takes the value 1 if the firm chooses to enter the market and 0 otherwise. Because $v^i(a, z)$ increases in z, there exists an endogenous cutoff $\underline{z}^i$ such that for all $z \geq \underline{z}^i$, potential entrants choose to enter. The measure of entrants in sector i is given by:

$$n_e^i = M^i \int \mathbb{I}\left\{\xi_e^i(a_0^i, z) = 1\right\} d\mu^* = M^i\left[1 - \mu^*(\underline{z}^i)\right], \tag{7}$$

where M^i is the mass of potential entrants in sector i.

Exit Once a firm becomes an incumbent, it is allowed to endogenously exit the market. The firm makes exit decisions in each period after observing its new productivity. The discrete exit choice is characterized by

$$max\left\{v^i(a, z), \bar{v}_e^i\right\}, \tag{8}$$

where $v^i(a, z)$ is the value of continuing production in this period, and $\bar{v}_e^i$ is an exogenous parameter that reflects the exit value of incumbent firms in sector i.

We use $\xi_x^i(a, z) \in \{0, 1\}$ to denote the exit decision, which takes the value 1 if the firm chooses to exit and 0 otherwise. The measure of incumbent firms in sector i is given by:

$$n^i = n_e^i + n_-^i \int \mathbb{I}\left\{\xi_x^i(a, z) = 0\right\} d\mu_-^i, \tag{9}$$

where μ_-^i is the distribution of incumbent firms in sector i in the previous period, and n_-^i is the measure of incumbent firms in the previous period.

Incumbent For incumbent firms, their corporate income is derived from operating profits $\pi^i(a, z)$. Firms that make positive profits are subject to a corporate income tax at the rate of τ_c. Incumbent firms in sector i solve the following recursive problem:

$$v^i(a,z) = \max_{d,a'}\left\{log(d) + \beta^i \mathbb{E}_{z'}\left[max\left\{v^i(a',z'),\bar{v}_e^i\right\}\right]\right\} \tag{10}$$

subject to

$$d + a' = (1+r)a + \pi^i(a,z) - \tau_c max\{\pi^i(a,z),0\}, \tag{11}$$

$$d, a' \geq 0. \tag{12}$$

Equation (11) imposes the restriction that incumbent firms cannot issue debt or equity. Note that the continuation value in equation (10) incorporates incumbents' exit option in the next period.

3.3 Firm Dynamics in the Post-Reform Period

In this section, we present the firm dynamics problem after the start of the SOE reform. In the post-reform period, the firm problems of CSOEs and POEs are the same as in the pre-reform period. The change applies only to the SOEs.

After the SOE reform begins, a fixed fraction, θ, of SOEs receive a transformation shock in each period. If hit by this shock, the SOE has the opportunity to transform to a CSOE or a POE in the same period, after paying a transformation cost, κ_{tr}^i. The transformation cost is sector-specific, i.e., $\kappa_{tr}^i \in \left\{\kappa_{tr}^C, \kappa_{tr}^P\right\}$. The SOE chooses to exit if the continuation value of either privatization or corporatization is lower than the exit value of a POE or a CSOE. Note that the transformation choice is permanent, which means that transformed firms are not allowed to switch back to the SOE sector in the future.

If an SOE receives the transformation shock in this period, the SOE's transformation or exit decision is described by the following discrete-choice problem:

$$v_{tr}^S(a,z) = max\left\{\underbrace{max\{\bar{v}_e^C, \bar{v}_e^P\}}_{\text{Exit}}, \underbrace{v^C(a,z) - \kappa_{tr}^C}_{\text{SOE to CSOE}}, \underbrace{v^P(a,z) - \kappa_{tr}^P}_{\text{SOE to POE}}\right\}, \tag{13}$$

where the first term in the curly bracket is the value of exit, the second term is the value of transformation to a CSOE, and the third term is the value of transformation to a POE. Here, we assume that a transformed SOE can perfectly inherit its own assets and productivity.

We use $\xi_{tr}^S(a,z) \in \{0,1,2\}$ to denote the transformation or exit decision of SOEs, which depends on a firm's level of assets and productivity. It takes the value 0 if the SOE chooses to exit, the value 1 if the SOE chooses to become a CSOE, and the value 2 if the SOE chooses to become a POE. The measure of transformed SOEs in sector i in period $t \geq 1$ is given by:

$$n^C_{tr,t} = \theta n^S_{t-1} \int \mathbb{I}\left\{\xi^S_{tr,t}(a,z) = 1\right\} d\mu^S_{t-1}, \tag{14}$$

$$n^P_{tr,t} = \theta n^S_{t-1} \int \mathbb{I}\left\{\xi^S_{tr,t}(a,z) = 2\right\} d\mu^S_{t-1}, \tag{15}$$

where n^S_{t-1} is the measure of SOEs in period $t-1$, which will be specified next.[14] In addition, μ^S_{t-1} is the distribution of incumbent SOEs over assets and productivity in period $t-1$. Notice that the measure of remaining SOEs geometrically decreases after the reform begins.

In the post-reform period, the measure of incumbent firms in sector $i \in \{C,P\}$ is given by:

$$n^i_t = n^i_{e,t} + n^i_{t-1} \int \mathbb{I}\left\{\xi^i_{x,t}(a,z) = 0\right\} d\mu^i_{t-1} + n^i_{tr,t}, \tag{16}$$

where $n^i_{e,t}$ is the measure of entrants, μ^i_{t-1} is the distribution of incumbent firms in period $t-1$, and $\xi^i_{x,t}(a,z)$ is the exit decision of firms in sector i in period t. The difference between the measure of incumbent firms in the pre-reform period (Equation (7)) and in the post-reform period (Equation (16)) results from the inflow of transformed SOEs.

In addition to offering the transformation opportunity to incumbent SOEs, we also shut down entry to the SOE sector as the other element of the SOE reform. SOEs that are not hit by the transformation shock continue to decide whether to exit. Accordingly, the measure of incumbent firms in the SOE sector in period t is given by

$$n^S_t = (1-\theta) n^S_{t-1} \int \mathbb{I}\left\{\xi^S_{x,t}(a,z) = 0\right\} d\mu^S_{t-1}. \tag{17}$$

With the transformation option, the firm problem of SOEs in the post-reform period is summarized to be

$$v^S(a,z) = \max_{d,a'} \left\{ log(d) + \beta^S \mathbb{E}_{z'} \left[\theta v^S_{tr}(a',z') + (1-\theta) max\left\{ v^S(a',z'), \bar{v}^S_e \right\} \right] \right\} \tag{18}$$

subject to

$$d + a' = (1+r)a + \pi^S(a,z) - \tau_c max\{\pi^S(a,z), 0\}, \tag{19}$$

$$d, a' \geq 0. \tag{20}$$

The expected continuation value in equation (18) reflects the probability of the transformation shock, θ, and the value of transformation given by equation (13).

[14] We assume that the reform shock hits the economy in $t = 1$. As a result, n^S_0 becomes the steady-state measure of SOEs before the start of the SOE reform.

Table 4: Externally Calibrated Parameters

Parameter		Value			Source/Target
Capital share	α		0.40		Bai, Lu, and Tian (2018)
Depreciation rate	δ		0.10		Bai, Lu, and Tian (2018)
Span of control	γ		0.83		Peng (2019)
Corporate income tax	τ_c		0.33		Chinese tax policy in 1998
Wage rate	w		0.90		Normalization: labor demand = 1
Savings interest rate (%)	r		4.05		Set $r = r^S$
Transformation rate	θ		0.00		No SOE transformation
		S	C	P	
Capital rental rate (%)	r^i	4.05	4.17	8.36	1998 ASI

4 Calibration

In this section, we discuss our calibration strategy. First, Section 4.1 shows the subset of parameters that are calibrated externally. The values we assign to these parameters are either standard ones in the literature or can be directly measured from the data. The rest of the parameters, which represent the unique features in the Chinese economy, are calibrated internally in Section 4.2. The internally calibrated parameters are chosen such that the pre-reform economy modeled in Section 3.2 matches the data of the 1998 ASI, the year before the SOE reform begins. Section 4.3 evaluates the performance of our calibration by comparing the non-targeted moments predicted by our model with their empirical counterparts.

4.1 Externally Calibrated Parameters

We calibrate the model at an annual frequency. Table 4 summarizes the externally calibrated parameters. Specifically, we set the capital share parameter $\alpha = 0.40$ and the capital depreciation rate $\delta = 0.10$, both of which are standard values in the literature (e.g., Bai, Lu, and Tian (2018)). Following Peng (2019), we set the span of control parameter $\gamma = 0.83$. The corporate income tax rate, $\tau_c = 0.33$, is consistent with China's corporate tax policy on domestic firms in 1998. We choose the wage rate $w = 0.90$ to normalize the aggregate labor demand to 1.

The interest rate for capital rent is estimated from the 1998 ASI. We calculate the sector-specific interest rate in the data as the ratio of the interest rate expense over total debt (including both short-term and long-term debt) and take the average across all firms in each sector. As shown in Table 4, the borrowing costs in the private sector are more than 4

Table 5: Internally Calibrated Parameters

Parameter		Value		
Persistence of z	ρ		0.88	
Standard deviation of z	σ		0.15	
		S	C	P
Discount rate	β^i	0.94	0.94	0.88
Sectoral inefficiency (%)	η^i	23.45	2.18	-
Collateral constraint	λ^i	12.93	3.09	1.22
Fixed operation cost	χ^i	0.05	0.18	0.08
Mass of potential entrants	M^i	0.10	0.01	0.09
Entry cost	κ^i	2.52	3.66	2.46
Initial asset	a_0^i	1.24	6.25	0.88
Exit value	v_e^i	-31.16	-8.29	-17.62

percentage points higher than in the state sector. The interest rate on corporate savings is set to equal the capital borrowing rate of SOEs. Last, since there is no transformation opportunity for SOEs in the pre-reform period, we set $\theta = 0.00$.

4.2 Internally Calibrated Parameters

Table 5 lists the remaining 25 parameters that are internally estimated within the model. We choose the set of parameters by minimizing the distance between the model statistics and their empirical counterparts.[15]

Table 5 lists the targeted moments and their empirical and model-predicted values. Even though every targeted moment is determined simultaneously by all parameters, in what follows, we discuss each of the moments in relation to the parameter for which, intuitively, the moment yields the most identification power.

We follow the strategy in Bai, Lu, and Tian (2018) in calibrating the parameters that govern the process of productivity shocks. We discretize it using the Tauchen (1986) method and choose ρ, the persistence of shocks, and σ, the volatility of shocks, to jointly match the one-year serial correlation of firms' output of 0.81 and the standard deviation of output

[15] Specifically, a vector of parameter Θ is chosen to minimize the minimum-distance-estimator criterion function

$$f(\Theta) = [\mathbf{m}_{data} - \mathbf{m}_{model}(\Theta)]'\mathbf{W}[\mathbf{m}_{data} - \mathbf{m}_{model}(\Theta)],$$

where $\mathbf{m}_{data}$ and $\mathbf{m}_{model}(\Theta)$ are the vectors of moments in the data and the model, and $\mathbf{W}_{ii} = \text{diag}(\omega_i/\mathbf{m}_{i,data}^2)$ is a diagonal weighting matrix, with i indexing the i_{th} moment. We place additional weight, ω_i, on the data we view as more important to match. We normalize $\sum_{t=1}^{26} \omega_i = 1$.

Table 6: Moments Used in Calibration

Target	Model	Data
Autocorrelation of output	0.81	0.81
Standard deviation of output	0.64	0.66

	S		C		P	
	Model	Data	Model	Data	Model	Data
Aggregate assets to output	1.38	1.40	1.73	1.79	0.96	1.00
Relative mean output to POE	1.16	1.15	3.56	3.60	-	-
Aggregate product of capital	0.44	0.45	0.50	0.51	0.98	0.95
Share of profit-making firms	0.56	0.58	0.71	0.71	0.86	0.84
Firm number share	0.60	0.59	0.07	0.07	0.34	0.34
Entrant relative mean output	0.50	0.49	0.72	0.72	0.72	0.71
Entrant relative mean asset	0.55	0.57	0.72	0.73	0.65	0.64
Firm exit rate	0.16	0.16	0.11	0.13	0.14	0.14

Notes: Moments in the data are calculated from the 1998 Annual Survey of Industries. Assets are defined as total assets net of total liability. Output is defined as value-added. All moments are normalized by their industrial mean.

growth of 0.66 in the ASI data.

We pin down β^i, the sector-specific discount factor, by matching the assets to output ratio of 1.40 (SOE), 1.79 (CSOE), and 1.00 (POE), in the 1998 ASI. As shown in Table 5, the discount rate in the state sector is larger than that in the private sector, reflecting the fact that SOEs and CSOEs are more patient and thus accumulate more internal assets relative to their output.

A lower sectoral production inefficiency, η^i, makes the average output of the SOE or CSOE sector larger relative to that of the POE sector.[16] Accordingly, the relative average output between sectors is particularly informative for η^i. However, the average output in each sector also changes with other parameter values, as we discuss in the following paragraphs. Our calibration strategy is that we first choose the values for parameters except for η^i, and then adjust η^i to minimize the gap between the model-generated statistics and the data counterparts.[17]

We choose λ^i to match the aggregate output to capital ratio in the data. A tighter col-

[16] We normalize $\eta^P = 0$, which means η^S and η^C measure the relative inefficiency of the SOE and CSOE sector compared to the POE sector.

[17] γ, the span of control parameter, also largely affects the size of firms. Evidence has shown that the size differences in different sectors may come from differences in the scale of production, not in production efficiency. To mitigate this effect on our calibration, we normalize firm sizes by the industry average in the data to control for the industry effect.

lateral constraint (a smaller λ) increases the marginal productivity of capital, so a smaller λ^i increases the aggregate output to capital ratio in sector i. As shown in Table 4, POEs under our calibration can only borrow up to 22 percent of their internal assets, while the financial constraints in the SOE and the CSOE sectors are substantially more relaxed. Therefore, financial constraints significantly limit the size of productive POEs from the optimal level.

The fixed operation cost, χ^i, mostly affects the number of loss-making incumbent firms. Therefore, we calibrate this parameter to target the share of profit-making firms in each sector. Under our calibration, CSOEs have to pay a significantly higher fixed cost, which also implies that the surviving CSOEs must be larger than firms in the other two sectors.

We now turn to explaining how we choose the sector-specific parameters that mainly affect firms' entry and exit decisions. First, we normalize the total measure of incumbent firms to 1 and choose the mass of potential entrants, M^i, to match their respective share of firms in the 1998 ASI. We then choose the initial assets for potential entrants and entry costs jointly by targeting the assets and output size of entrants relative to incumbents. Under our calibration, CSOEs pay about a 50 percent higher entry cost and their initial asset endowment is 5 to 7 times larger than that of SOEs and POEs. A large entry cost screens out small potential entrants and a large initial asset makes the productive firms less constrained. Therefore, both entrants and incumbent firms in the CSOE sector are larger relative to the other two sectors.

Next, the exit value, v_e^i, is informed by the sectoral exit rates of incumbent firms. In our model, the exit value reflects the opportunity cost for an incumbent to continue its business. As a result, a higher exit value leads to a higher exit rate. Our estimation yields the lowest exit value for SOEs, which reconciles the empirical fact that SOEs, even the least profitable ones, rarely exit in the pre-reform period. Moreover, a lower exit value also makes it easy for the small SOEs to enter but hard for them to exit, which reduces the relative average size of firms in the SOE sector.

Finally, in line with the calibration strategy discussed above, we choose η^i to ensure that the relative average output between sectors fits the corresponding statistics in the 1998 ASI. As shown in Table 6, the average output of SOEs (CSOEs) is 1.2 (3.6) times larger than that of POEs. Our calibration implies that the SOE sector is 23 percent less efficient, and the CSOE sector is 2 percent less efficient than the POE sector. The transformation costs, κ_{tr}^S and κ_{tr}^P, are the two remaining parameters not relevant in the pre-reform economy. We will discuss how to calibrate them in Section 6.1.

Table 7: Non-targeted Moments

Moment	Model	Data
Share of top 10% employment	0.57	0.56
Share of top 20% employment	0.72	0.71
Share of top 10% capital	0.61	0.72
Share of top 20% capital	0.76	0.84

	S		C		P	
	Model	Data	Model	Data	Model	Data
Relative median output to POE	0.43	0.62	2.49	2.16	-	-
Relative median capital to POE	0.87	1.36	4.97	4.76	-	-
Median product of capital	0.42	0.38	0.43	0.40	0.88	0.86
Standard deviation of log output	1.85	1.93	1.41	1.69	0.93	1.11
Standard deviation of log capital	1.83	2.09	1.34	1.88	0.81	1.42

Note: Moments in the data are calculated from the 1998 Annual Survey of Industries. All moments are normalized by their industrial mean (or median).

4.3 Model Performance

In this section, we show that our model predictions match reasonably well with the empirical counterparts for the moments that we do not directly target in the calibration.

As shown in Table 7, our model reproduces well the concentration of employment at the top of the distribution. For example, the largest 10 percent of firms hire 57 percent of labor in the model and 56 percent in the data. Similarly, the largest 20 percent of firms hire 71 percent of labor in the data and 72 percent in the model. Although our model understates the concentration of capital at the top compared to the data, it predicts that the distribution of capital is more concentrated than that of labor, which is consistent with the data.

In our calibration, we only target the mean output in the SOE and CSOE sector relative to the POE sector and the aggregate product of capital in each sector. For the CSOE sector, our model-predicted median output and capital relative to those of POE are 2.69 and 4.97, both of which match the data (2.16 and 4.76) very well. The model also reproduces well the median product of capital in each sector. Finally, although our model understates the standard deviation of log output and capital in all sectors, the model predicts that the distribution of firms in the state sector is more dispersed than that in the private sector, which is in line with the data.[18]

[18]Due to the presence of financial frictions, the size of firms with high productivity but low assets is lower than their optimal scale. In particular, the tighter borrowing constraint in the POE sector reduces the size of a larger fraction of productive POEs. Therefore, the dispersion of (log) capital and output of POEs would

5 SOE Reform and TFP Growth in the Long Run

We model two main aspects of the SOE reform. First, the entry of new SOEs is shut down ($M^S = 0$). Second, incumbent SOEs are given the opportunity to choose between exiting the market, corporatization, or privatization. To investigate the long-run impact of the SOE reform, only the first aspect matters. This is because all transformed SOEs will exit before the economy reaches the final steady state, so the measure of transformed SOEs converges to zero.

In this section, we analyze how the closure of the SOE sector improves aggregate TFP in the long-run steady state. To this end, we first specify the accounting framework for sectoral TFP in the pre-reform period (Section 5.1). Then, in Section 5.2, we calculate the productivity gap between the SOE and the other two sectors and quantify how each feature of the SOE sector explains its productivity gap. Last, in Section 5.3, we show how the effects of the SOE reform on aggregate TFP depends on reallocative efficiency.

5.1 Sectoral TFP Accounting Framework

We apply the TFP accounting framework developed in Karabarbounis and Macnamara (2021)[19] to compute measured TFP, efficient TFP, and TFP loss in each sector. Aggregate output produced in sector i can be expressed as:

$$Y^i = A^i_m (M^i)^{1-\gamma} [(K^i)^\alpha (L^i)^{1-\alpha}]^\gamma, \tag{21}$$

where Y^i is aggregate output, A^i_m is measured TFP, M^i is the mass of firms, K^i is aggregate capital and L^i is aggregate labor. Rearranging equation (21) implies that the measured TFP in sector i can be computed as follows:

$$A^i_m = \frac{Y^i/M^i}{[(K^i/M^i)^\alpha (L^i/M^i)^{1-\alpha}]^\gamma}. \tag{22}$$

The efficient level of TFP in sector i, A^i_e, can be derived by the social planner's problem, which allocates capital and labor across firms to maximize total output subject to the aggregate supply of capital K and labor L in the economy. At the efficient level, the marginal

be much lower than that of SOEs or CSOEs.

[19] Midrigan and Xu (2014)) first proposed this accounting framework. However, their method generates a love-for-variety effect, meaning that TFP increases with the number of producers in a sector, which is not suitable in our analysis. Using the method developed by Karabarbounis and Macnamara (2021), sectoral TFP is adjusted by the measure of firms in each sector and can be computed as the Solow residual using average output, independent of the scale of the sector.

Table 8: TFP Accounting

	TFP (measured)			
	All	SOE	CSOE	POE
Incumbent	100	93	117	118
Entrant	92	83	110	110
Exiter	55	25	83	55

products of capital and labor are equated across all firms. Efficient TFP of sector i can be computed as follows:

$$A_e^i = (\frac{1}{M^i} \int [(1-\eta^i)z]^{\frac{1}{1-\gamma}} \mu^i)^{1-\gamma}, \tag{23}$$

where μ^i is the distribution of firms in sector i.

The TFP loss in sector i is defined as the percentage difference between the efficient and measured level of TFP:

$$(\text{TFP Loss})^i = (\frac{A_e^i}{A_m^i} - 1). \tag{24}$$

In our model, the financial market imperfection discussed in Section 3.1 leads to dispersion in the marginal products of capital, which increases the difference between A_e^i and A_m^i. As a result, TFP loss measures the extent of inefficiency due to capital misallocation.

5.2 What Explains the Difference in Sectoral TFP?

In this section, we compare TFP in each sector and study the factors that contribute to the differences in sectoral GDP in the pre-reform period. To do so, we first apply equation (22) to calculate aggregate TFP and sectoral TFP in the pre-reform period. To make it easier to compare, we normalize measured TFP of all incumbent firms to 100.

Table 8 reports the TFP of incumbent firms, entrants, and exiters in all three sectors. It shows that the TFP gap between the SOE sector and the other two sectors is very significant, whereas the TFP gap between the CSOE and the POE sector is very small. While the TFP of entrants in all sectors is around 10 percent below that of incumbents, the relative TFP of exiting firms (to incumbents) varies dramatically across sectors. Specifically, the TFP gaps between exiting firms and incumbents are about 70 percent (SOE), 50 percent (POE), and 30 percent (CSOE). This result indicates that the heterogeneity in exit criteria plays a significant role in explaining the TFP gap across sectors. We further quantify the importance of the exit value, v_e^i, by the following decomposition analysis.

We conduct a two-way decomposition to analyze the TFP gap in the SOE sector relative to the POE and the CSOE sector. First, we decompose the impact of each sectoral feature[20] on measured TFP in the sector. We implement this exercise by answering the following question: how much would the measured TFP of the CSOE (or POE) sector change if we counterfactually impose an SOE feature on this sector?[21]

Second, we apply equations (23) and (24) to calculate the sectoral efficient TFP and TFP loss due to capital misallocation. In this way, we analyze the two channels through which each sectoral feature affects measured TFP in the corresponding sector. The first channel is the effect on the distribution of productivity, which determines efficient TFP, A^i_e. The second channel is the effect on capital misallocation, which is captured by TFP loss. As shown in Table 9, because the POE sector has the tightest financial constraint, it has the highest TFP loss (8.8 percent). In comparison, the TFP loss in the CSOE sector is lower (3.5 percent) and the TFP loss in the SOE sector is the lowest (0.8 percent).[22]

The decomposition results shown in Table 9 answer the question of what explains the TFP gap between the SOE sector and the other two sectors. In particular, the low TFP in the SOE sector is primarily driven by two factors: the low production efficiency (η^S) and the low exit value (v^S_e) of this sector.

In particular, if we set the production inefficiency for CSOE firms equal to that of SOE firms (i.e., $\eta^C = \eta^S = 23.45$ percent) and re-solve the CSOE problem,[23] then the measured TFP of the CSOE sector, A^C_m, would be 8.6 percent below the benchmark economy. The difference is due to the combined effects of the two channels. First, the efficient TFP is 9.7 percent lower, which is the direct effect of a higher production inefficiency. Second, the TFP loss is 1.2 percent lower, equivalent to a 1.2 percent TFP gain relative to the benchmark economy. This is because each CSOE firm demands lower capital, making collateral constraints less binding in the CSOE sector. We repeat the same procedure for all relevant sector-specific parameters and Table 9 reports the results.

In addition, if the CSOE (or POE) sector has an exit value as low as that of the SOE sector, the measured sectoral productivity would largely decrease. The effect of exit value on measured TFP is mainly driven by the changes in efficient TFP. The low exit value prevents

[20] These features are the discount rate, sectoral efficiency, collateral constraints, fixed operational cost, entry cost, initial asset, exit value, and capital rental rate. Note that although the mass of potential entrants also varies by sector, our TFP accounting framework ensures that M^i has no effect on sectoral TFP since it is irrelevant to the measure of firms.

[21] We impose all features one at a time to see the effect of these features separately. Indeed, imposing two or more features at the same time would generate a complementary effect, but it is not the focus of this decomposition analysis.

[22] To save space, we do not report the TFP loss in the SOE sector in Table 9.

[23] We solve the model using the new set of parameters and approximate the stationary distribution, keeping all prices constant. In other words, in this exercise, we assume there is no resource reallocation due to the general equilibrium effects.

Table 9: Decomposition of the TFP Gap

	A_m^i		A_e^i		TFP loss (%)	
	CSOE	POE	CSOE	POE	CSOE	POE
	117	118	121	128	3.5	8.8
β^S	+0.0	+12.2	+0.0	+16.4	+0.0	+4.0
η^S	−8.6	−8.6	−9.7	−11.0	−1.2	−2.9
λ^S	+1.5	+3.5	−1.3	−3.7	−2.9	−7.5
χ^S	−3.4	−2.1	−3.5	−2.1	−0.2	+0.0
κ^S	−3.2	+0.9	−3.1	+0.9	−0.0	−0.0
a_0^S	+12.4	−4.9	+18.5	−5.3	+5.6	−0.4
v_e^S	−7.9	−9.0	−8.8	−9.3	−1.0	−0.4
r^S	−0.1	−4.2	−0.0	−2.8	+0.0	+1.7

less productive SOEs from exiting the market, shifting the distribution of firm productivity in the SOE sector to the left. This also implies that the importance of relative production inefficiency may be overestimated if one overlooks the dynamics of firm entry and exit.

Interestingly, Table 9 also shows that the presence of collateral constraints (measured by λ^P) in the POE sector (relative to that in the SOE sector) only causes a modest decrease in measured TFP. Although misallocation due to collateral constraints causes a 7.5 percent TFP loss, efficient TFP also decreases, partially offsetting the reduction in TFP loss. The intuition is that a more relaxed financial constraint allows less productive POEs to enter, shifting the productivity distribution to the left. This suggests that relaxing the borrowing constraints for POEs has a limited effect on the measured TFP of the POE sector. However, the changes in the borrowing constraints may have a much larger effect on aggregate TFP, which we discuss in Section 5.3.

5.3 Resource Reallocation and TFP Growth

The magnitude of long-run TFP growth due to the SOE reform depends not only on the TFP gap in the SOE sector but also on how resources are reallocated to other sectors following the closure of the SOE sector. The reallocation is efficient if productive firms in the POE and the CSOE sector can absorb the resources released from exited SOEs. In this section, we show the importance of reallocative efficiency in determining the aggregate TFP growth.

We conduct two experiments. In each of the experiments, we adjust one sector-specific parameter to make sure the aggregate capital stays the same between the pre-reform and the post-reform steady states, For both experiments, we adjust the wage rate to ensure that

Table 10: The Long-Run Impact of the SOE Reform on TFP

	(A) TFP (measured)			(B) TFP (efficient)			(C) TFP loss (%)		
	All	CSOE	POE	All	CSOE	POE	All	CSOE	POE
Benchmark									
Pre-reform	100	117	118	113	121	128	12.9	3.5	8.8
Experiment									
(a)	120	122	122	126	122	126	4.4	0.0	3.2
(b)	105	112	109	121	117	122	15.2	4.6	12.0

aggregate labor demand stays at 1. In the first experiment (experiment (a) in Table 10), we assume that the collateral constraints in the CSOE and the POE sectors are relaxed, which allows firms in these two sectors to absorb the capital released from the closure of the SOE sector. In addition, we assume that the CSOE sector still has better access to credit than the POE sector. To do so, we set $\lambda^C = \infty$ and adjust λ^P to make sure that aggregate capital does not change from the pre-reform steady state.[24] In the second experiment (experiment (b) in Table 10), we reduce the capital rental rate of both sectors to 0.6 percent.[25]

Table 10 compares the implications of the two experiments for long-run TFP growth. Row (a) shows that if capital reallocation is enabled by relaxing of the collateral constraints, the measured TFP would increase by 20 percent. The economy-wide efficient TFP increases by 11.3 percent, which is primarily due to the exit of the less-efficient SOE sector. In addition, the economy-wide TFP loss due to capital misallocation also declines by 8.5 percent, which means that the improvement in allocative efficiency also contributes to the increase in measured TFP by a significant amount.

Row (b) shows that if the closure of the SOE sector causes the lender of capital to lower the capital rental rate, the implications for TFP would be substantially different from the previous case. Specifically, because of a lower price of capital, low-productivity firms can enter and remain in the CSOE and POE sectors. As a result, the economy-wide efficient TFP only increases by 8 (121 - 113) percent from the pre-reform economy. In addition, due

[24]In other words, we assume that the collateral constraint arises from the credit rationing system in China's financial market. Banks prioritize capital demand from the SOE sector before they allocate capital to the CSOE and POE sector. After the closure of the SOE sector, we assume that CSOEs are favored over POEs, and therefore, we completely remove the borrowing limit for all CSOEs.

[25]Here, we assume that because of the over-borrowing and high default rate of SOEs, financial intermediaries are subject to large lending costs. Therefore, banks charge POEs a higher capital rental rate to compensate for their losses. After the closure of the SOE sector, the interest rate premium paid by the POE sector would decline.

to the lower capital rental rate, all firms demand more capital, which exacerbates resource misallocation and leads to a 2.3 ($15.2-12.9$) percent higher TFP loss in the aggregate economy. Combining these two effects, measured TFP only modestly increases by 5 percent.

The comparison between the two experiments suggests that the post-reform TFP crucially depends on reallocative efficiency after the closure of the SOE sector. As shown in Table 10, compared with experiment (b), the growth in measured TFP in the aggregate economy is 15 percentage points higher in experiment (a), about a third of which is due to the difference in efficient TFP, while two thirds is due to the difference in TFP loss. The intuition is that relaxing collateral constraints allows more productive firms to get more of the capital released from the closure of the SOE sector, while lowering the interest rate for capital makes all firms demand more capital. However, since the degree of collateral constraints stays the same, only the less productive firms that are unconstrained in the pre-reform steady state get more capital. Therefore, capital misallocation is exacerbated in this case.

6 Post-Reform Transition Dynamics

In this section, we evaluate the short-run effects of the SOE reform. To this end, we study the perfect foresight transition dynamics of the model triggered by a gradual closure of the SOE sector. In Section 6.1, we discuss the implementation details of our exercise, especially how we construct the aggregate shocks. Next, in Section 6.2, we analyze the optimal transformation decision of SOEs between corporatization, privatization, and exiting the market, and show that our model can replicate the empirical patterns during the economic transition. In Section 6.3, we quantify the impacts of the SOE reform on aggregate output and TFP during the first decade of the transition period. In Section 6.4, we illustrate why SOEs' corporatization option is crucial for China's short-run output and TFP growth. We close this section by emphasizing the connection between our model predictions and the empirical evidence provided in Section 2.

6.1 Constructing Aggregate Shocks

In our model, the SOE reform is completely unexpected, but once it happens, every firm understands that it is a permanent change. The economy starts in the steady state (period 0), which we calibrate to the 1998 ASI data. We assume that the government gradually closes the SOE sector from the beginning of period 1. Specifically, we first lower the mass of potential entrants in the SOE sector, M^S, to 0 at a constant rate through period 10. We next set $\theta_t = 0.26$ for $t \geq 1$, meaning that 26 percent of the remaining SOEs receive the reform shock in each period. θ_t is chosen to match the 77.2 percent decline in the number of SOEs from 1998 to 2007 in the data. Since there are no new SOE entrants after period 10 and all remaining SOEs either exit or transform to CSOEs or POEs, the SOE sector is completely shut down before the economy reaches the final steady state.

We use the experiment (a) in Section 5.3 as the final steady state of the transition dynamics,[26] because the data show little change in the interest rate charged in the CSOE and POE sectors from 1998 to 2007. During the transition, we ensure that aggregate labor demand is fixed at $L = 1$ by adjusting the wage rates along the transition path. However, we do not set aggregate capital demand to be fixed over time. Instead, we consider the relaxation of collateral constraints as an exogenous shock. Specifically, we raise λ^C from 3.09 (the level in the pre-reform steady state; see Table 5) to the level of $\lambda^C = 12.93$ (same as λ^S in the pre-reform steady state; see Table 5) at a constant rate through period 10, and then set $\lambda_t^C = \infty$ for all $t \in [11, T]$. We raise λ^P from 1.22 (the level in the pre-reform steady state; see Table 5) to 5.27 (the level in the post-reform steady state; explained in Section 5.3) at a constant rate through period 30, and then fix it for the rest of the periods. By doing so, we assume a more gradual improvement of financial conditions for POEs than for CSOEs.

The remaining parameters to calibrate are κ_{tr}^C and κ_{tr}^P, which govern the transformation decision for the incumbent SOEs. We set the cost of corporatization, $\kappa_{tr}^C = 10.0$, and the cost of privatization, $\kappa_{tr}^P = 4.9$. These two parameters are calibrated to match the empirical moments that among all the SOEs (including new entrant SOEs) hit by the reform shock between periods 1 and 9 (corresponding to the years between 1999 and 2007 in the data), 15 percent transform to POEs, 13 percent transform to CSOEs, and the rest exit the market in the data.[27]

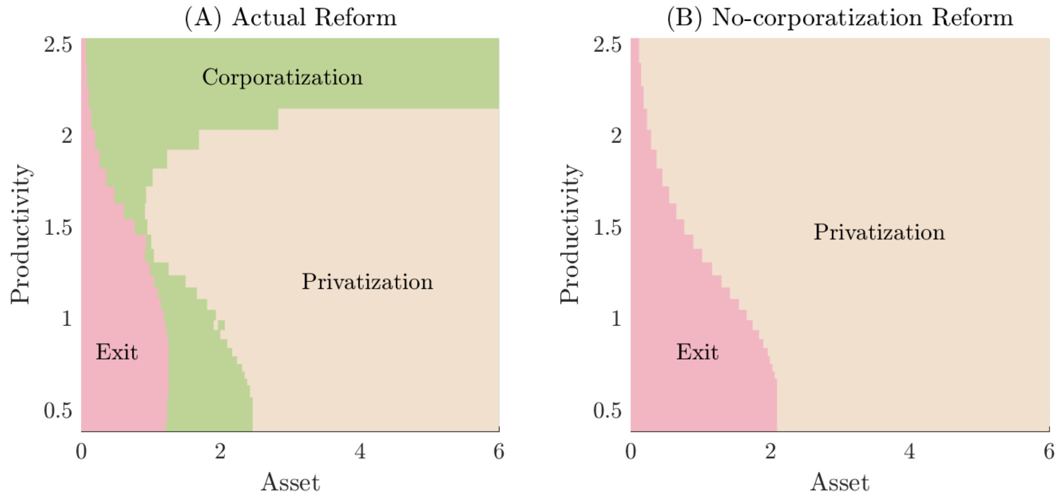
6.2 Characterizing SOE Transformation Decisions

Figure 6 (A) shows the optimal transformation decision made by SOEs in the first year of the actual SOE reform. Upon receiving the reform shock, if an SOE has a very high productivity level, it chooses to become corporatized regardless of its asset level. The intuition is that when the SOE chooses to become a CSOE rather than a POE, the benefit is a higher borrowing limit and the cost is a smaller increase in production efficiency and higher transformation cost. With high productivity, the firm demands more capital, which makes it more important

[26] To ensure that the economy has enough time to converge to the final steady state, we set $T = 300$, which is the final period of the transition.

[27] These numbers are different from those in Table 1, because Table 1 does not include entry of new SOEs after 1998.

Figure 6: Optimal Transformation Decision for SOEs



to maintain a high borrowing capacity.

SOEs with low productivity and low asset levels choose to exit, as the firms' continuation value is lower than their exit value. Moreover, if an SOE has low productivity but a high asset level, it chooses to become a POE, since this type of firm is able to self-finance its capital demand. In this case, it chooses to become a POE to benefit from the larger efficiency gain and the lower transformation cost.[28]

Figure 7 plots the share of exited SOEs among all SOEs that are hit by the transformation shock and the share of corporatized SOEs among all transformed SOEs (including both corporatized and privatized SOEs.) according to the output size percentile. It show that our model predictions are consistent with the "grasp the large and let go of the small" effect of the SOE reform. Specifically, our model predicts that the exit ratio significantly declines with firms' output size. Moreover, the corporatization ratio increases with output size, and this pattern is more significant at the top of the size distribution.

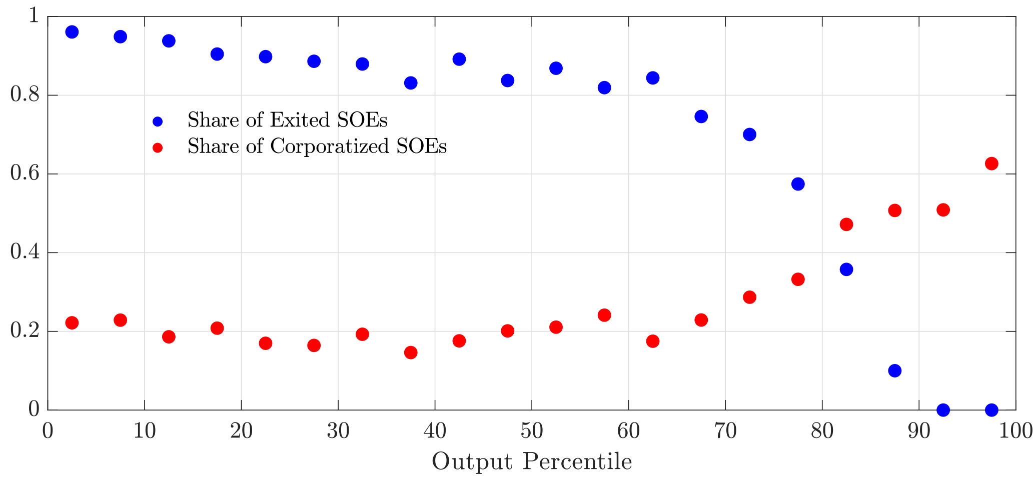
6.3 Short-Run Impact of the SOE Reform

To study the aggregate effect of the SOE reform along the transition dynamics, we simulate the model in response to the aggregate shocks described in Section 6.1.

Figure 8 (A) calculates the percentage change in aggregate output along the transition path under the actual reform from the initial steady state in 1998. It shows that the SOE

[28]Ample evidence has shown that collateral constraints may vary with productivity. Although we do not directly measure λ to be time variant or firm specific, our model implies that the *changes* in λ may be correlated with z and this result comes from firms' optimal transformation decision. Specifically, high z SOEs choose to be CSOEs and enjoy a higher λ than low z SOEs that choose to be POEs.

Figure 7: Transformation Decision by Output Size



Notes: For each year between 1999 and 2007, we first group SOEs by their output size and then calculate the share of exited SOEs among all SOEs that are hit by the transformation shock and the share of corporatized SOEs among all transformed SOEs for each output size bin. Each dot represents the average ratio across different years.

reform increases aggregate output, and the difference reaches the maximum in 2005 at 8.6 percent. The blue line in Figure 8 (B) shows that the SOE reform leads to 15.6 percent increase in measured TFP from 1998 to 2007. We then decompose the changes in measured TFP into the contribution of efficient TFP (green line) and TFP loss (red line). We find that roughly 60 percent of measured TFP gain is due to the increase in efficient TFP, and the rest is due to the decline in TFP loss caused by capital misallocation.

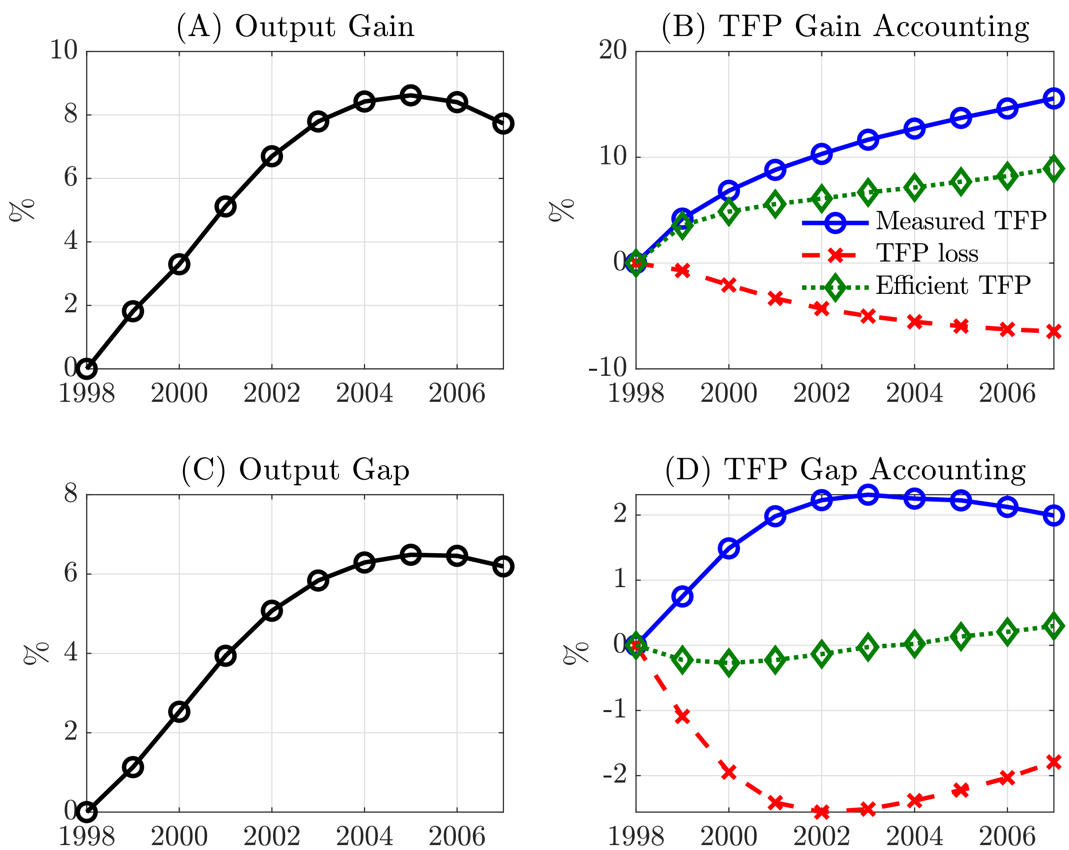
6.4 The Role of SOE Corporatization

To analyze the importance of the SOEs' corporatization option during the reform, we perform a counterfactual experiment where we allow only exit or privatization when an SOE receives a transformation shock. To eliminate the corporatization option for SOEs, we set the corporatization cost $\kappa_{tr}^{C} = \infty$ and keep everything else unchanged. As in the analysis of the actual reform, we allow the wage rate to adjust so that aggregate labor demand equals its initial steady-state level over the entire transition path.

Panel (C) of Figure 8 calculates the difference in aggregate output between the actual reform and the counterfactual reform along the transition path. It shows that aggregate output under the counterfactual reform policy is much lower than under the actual reform, and the largest output gap reaches 6.5 percent in 2005.

The blue line in panel (D) of Figure 8 shows that the corporatization option in the actual

Figure 8: The Percentage Change in Aggregate Output and TFP



Notes: The top panels compare the differences between the initial steady state and the actual reform. The output gain or TFP gain in year t is calculated as $X_t/X_{1998} - 1$ where X_t represents aggregate output or TFP in the post-reform period, and X_{1998} represents aggregate output or TFP in the pre-reform steady state.
The bottom panels compare the actual reform and the counterfactual reform. The output gap or TFP gap in year t is calculated as $X_t/X_t^* - 1$ where X_t represents aggregate output or TFP under the actual reform, and X^* represents aggregate output or TFP under the no-corporatization reform.

reform leads to higher TFP growth than in the counterfactual no-corporatization reform, and the difference in TFP growth could be larger than 2 percent. We then decompose the total difference in measured TFP into the contribution of efficient TFP (green line) and TFP loss (red line). It shows that the primary driver of the difference in measured TFP is that the actual reform leads to a larger reduction in TFP loss than the counterfactual reform.

The intuition can be explained by the decision rule in the counterfactual no-corporatization reform, which is shown in panel (B) of Figure 6. Comparing it with the decision rule under the actual reform, we find that without the corporatization option, SOEs with higher productivity now have to become POEs instead of CSOEs. Although transforming to a POE results in a larger gain in production efficiency, it also leads to tighter financial constraints. Therefore, TFP loss due to capital misallocation increases in the no-corporatization reform.[29]

Figure 8 also shows that output and the TFP gap between the actual and the counterfactual reform declines over time. This is mainly driven by two factors. First, although privatized SOEs are smaller and more capital constrained right after the transformation, they gradually accumulate assets to overcome financial constraints and expand the scale of production. Therefore, privatized SOEs have a more persistent output growth compared to CSOEs after the transformation. Second, the impact of transformed SOEs on aggregate output will vanish in the long run, since they will eventually exit the market, meaning that the two economies converge to the same final steady state.

6.5 Connections with the Empirical Evidence

In this section, we discuss how our model predictions on the transition dynamics following the SOE reform can explain the empirical patterns documented in Section 2.

First, Section 2 shows that the exit rate and corporatization rate of SOEs are highly correlated with firm size. In Section 6.3, we illustrate that with the endogenous transformation choice and heterogeneities in firm productivity and assets, our model can replicate the empirical features during the transition period.

More importantly, this implies that the "*grasp the large and let go of the small*" policy implemented by the government is, to a large extent, consistent with the optimization choice of individual firms. For this reason, we can use our model to conduct counterfactual analysis to study the possible effects of alternative policies.

Second, we empirically document that the improvement in TFP after the SOE reform comes from both an increase in efficient TFP and a reduction in TFP loss due to capital misallocation (Section 2.4). The transition dynamics analysis in Section 6.3 also shows that the SOE reform contributes to both sources of TFP growth. First, the exit of inefficient SOEs increases efficient TFP in the aggregate economy. Second, as shown in Section 6.4, the corporatization option largely increases reallocative efficiency and therefore, it reduces TFP loss than privatization. This is because it allows more productive SOEs to have a higher collateral constraint than what they would under the no-corporatization policy.

[29]The differences between Panels (A) and (B) in Figure 6 also include the extra fraction of firms that make exit decisions, but this effect is much smaller than it is for the firms that choose corporatization instead of privatization.

7 Conclusion

This paper studies firm dynamics during China's SOE reform. We first document the empirical patterns of the transformation in the state sector. We show that the "grasp the large and let go of the small" policy promotes the exit of the firms in the state sector that have low productivity and low returns to capital. Both the exit channel and the transformation channel contribute to TFP growth in the manufacturing sector by increasing average firm productivity and reducing capital misallocation.

The key contribution of our paper is to quantify the effect of the SOE reform on aggregate output and TFP. To do so, we build a heterogeneous-firms model in a three-sector economy, in which firms are subject to financial frictions and make endogenous entry and exit decisions. We model SOE reform as shutting down new entrants in the SOE sector and allowing the incumbent SOEs to optimally choose between exiting the market, corporatization, or privatization.

Using our calibrated model, we show that in the pre-reform period, TFP in the SOE sector is much lower than in the rest of the economy due to its low efficiency and low exit criteria. In the long run, the SOE reform improves TFP due to its role in facilitating resource reallocation to more efficient sectors, but the magnitude of growth depends on the reallocative efficiency. In the short run, the SOE reform increases both aggregate output and TFP by increasing the efficient TFP level as well as reducing the TFP loss. In addition, with the corporatization option, the gains in aggregate output and TFP are higher than the counterfactual policy, which only allows SOEs to exit or become privatized. This is because when most productive incumbent SOEs can choose corporatization, they enjoy a higher borrowing capacity, which results in higher aggregate output and less TFP loss from capital misallocation.

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Appendices

A Data Cleaning and the Definition of Ownership Types

In this appendix we describe our data-cleaning steps and our definition of the three ownership types: SOEs, POEs, and CSOEs using the Annual Survey of Industries.[30]

A.1 Data Cleaning

We implement the following standard steps to drop observations with reporting errors.

1. We drop firm-year observations that are not in operation.

2. The data do not report value added in 2001 and 2004. We compute value added as

$$\textit{value added} = \textit{total output} - \textit{intermediate input} + \textit{tax on value added}$$

   We also checked that this definition yields the same results for value added reported in other years.

3. We drop firm-year observations that report missing information or report negative values of value added, employment, fixed assets, or total assets.

A.2 Definition of Ownership Types

Since our paper focuses on the comparison between firms of different ownership types, we take the following steps to further restrict our sample for analysis:

- We drop firm-year observations that have missing information on registration type or controlling share.

- We define a firm as *state-owned* by *registration type* if its registration type is one of the following: 1) state-owned, 2) state jointly owned, or (3) state and collective jointly owned.

- We define a firm as *privately owned* by *registration type* if its registration type is one of the following: 1) private enterprise, 2) private partnership enterprise, 3) limited liability company, or 4) share-holding corporation.

[30] To match firms over time, we follow Brandt, Van Biesebroeck, and Zhang (2012) and Nie, Jiang, and Yang (2012) by first linking firms by their firm IDs and then we use additional information, including firm name, name of legal person, geographic code, etc.

Table A1: Number of Firms by Types, 1998 - 2007

Year	SOE	POE		CSOE		Total	
		D Only	F Included	D Only	F Included	D Only	F Included
1998	42.1	23.9	43.0	4.8	8.1	70.8	93.1
1999	40.0	30.6	52.4	5.4	8.4	76.2	100.8
2000	33.5	41.8	65.8	6.3	9.0	81.6	108.2
2001	28.2	60.7	87.9	7.1	9.8	96.0	125.9
2002	24.5	75.7	105.6	7.2	9.6	107.3	139.6
2003	20.3	98.7	134.1	7.3	9.4	126.3	163.9
2004	18.1	160.0	211.6	8.2	10.5	186.2	240.2
2005	14.1	160.6	213.9	7.3	9.2	182.0	237.2
2006	12.5	179.7	236.4	16.2	18.8	208.5	267.7
2007	9.6	221.2	284.8	17.2	20.1	248.0	314.5

Source: Authors' calculation, based on China's Annual Industrial Survey
Notes: Number of firms is in thousands. D means domestic firms only. F means including firms registered as Hong Kong/Macao/Taiwan owned or foreign owned.

- We define a firm as an **SOE** if 1) the state has absolute or relative controlling shares in the firm, and 2) the firm is state-owned by registration type.

- We define a firm as a **POE** if 1) the state does not have absolute or relative controlling shares in the firm, and 2) the firm is privately owned by registration type.

- We define a firm as a **CSOE** if 1) the state has absolute or relative controlling shares in the firm, and 2) the firm is privately owned by registration type.

- We drop the firms where 1) the state does not have absolute or relative controlling shares in the firm, and 2) the firm is state-owned by registration type.

- Notice that under our definition, we do not count firms that are collective owned (except state and collective jointly owned).

- In addition, since we focus on financing patterns in mainland China, we do not count firms that have access to foreign capital markets, i.e., firms that are Hong Kong/Macao/Taiwan owned or foreign owned. These types of firms are mostly POEs, as shown in Table A1. The exclusion of these types of firms does not affect our main analysis of the SOE reform, as shown in Table A2.

Table A1 shows the number of firms of each type by year after we take the above procedures to restrict our data for analysis.

Table A2: Firm-Type Changes

	No. of firms		Employment	
	D only	F included	D only	F included
SOE in 1998	42.1	42.1	24.6	24.6
→ Exit by 2007	30.5	30.3	12.3	12.1
→ POE by 2007	4.2	4.4	2.0	2.1
→ CSOE by 2007	2.8	2.8	5.0	5.4
POE in 1998	23.9	43.0	5.0	10.0
→ Exit by 2007	15.0	26.0	3.1	5.3
→ SOE by 2007	0.1	0.1	0.05	0.06
→ CSOE by 2007	1.2	2.0	0.4	0.6

Source: Authors' calculations based on ASI.
Notes: Number of firms and employment are in thousands. D stands for domestic firms and F stands for foreign firms.

Table A2 illustrates the large-scale reform in the state sector. First, the exit ratio of SOEs is significantly higher than the exit ratio of POEs during the same period.[31] Among the SOEs that survived through 2007, around 35 percent were privatized and 24 percent were corporatized. This number does not change much when we include foreign firms (firms whose registration type is Hong Kong/Macao/Taiwan or foreign owned) in the private sector.

[31]Since the ASI only includes POEs above the scale of the annual revenue, the number of exited POEs in Table A2 is an overestimate of the actual number of exited POEs, because a drop in observations may also be caused by a revenue decline to below the scale.