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Privatization's Impacts on State-Owned Enterprises: A Tale of Zombie versus Healthy Firms
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ABSTRACT

We estimate the effects of privatization on zombie versus healthy state-owned enterprises (SOEs) in China, extending our analysis beyond TFP to a broad array of financial and economic indicators. Privatizing zombie SOEs enhances labor productivity and TFP, reduces bank and government subsidies, alleviates leverage and administrative expenses, improves liquidity, boosts profits, and accelerates sales growth. These benefits are more pronounced than for healthy SOEs and are robust across regions and industries. Our findings offer policy implications for emerging markets, suggesting that prioritizing the privatization of underperforming, zombie-like entities can lead to substantial economic improvements and greater efficiency.

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1 Introduction

From the late 1990s to the 2000s, China experienced economic growth with an average annual rate of over 9% of real GDP. This spectacular growth is often credited to the privatization of state-owned enterprises (SOEs), which bolstered total factor productivity (TFP) for the economy (Chen et al. 2021). One key unexplored question is whether privatization uniformly improved the performance of all SOEs, or whether its effects were concentrated on a specific subset of firms. In China, SOEs historically consumed more than half of bank credits, saddling the state-dominated banking system with high levels of non-performing loans (Allen, Qian, and Qian 2005). With easy access to government subsidies and subsidized bank loans, the state sector over-expanded, aggravating the problem of industrial overcapacity. Firms with such soft budget constraints, where governments have incentives to bail them out, are often classified as "zombie" firms (Hoshi 2006; Caballero, Hoshi, and Kashyap 2008; Fukuda and Nakamura 2011).

In this paper, we find that the privatization of zombie SOEs generates significantly larger gains than the privatization of healthy (non-zombie) SOEs. These gains extend beyond TFP to multiple dimensions, including labor productivity, leverage, liquidity, operating profits, employment, investment, and sales growth. Our findings are based on comprehensive firm-level data from the Annual Survey of Industrial Firms (ASIF), which includes all SOEs and "above-scale" non-SOEs during 1998–2012 in the mining, manufacturing, and utility sectors.[1] This period encompasses the large-scale privatization wave and the prominence of zombie SOEs, especially in the early 2000s.

At the onset of privatization, the proportion of zombie SOEs in all industrial sectors accounted for over 40% of SOEs by number, assets, and liabilities in 2000.[2] By 2012, after privatization, the zombie fraction fell to under 15% by all three measures. This drastic reduction reveals that privatization was effective in addressing the significant prevalence of zombie firms within the SOE sector. The privatized zombie firms experienced significant improvements not only in their TFPs but also in labor productivity, leverage, profitability, employment, and sales. In contrast, the privatization of healthy SOEs did not yield

[1]The term "above scale" refers to annual sales of above 5 million yuan (20 million yuan for the last two years 2011 and 2012 in the sample).

[2]This proportion is notably high compared to other countries. For example, the share of listed zombie firms in the U.S. is below 15% from 1995 until now, even though it spiked after the dotcom bubble burst and the global financial crisis (https://www.federalreserve.gov/econres/notes/feds-notes/us-zombie-firms-how-many-and-how-consequential-20210730.html). For recent years (2014-2019), Favara, Minoiu, and Perez-Orive (2024) document that the share of U.S. zombie firms (both private and publicly listed firms) is below 7%. In Japan, the share of zombie firms peaked during the global financial crisis in 2008 and 2009, approaching 20%. The share declined afterwards but began to rise in recent years, reaching 17.1% in 2022. See https://www.nippon.com/en/japan-data/h01890/.

comparable gains across these dimensions. Our empirical findings highlight this stark difference in privatization's impacts, underscoring the importance of considering a firm's financial health for future theoretical work on SOE reforms.

We classify financially unhealthy SOEs as "zombie" SOEs based on the criteria established by Caballero, Hoshi, and Kashyap (2008) and Fukuda and Nakamura (2011), with an additional consideration of government subsidies, a unique feature of the Chinese economy. When calculating earnings before interest and taxes, we use operating profits, which exclude government subsidies. In China, these subsidies provide a lifeline for financially struggling SOEs, whose survival often hinges on such fiscal policy support. Our analysis reveals significant pre-privatization differences between zombie and healthy (non-zombie) SOEs. Notably, zombie firms exhibit lower efficiency (in both labor productivity and TFP), reduced profitability, higher leverage, and greater financial constraints, among other important factors. These substantial differences underscore the importance of studying the differential impact of privatization on these two groups of SOEs.

To quantify the effects of privatization on zombie versus healthy SOEs, we combine difference-in-differences (DID) and propensity score matching (PSM) approaches to create a valid control group. The DID approach accounts for both observable and unobservable time-invariant factors influencing privatization decisions. Selection bias, however, may still arise if the treatment and control groups differ significantly in time-varying covariates. To address this issue, we employ the PSM approach to compare only firms with similar observable characteristics and parallel pre-treatment trends (pre-trends). This parallel trends assumption is essential for establishing the causal effects of privatization using the DID approach.

Among the matched samples of treated (privatized) and control (non-privatized) SOEs, we demonstrate that key indicators such as efficiency (labor productivity and TFP), interest rate subsidies, profits, leverage, and liquidity exhibit parallel pre-trends. Our PSM-DID estimates reveal that privatization of zombie SOEs generates significantly larger gains than healthy SOEs across all these indicators. Privatizing zombie SOEs not only relieves the government's financial burdens and resolves non-performing loans in the banking system, but also frees up scarce resources previously allocated to these nonviable SOEs for use by healthy firms.

Chen et al. (2021) use a structural model to study the impact of ownership changes on the TFP of all SOEs. Our paper complements their work in several important respects. First, we show that not all SOEs benefited equally from privatization; zombie SOEs faced substantially more difficult financial challenges and, relative to never-privatized zombie SOEs, experienced an approximately 30% increase in labor productivity three years after privatization, which is much larger than the effects on healthy SOEs. Second, our results

on TFP reinforce the findings of Chen et al. (2021), but highlight the differential impacts on zombie versus healthy SOEs. Third, while we do not employ a structural model, our empirical method has the advantage of quantifying a broader array of important indicators beyond TFP, including profits, employment, sales, subsidies, leverage, and liquidity. As Estrin et al. (2009) emphasize, such a broad array of indicators is necessary to achieve rich and robust conclusions.

In summary, our paper makes several contributions to the literature. It extends the analysis beyond TFP to include a wide range of financial and economic indicators, providing a comprehensive understanding of the impacts of privatization. It highlights the differential impacts of privatization on zombie versus healthy SOEs, demonstrating that zombie SOEs benefit significantly more from privatization. The use of a robust empirical methodology (PSM-DID) addresses selection bias and ensures valid comparisons between treated and control groups. Our findings offer valuable policy implications, suggesting that prioritizing the privatization of zombie SOEs can lead to substantial economic improvements and greater efficiency in emerging markets.

2 SOEs: healthy versus unhealthy firms

In the mid-1990s, the Chinese government launched a privatization initiative aimed at revitalizing the SOE sector. Despite these initial efforts, a significant portion of SOEs still struggled financially by 2000, characterized by excessive debt and low productivity. These "zombie firms" posed a unique challenge to economic reforms, as their survival often depended on government subsidies and soft budget constraints. Between 2000 and 2012, the government intensified reform efforts to privatize these financially unhealthy firms.

2.1 Zombies: classifying financially unhealthy firms

We follow Guariglia, Liu, and Song (2011) to classify SOEs based on the share of paid-in-capital contributions. Specifically, a firm is classified as state-owned in a given year if the state owns at least 50% of its capital.[3] We then define zombie SOEs following the criteria established by Caballero, Hoshi, and Kashyap (2008) and Fukuda and Nakamura (2011). Specifically, firm i is classified as a zombie firm in year t if it meets either of the

[3]Guariglia, Liu, and Song (2011) discuss the unreliability of another classification approach that simply uses firms' registration codes. The results remain robust if we only use the first two sets of variables or if we set the cutoff to be 30% (See Appendix Table D.4).

following conditions:

$$R_{i,t} < R^*_{i,t} = rs_{t-1} BS_{i,t-1} + \left(\frac{1}{5} \sum_{j=1}^{5} rl_{t-j} \right) BL_{i,t-1} \text{ and } EBIT_{i,t} < R^*_{i,t}, \tag{1a}$$

$$EBIT_{i,t} < R^*_{i,t}, \ Leverage_{i,t-1} > 0.5, \text{ and } Debt_{i,t} > Debt_{i,t-1}, \tag{1b}$$

where

- The subscript i indicates firm i;
- $R_{i,t}$ is the actual interest payment made in year t;
- $R^*_{i,t}$ is the minimum required interest payment based on short-term and long-term prime rates in year t;
- rs_{t-1} is the average short-term prime rate in year $t-1$;
- rl_{t-j} is the average long-term prime rate in year $t-j$;
- $BS_{i,t-1}$ is short-term bank loans (less than one year) in year $t-1$;
- $BL_{i,t-1}$ is long-term bank loans (more than one year) in year $t-1$;
- $EBIT_{i,t}$ represents operating profits before interest and tax in year t;
- $Debt_{i,t}$ is the total external debt, including both short-term and long-term bank loans outstanding in year t;
- $Leverage_{i,t-1} \equiv \frac{Debt_{i,t-1}}{TotalAssets_{i,t-1}}$.

Condition (1a), proposed by Caballero, Hoshi, and Kashyap (2008), classifies firms receiving substantial interest rate subsidies. That is, firm i's actual interest payment ($R_{i,t}$) is less than the minimum required interest payment ($R^*_{i,t}$) based on prime rates, and its operating profits before interest and tax ($EBIT_{i,t}$) is also less than the minimum required interest payment. Condition (1b), proposed by Fukuda and Nakamura (2011), captures financially distressed firms that continue to receive new loans, potentially due to banks' risk-taking behavior in anticipation of future recovery or government bailouts (Peek and Rosengren 2005). Thus, when condition (1b) is met, a zombie firm is heavily indebted.

While conditions (1a) and (1b) are standard, they also take into account the unique characteristics of SOEs. Local governments in China often subsidize SOEs, as well as large privately owned firms, to boost regional investment (Li and Zhou 2005; Xu 2011; Xiong 2018). These government subsidies are crucial for helping ailing SOEs overcome financial difficulties (Girma et al. 2009; Allen, Qian, and Qian 2005). Therefore, we use

operating profits, which exclude government subsidies, for EBIT in conditions (1a) and (1b).[4]

[Table 1 about here.]

Table 1 compares zombie and healthy (non-zombie) SOEs across various variables and shows statistically significant differences. The period 1999-2008 is chosen because we use information on ownership in 1998 to classify SOEs and reserve the final three years in the sample (2009, 2011, and 2012) for assessing the effects of privatization, which are discussed in later sections. Compared to healthy SOEs, zombie SOEs received more favorable government and interest rate subsidies, faced lower interest rates, were less profitable, more highly leveraged, more financially constrained (measured by liquidity), less capital-intensive, less efficient (in both labor productivity and TFP), paid lower wages, and invested less in fixed assets. They were also smaller and older. Due to these substantial pre-privatization differences, it is crucial to examine how privatization affected zombie and healthy SOEs. Besides, as shown in Figure 1, the share of zombie SOEs within the entire state sector was more than 55% by 1999 in number, assets, and liabilities. As economic reforms deepened, especially with China's accession to the WTO, the proportion of zombies in the state sector declined rapidly to below 20% in both liabilities and assets by 2007. This trend, however, was temporarily interrupted during the global financial crisis of 2008 and 2009, when the zombie share saw a brief uptick. Despite this interruption, the downward trend driven by the privatization process resumed after 2009.

[Figure 1 about here.]

2.2 Privatization

In 1998, 40.6% of China's SOEs were unprofitable, and these losses accounted for 1.4% of GDP (Lardy 2014). The accumulation of non-performing loans and the deteriorating financial health of SOEs posed a significant threat to the country's banking system and overall economy. In response to this crisis, the central government gradually accepted privatization as the solution to reform the state sector.[5] In particular, local SOEs were allowed to be privatized via various methods, including direct sales, public offerings, joint ventures, leasing, and employment shareholding.[6] The 15th National Congress of

[4]In Appendix C, we use an alternative criterion based on "actual profits," defined as net profit excluding only government subsidies and interest rate subsidies, to identify zombies. The results are similar with this criterion.

[5]Due to ideological reasons, the term "privatization" was never used in the official documents and speeches. Instead, they used the term "gaizhi", which includes the concept of privatization.

[6]Direct sales include sales to insiders (management buyouts) and sales to outsiders, with the former being the most popular form of privatization (Garnaut et al. 2003; Gan, Guo, and Xu 2017).

the Communist Party of China authorized local governments to design and implement privatization reforms of SOEs under their jurisdiction, granting local governments greater autonomy in the reform process.

Local governments and SOEs, working in tandem, successfully implemented the privatization process. Local officials saw SOE restructuring as key to boosting economic growth and tax revenues, and privatization significantly reduced the SOE share in the economy. Official statistics (Statistical Yearbooks of China 1999 and 2008) show that in 1998 SOEs accounted for 50% of the total output and 57% of the industrial value-added. By 2007, the figures decreased to 30% and 34%, respectively. It is estimated that close to three-quarters of large and medium-sized industrial SOEs were privatized by 2005 (Gan, Guo, and Xu 2017). The aggregate privatized assets between 1995 and 2005 totaled about 11.4 trillion yuan, comprising two-thirds of China's SOEs and state assets (Guo, Gan, and Xu 2008).

For each firm-year observation in our constructed dataset, privatization is defined as the change of state-owned to non-state-owned. We exclude privatized SOEs that reverted to SOEs within four years after privatization.[7] Our measure of privatization captures the essence of the ownership restructuring. Although collective ownership differs from private ownership, previous studies find that collective ownership is very successful in boosting efficiency and growth, and as a result, significantly outperforms state ownership (Dong and Putterman 1997; Fu and Balasubramanyam 2003). Following Bai, Lu, and Tao (2009) and Tong (2009), we group collective ownership with private ownership (both domestic and foreign) as non-state.[8]

[Table 2 about here.]

Table 2 presents the distribution of privatization events by year (columns 2–3) and region (columns 5–6) for the period 1999-2008. As shown in Table 2, the vast majority of SOEs were privatized by 2007, with a peak in privatization activity occurring in the early 2000s, with over 2,000 firms privatized annually in 1999, 2000, and 2001. The pace then gradually declined but surged again in 2004 before slowing considerably after 2005, with fewer than 1,000 firms privatized each year.

Similarly, the number of remaining SOEs fell drastically during the period 1999–2008, from 50,541 in 1999 to 15,593 in 2008, a decrease of 70%. While all regions experienced massive privatization, the extent varied across regions. The eastern coast region saw the most pervasive privatization, with 34.7% (2936/8462) of SOEs prior to privatization, followed by the southern coast (22.4%), the middle reaches of the Yellow River (21.7%), and

[7]The results remain very similar if we drop privatized SOEs that reverted to SOEs (see Table D.5).
[8]See Appendix B for further analysis.

the northern coast (20.8%). In Section 5.2.1, we discuss the distribution of privatization's effects on a broad array of indicators across regions.

3 Data and econometric methodology

3.1 Data

Our study utilizes the ASIF dataset compiled by the National Bureau of Statistics (NBS) of China, covering the period from 1998 to 2012. This dataset provides comprehensive coverage of firms across all industrial sectors, including all SOEs and "above-scale" non-SOEs in mining, manufacturing, and utilities. Representing over 90% of China's industrial output during this period (Brandt, Van Biesebroeck, and Zhang 2012), the ASIF data offers detailed information about the distribution of firms across various dimensions and the large-scale privatization efforts initiated in the late 1990s.

The dataset includes detailed information on firms' ownership structures, such as the firm's legal registration type and the share of the firm's registered capital owned by the state, collective groups, individuals, or foreign entities. Specifically, it contains information on the firm's controlling shareholder, classifying the controlling shareholder as the state, collective groups, foreign entities, private individuals, or others. Moreover, the dataset encompasses extensive firm-level characteristics and financial variables from balance sheets, income statements, and cash flow statements, which are necessary for classifying zombie firms using the criteria discussed in Section 2.1.

We create a panel dataset by matching observations over time using a firm's numerical ID, the unique identifier assigned by the NBS, and additional information such as the firm's name, legal representative, and address. Linking new and old firm IDs is crucial in our context, as firms may receive new IDs following restructuring, mergers, or acquisitions. The vast majority of year-to-year matches (96%) are made using NBS IDs, with the remainder linked through other information. Detailed procedures for handling the dataset and potential challenges are outlined in Brandt, Van Biesebroeck, and Zhang (2012, 2014).[9] Our analysis focuses on firms that were originally state-owned in the data. Thus, we exclude SOEs that were non-SOEs in the early sample. Following the literature, moreover, we exclude the 2010 survey due to concerns about data reliability (see, e.g., Tan et al. (2017) and Chen (2018)) and winsorize all continuous variables at the 1% and

[9]We closely follow Brandt, Van Biesebroeck, and Zhang (2012, 2014) in cleaning the data and constructing related variables. Detailed procedures are available from the authors upon request. We exclude observations with negative values for sales, total assets minus total fixed assets (or net value of fixed assets), total assets minus liquid assets, and accumulated depreciation minus current depreciation, as well as firms with fewer than 10 employees.

99% levels to mitigate the influence of outliers.

3.2 Econometric methodology

As discussed in the introduction, we use the PSM-DID approach to estimate the effects of privatization on zombie versus healthy SOEs. Propensity score matching, first proposed by Heckman, Ichimura, and Todd (1997), is extensively used to study the effects of ownership changes on the behavior of firms (see, for example, Arnold and Javorcik (2009), Wang and Wang (2015), and Javorcik and Poelhekke (2017)). It's well recognized that if the covariate distributions differ between the treatment and control groups, the linear regression estimator is generally biased (Dehejia and Wahba 2002; Imbens 2015). Since private acquirers may specifically target SOEs with certain characteristics, privatized SOEs and those never privatized could be significantly different along a number of dimensions (as shown in Table D.2). The matching procedure addresses selection bias by restricting the comparison to carefully selected pairs of firms with similar observable characteristics and pretreatment trends prior to the ownership change.

We obtain the propensity score (i.e., the probability of being privatized) for both zombie and non-zombie SOEs in the pre-privatization year using a logit model to predict the probability of privatization, where the dependent variable takes on the value of one when an SOE is privatized. The estimation results, displayed in Table A.1 of the appendix, are reported for both zombie and healthy SOEs. Since private acquirers relied heavily on observable firm-level information to screen potentially targeted SOEs, we include a large array of explanatory variables in the logit model, including the important determinants of privatization found in the literature (Guo and Yao 2005; Tong 2009) such as leverage, interest rate subsidies, and government subsidies that are crucial for separating zombie from healthy SOEs. The explanatory variables, all lagged one year relative to privatization, include interest rate and government subsidies (to measure the soft-budget constraints), leverage, squared leverage, debt growth, operating profits (scaled by assets), the logarithm of TFP, TFP growth, the logarithm of employment, the logarithm of squared employment, age, squared age, liquidity ratio (the difference between current assets and current liabilities, scaled by total assets), the logarithm of average real wage, the logarithm of capital intensity (the capital-labor ratio), the logarithm of output, fixed investment rate (fixed investment assets scaled by lagged total assets), export status (equals one if the firm exported in the year and zero otherwise), affiliation dummies, province dummies, and several interaction terms (see Becker and Ichino (2002)).[10] We control for three macroeconomic variables: GDP growth, the logarithm

[10]Coefficients on province dummies are not shown for brevity. In China an SOE is typically affiliated

of GDP per capita at the city level, and the Herfindahl-Hirschman Index (HHI) at the 3-digit industry level.[11]

To check the quality of matching, in Table D.2 of the appendix, we conduct the balance test on the covariates used in the matching procedure. As shown in the table, while there are considerable differences in almost every variable before matching between privatized and remaining zombie SOEs, there are no significant differences after matching. The standardized bias is generally under 5%, and the p statistic value indicates that none of the differences in the matched sample is statistically significant.[12] Once we obtain the propensity score, we apply the one-to-one nearest neighbor propensity score matching with replacement. We require that each privatized SOE is paired with an observably similar non-privatized one that is operating in the same 2-digit CIC industry and year, which ensures that we control for industry-specific and time-specific confounding factors that may exert influence on both privatized and control SOEs. We also impose the common support restriction as well as a caliper of 2 percentage points to ensure enough similarity within matched pairs.[13]

After obtaining the firms through the PSM procedure, we estimate the following regression on the matched sample:

$$\Delta_s y_i = y_{i\,t+s} - y_{i\,t-1} = \alpha_s + \beta_s Privatized_i + \epsilon_{sit}, \tag{2}$$

where the dependent variable in the regression, $\Delta_s y_i$, denotes the (accumulative) change in performance of firm i over the sth year ($s = 0, 1, 2, 3$) following privatization, relative to the pre-privatization year. A regression is estimated for each value of s, and β_s, the coefficient of interest, captures the treatment effect on the treated, i.e., the effect of privatization. For zombie SOEs (i.e., SOEs that were zombies in the pre-privatization year), we find a match for each of them from the firm-year observations, which were never privatized during our sample period and were also zombies in the preceding year. For healthy SOEs, the treatment group consists of SOEs that were privatized and were *not* zombies in the pre-privatization year, and the comparison group is similarly limited to the firm-year observations that were *not* zombies in the preceding year. In summary, the

with a specific oversight government. "Medium-level" affiliation and "low-level" affiliation refer to the SOE's affiliation to the city-level government and county-level government, respectively. The omitted group is those affiliated with the central and provincial governments.

[11]We find that the coefficients on interest rate and government subsidies are significantly negative, suggesting that hardening budget constraints facilitates SOE privatization (consistent with Guo and Yao (2005) and Tong (2009)). Similarly, SOEs with slower debt growth rates are more likely to be privatized. Detailed discussion of the logit regression results is in Appendix A.

[12]Imbens and Wooldridge (2009) recommend that the standardized bias should not exceed 25% to retain viable statistical properties.

[13]The results are robust to alternative matching methods (see Tables D.6–D.9 in the appendix), including Mahalanobis matching and coarsened exact matching (Iacus, King, and Porro 2017).

treatment group and the control group have the same zombie status in the year preceding privatization in the matching process. In Table 3, we list the number of privatized SOEs (treated) and never privatized SOEs (control) by year and by the zombie status in the year prior to privatization. Consistent with the outcome trend of privatization reported in Table 2, the number of both zombie and healthy firms declined over time.

[Table 3 about here.]

The parallel trends assumption is essential for estimating the effects of privatization using the DID approach. To verify whether the treated and control groups have parallel pretreatment trends across a broad array of key indicators, we display Figure 2. This figure plots the time trends of the key variables used in our regression analysis, showing the average values for each group (treated and control) of matched zombie SOEs (Panel A) and matched healthy SOEs (Panel B). In addition to labor productivity, TFP, interest rate subsidies, government subsidies, operating profits, leverage, liquidity, and sales growth, we also consider administrative expenses. In China, administrative expenses significantly affect a firm's profit margins and financial situation. As shown in the figure, the treatment and control groups exhibit similar trends in the years before privatization (with "Year" equal to zero, indicating the privatization year) across many variables, and then diverge significantly after privatization, especially for zombie SOEs.[14]

[Figure 2 about here.]

4 Effects of privatization on zombie versus healthy SOEs

In this section, we present the empirical results for the effects of privatization on zombie versus healthy SOEs along multiple dimensions. Our analysis begins with two major performance metrics: labor productivity and total factor productivity (TFP). These indicators represent how privatization affects efficiency in both types of SOEs. We then extend our analysis to a broad array of indicators related to firms' financial health, including profitability (operating profits), leverage, liquidity, subsidies, and administrative expenses. To understand the broader economic impact of privatization beyond firms' financial situations, we examine the effects on firms' fundamental economic variables such as sales growth, employment, and investment.

[14]Prior to privatization, healthy SOEs performed better than zombie SOEs across all variables reported in Figure 2. For instance, the average liquidity ratio (scaled by total assets) for zombie SOEs was much more negative than that of healthy firms, indicating that zombie SOEs were more liquidity-constrained.

4.1 Efficiency metrics

Table 4 shows that the effects of privatization on labor productivity and TFP are large and statistically significant in the privatization year and each year after privatization. Relative to never privatized zombie SOEs, TFP of privatized zombie SOEs increases by 8.5% in the privatization year, and this gap between treated (privatized) and control (never privatized) firms widens even further to 17% in the third year after privatization. Privatization's effects on the labor productivity of privatized zombie SOEs are even more sizable, ranging from 21% to 31%. Our results show that there are immediate impacts of privatization during the year of privatization, in line with the previous findings about the effects of firm ownership changes (Frydman et al. 1999; Arnold and Javorcik 2009; Wang and Wang 2015).

These results align well with the labor productivity and TFP results reported in Panel A of Figure 2. While both treated and control SOEs exhibit very similar paths in the three years leading up to privatization, privatized zombie SOEs experience a significant rise in labor productivity and TFP. The differences in these privatization effects between privatized zombie SOEs and never privatized zombie SOEs persist for three years following privatization.[15]

[Table 4 about here.]

[Figure 3 about here.]

By contrast, the impacts of privatization on healthy SOEs are much smaller in magnitude (Panel B of Table 4). The effect on labor productivity, for instance, is only 6% in the third year following privatization. The privatization effects on labor productivity and TFP of zombie SOEs are 3–5 times larger than those of healthy SOEs. To illustrate such large differences visually, we plot these estimated effects together with the 95% confidence intervals for both zombie and healthy SOEs in Figure 3. Our results are consistent with the argument that the least efficient firms experience the largest improvements in efficiency through privatization (Frydman et al. 1999; Gupta, Ham, and Svejnar 2008).

4.2 A broad array of financial indicators

In addition to the above two efficiency indicators, a firm's performance should be measured by a broad array of indicators. We extend our analysis to include an array of

[15]Since our results are conditional on survival, the effects could be stronger if we take into account exit. The reason is as follows. Never privatized SOEs (the control group) are more likely to exit and also their pre-exit performance is much worse than the privatized (treated) group, especially for zombie firms.

indicators related to profitability, such as operating profits, leverage, liquidity, subsidies, and administrative expenses. These profitability indicators reflect the firm's financial health.

Since zombie firms are characterized by extremely low interest payments, we first assess the financing costs of privatized zombie SOEs relative to never privatized zombie SOEs. Because we cannot observe the exact interest rates of specific loans and their maturities in the data, we impute the average interest rate as paid interest payments divided by lagged total debt. According to Panel A of Table 5, the interest rate charged to a privatized SOE increases by 0.4 percentage points (pps) during the first year after privatization, and this large and statistically significant increase continues in the next two years.[16] By contrast, the privatization effect for healthy SOEs is much smaller and statistically insignificant for most years during and after privatization (Panel B of Table 5).

The increase in the interest rate charged by banks to privatized zombie SOEs is a clear indication of firms' improved ability to pay off interest charges, as highlighted in Frydman et al. (2000). This result is consistent with the privatization effect on interest rate subsidies and government subsidies, the two most important forms of lifeline support for zombie firms in China.[17] Interest rate subsidies decline by 0.8 pps three years after privatization relative to never privatized zombie SOEs.[18] In comparison, the privatization effect on interest rate subsidies for healthy SOEs is, for the most part, statistically insignificant. In the second year following privatization, government subsidies to privatized zombie SOEs decline by 0.3 pps relative to never privatized zombie SOEs, amounting to a 38% decrease from the pre-privatization average. By contrast, the privatization effect on government subsidies for healthy SOEs is much smaller in magnitude and statistically significant in only one of the four periods. To summarize, these results provide evidence that privatization leads to the hardening of budget constraints for zombie SOEs, with reductions in both interest rate subsidies and government subsidies, while the evidence for healthy SOEs is generally much weaker.[19]

The liquidity ratio for privatized zombie SOEs, as shown in Panel A of Table 5, increases immediately by 6.4 pps in the privatization year. The privatization effect continues to increase in the subsequent years and reaches 14 pps in the third year. This

[16] Given the average interest rate in the pre-privatization year, this amount corresponds to a 40% increase.

[17] We follow Caballero, Hoshi, and Kashyap (2008) and calculate the interest rate subsidy as $(R^*_{i,t} - R_{i,t})/Debt_{i,t-1}$.

[18] This amount corresponds to a 55% decline from the pre-privatization period.

[19] Our results complement the findings of Borisova and Megginson (2011), who use European firm data to show a significantly negative relationship between government ownership and the cost of debt. They attribute this negative relationship to the dominant role played by the implicit government guarantee.

effect is substantial, considering that the pre-privatization liquidity ratio is -0.204 on average for zombie SOEs. By contrast, the privatization effect on healthy SOEs is generally limited and, in some cases, statistically insignificant. The improvement in liquidity for privatized zombie firms is consistent with improvements in leverage and profits for these firms. Privatized zombie SOEs experience significant deleveraging and rapid increases in profits after privatization. In the third year after privatization, leverage declines by 18.5 pps, operating profits increase by 10 pps, and administrative expenses decrease by 8.6 pps (amounting to 36% of their pre-privatization level). Consistent with the findings of Bai, Lu, and Tao (2009), the reduction in administrative expenses plays an important role in helping firms become profitable.[20]

[Table 5 about here.]

4.3 Sales growth, employment, and other firm fundamentals

To understand the broader economic impact of privatization beyond firms' financial situations, we now examine the effects on other firm fundamental variables such as sales growth, employment, and investment.

We begin with the impact of privatization on employment and wages. One major concern is that privatization could lead to massive layoffs, potentially destabilizing the labor market. This concern is particularly relevant as the Chinese government places great importance on social stability. The estimation results reported in Panel A of Table 6 show that privatization leads to significant and persistent employment restructuring in zombie SOEs. The largest effect occurs two years after privatization, with an estimated decline of 10%. The effects on healthy SOEs are much smaller, with declines of 4–6% during and after privatization (Panel B of Table 6). The maximum employment decline of 10%, while sizable, is by no means disruptive to the reform process. Moreover, the decline in employment is consistent with the large increase in labor productivity for zombie SOEs after privatization. Privatization, however, has almost no significant effect on average wages in privatized zombie SOEs (Panel A), but it does have statistically significant effects on wages for healthy SOEs, with declines of 2–11%. According to our estimates, privatized zombie SOEs are downsized through more layoffs of workers (extensive margins) and fewer wage cuts than privatized healthy SOEs.

The effects of privatization on fixed-assets investment are positive and statistically significant for both zombie and healthy SOEs during and after privatization, although the effects for zombie SOEs are larger. What is more important, there is a substantial rise

[20] In Appendix Table D.3, we conduct our analysis based on a balanced panel to eliminate the influence of firm entry and exit. The results are very similar to those in the baseline analysis.

in sales growth for zombie SOEs (relative to the control group—never privatized zombie SOEs) during and after privatization, especially with a large increase of 26 pps in the privatization year (Panel A of Table 6). By contrast, the largest increase in sales growth for healthy SOEs is 8.7 pps during the first year after privatization.[21]

[Table 6 about here.]

In summary, our estimation results illustrate the multiple dimensions along which privatization improves firms' efficiency: reduced reliance on subsidies, decreased leverage, improved liquidity, increased profits, larger worker layoffs, greater fixed-assets investment, and stronger sales growth. These broad economic and financial impacts on zombie SOEs outweigh those on healthy SOEs, generating significant returns on privatization. Therefore, important lessons drawn from our study are that (a) not all SOEs benefit equally from privatization, and (b) focusing privatization efforts on zombie firms is a more effective policy.

5 Robustness Analysis

In the appendix, we provide a robustness analysis of our estimation results, exploring alternative matching methods to examine the sensitivity of our results (Tables D.6–D.9) and an alternative criterion for classifying SOEs in our sample (Table D.4). In this section, we analyze the effects of renationalization and the robustness of the privatization effects on economic and financial indicators of zombie and healthy SOEs across regions and industries.

5.1 Effects of renationalization

Renationalization is the reversal of privatization. Given that privatization leads to improvements across a wide range of economic and financial indicators for zombie SOEs, it is important to examine whether renationalization reverses these improvements. During our sample period, when the privatization process was still active, local governments occasionally repossessed ownership of privatized firms.[22] Our analysis focuses on SOEs that had completed privatization during our sample period. The treatment group consists of privatized SOEs that became state-owned again, and the control group consists

[21] Despite the reductions in the workforce, the privatization effect on output is also large and statistically significant, ranging from 15–26%.

[22] Local governments may sometimes need to renationalize certain privatized firms to ease the burden of unemployment in local labor markets. See, for example, Huang et al. (2021) for details.

of privatized SOEs that remained non-state firms until the end of our sample period.[23]

Table 7 reports our estimated results. We find large and persistent effects of renationalization on most financial and economic variables, with signs opposite to those of the privatization effects. By the third year following renationalization, both TFP and labor productivity decline by about 18% (relative to the control group), and these negative effects occur immediately during the renationalization year. The effects on interest rate subsidies and government subsidies, however, are generally small and mostly insignificant statistically, as it takes time for renationalized firms to regain bank and government support. The employment effect of renationalization is also statistically insignificant. The effects on sales growth, liquidity, and profits are negative and highly significant. The effects on leverage and administrative expenses are positive and highly significant. Our results clearly show the negative impacts of renationalization on a number of financial and economic variables.

[Table 7 about here.]

5.2 Distribution of zombie SOEs

In this section, we discuss the privatization effects on zombie and healthy SOEs across regions and industries. In Figures 4 and 5, we plot the geographic and industrial distributions of zombie SOEs in 2000 and 2008 for comparison. As shown, while there are considerable variations in the proportion of zombie SOEs across provinces and 2-digit industries, the proportion declined significantly in 2008 for most provinces and industries by assets and liabilities, consistent with the overall declining trend shown in Figure 1.

[Figure 4 about here.]

[Figure 5 about here.]

5.2.1 Across regions

Given that economic development and the privatization process varied across regions during our sample period, it is informative to examine whether the impacts of privatization on zombie SOEs differ significantly across regions. To ensure sufficient observations for estimation, we divide the 31 provinces into two groups using two different criteria: North versus South, and Coast versus Inland.[24]

[23] We exclude renationalized firms that were privatized again within four years following renationalization, but these firms are rare in the data.

[24] The South includes Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, Hainan, Guangxi, Jiangxi, Hunan, Anhui, Hubei, Sichuan, Yunnan, Guizhou, and Tibet; and the North includes the rest of the provinces. The Coastal region includes Liaoning, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, and Hainan; and the Inland region includes the rest of the provinces.

Figure 6 reports our estimation results with 95% confidence intervals for the North and South. Interestingly, there is not much difference between the North and the South, as the confidence intervals for both regions overlap. For the Coast-Inland division (Figure 7), the privatization effects, as indicated by the confidence intervals, are similar across these two regions, except for labor productivity and leverage. For these two indicators, the effects in the Inland region are significantly stronger than those in the Coastal region. This outcome is likely because SOEs in the more developed Coastal region are relatively better managed than those in the Inland region. Therefore, our estimation results are not driven by any particular geographic region.

[Figure 6 about here.]

[Figure 7 about here.]

5.3 Across industries

Our sample includes a variety of 2-digit industries such as manufacturing, transportation, technology, and food processing. To ensure sufficient observations for our analysis, we group industries in two ways. First, we classify them based on the capital-labor ratio: heavy industries, with capital-labor ratios above the average; and light industries, with capital-labor ratios below the average. Second, we follow Huang et al. (2017) to group industries into strategic and non-strategic categories. Strategic industries are those the government deems crucial for China's growth and national security, often subject to stricter regulatory scrutiny. The non-strategic group includes the remaining industries.

Figures 8 and 9 display our estimation results based on these two grouping approaches. According to the results, the effects of privatization on administrative expenses, profits, and employment are significantly more pronounced for SOEs in heavy industries than those in light industries. For other indicators, the differences in privatization effects are not statistically significant between heavy and light industries. In the strategic and non-strategic groups, the effects in most cases are stronger among non-strategic industries, though the differences seem not large. Thus, our main estimation results are not driven by any particular group of industries.

[Figure 8 about here.]

[Figure 9 about here.]

6 Conclusion

This paper demonstrates that privatizing zombie SOEs, rather than healthy SOEs, is a more effective policy for improving firm performance across a broad array of financial and economic indicators. These indicators include not only TFP but also labor productivity, bank and government subsidies, leverage, liquidity, profits, employment, and sales growth. Using the PSM-DID approach, we effectively remove selection bias and ensure parallel trends between the treatment and control groups prior to privatization, which is a key assumption for assessing the effects of privatization.

Our results show that privatization significantly reduces interest rate subsidies and leverage for zombie SOEs, while improving liquidity, increasing profits, and boosting sales growth. In contrast, the effects of privatization on healthy SOEs are limited and smaller in magnitude. Our findings are robust across different regions and industries, indicating that the benefits of privatizing zombie SOEs are widespread and not confined to specific geographic areas or sectors.

Our empirical evidence suggests that future theoretical or structural models should account for multiple dimensions of privatization effects beyond TFP. Furthermore, the stark contrast between the effects of privatization on zombie versus healthy SOEs indicates that SOEs should not be treated equally in theoretical work. Our estimated results on renationalization also provide important policy implications, particularly in the context of China's recent efforts to support SOEs with preferential credit. More broadly, our findings suggest that prioritizing the privatization of zombie-like entities can unlock substantial economic improvements and greater efficiency in emerging markets.

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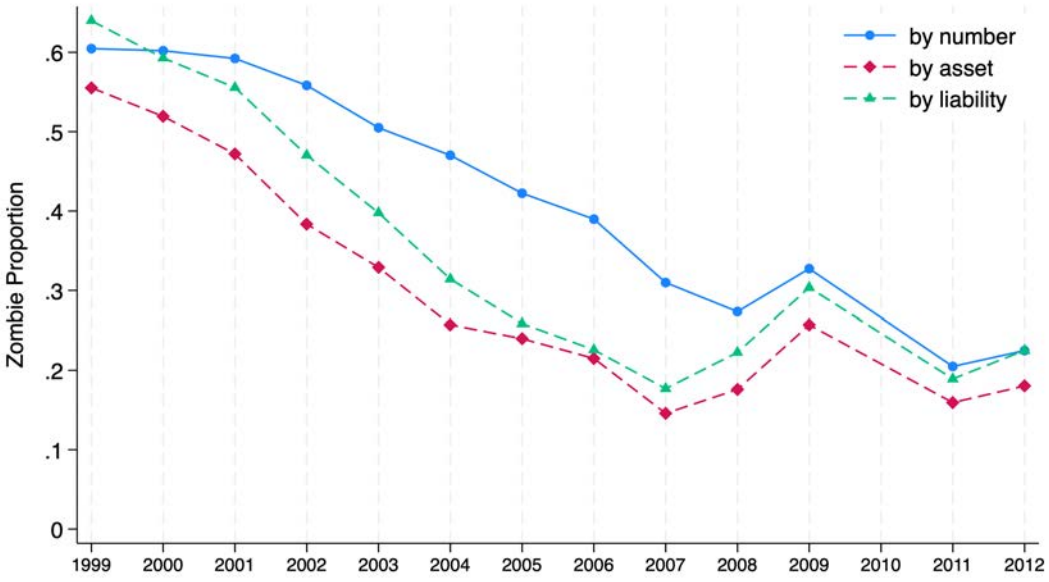

Figure 1: Time trends of the proportion of zombie SOEs

Note: Calculated by the authors using the ASIF dataset.

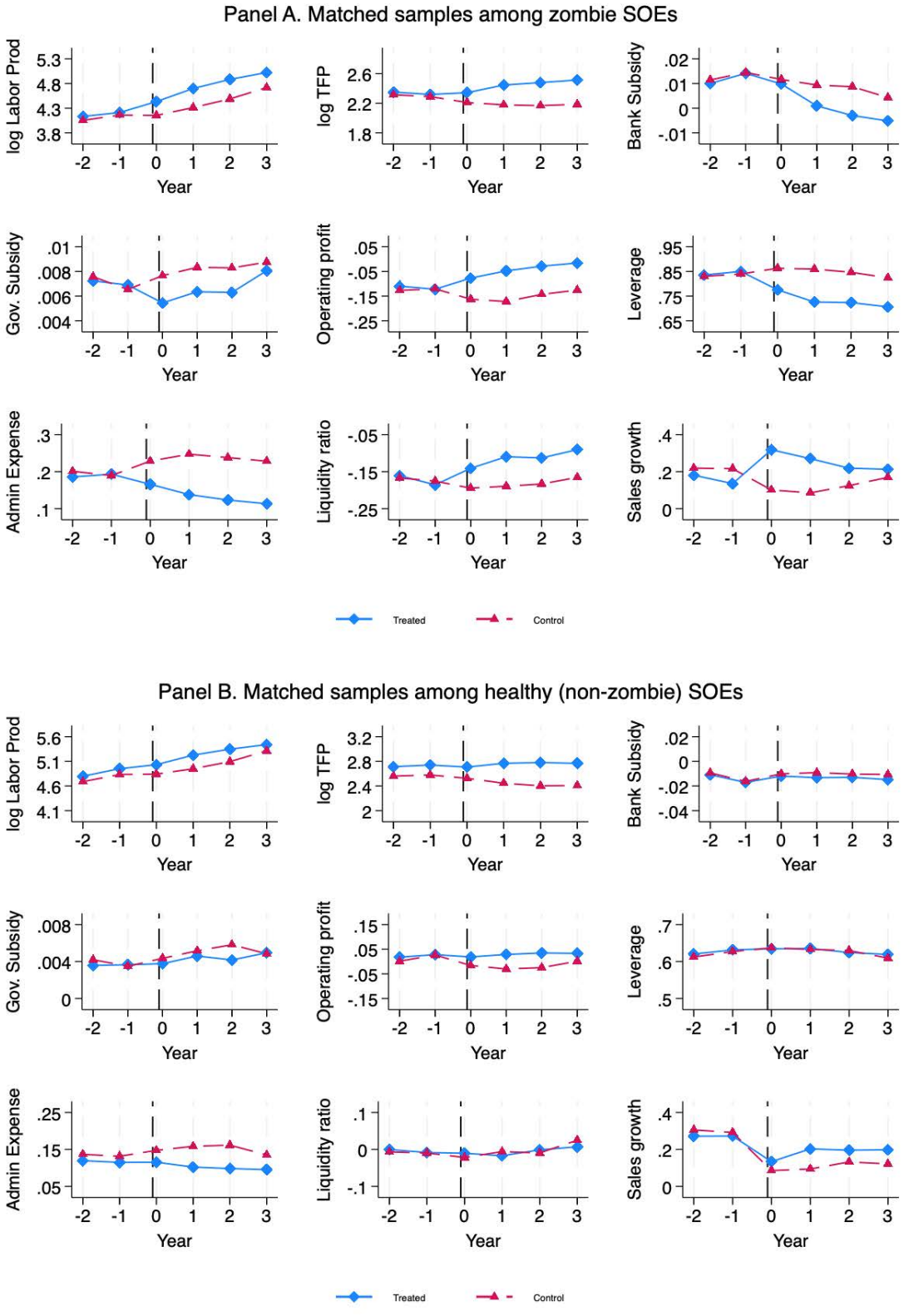

Figure 2: Time trends of key variables among matched treated and control SOEs

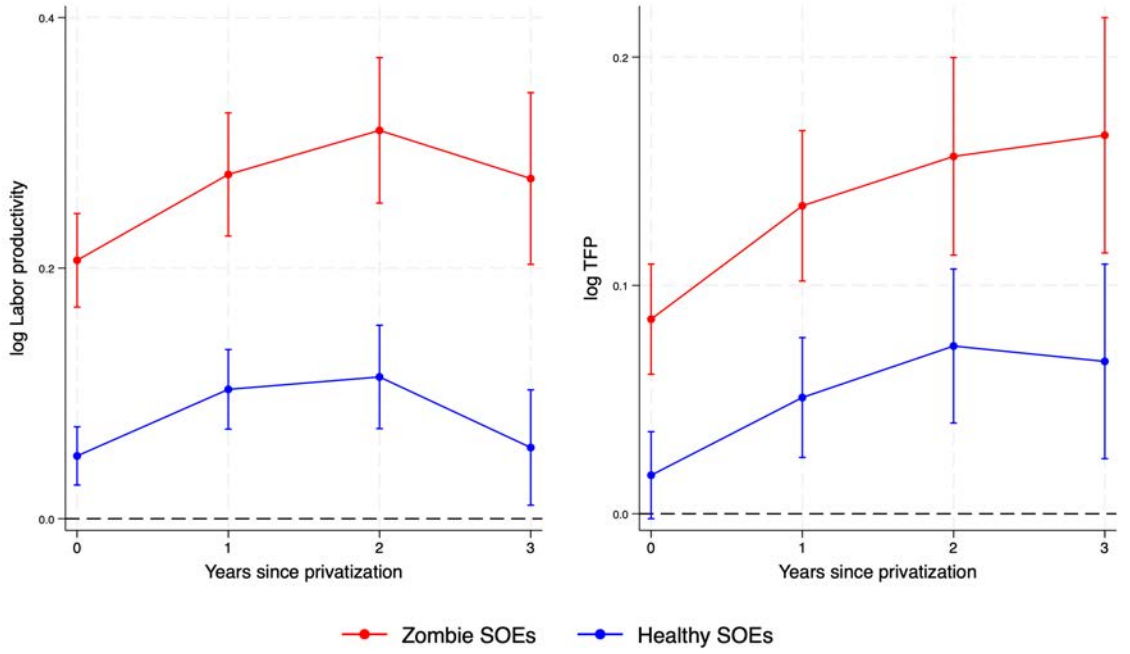

Figure 3: Effects of privatization on zombie and healthy SOEs

Note: The vertical lines represent the 95% confidence intervals.

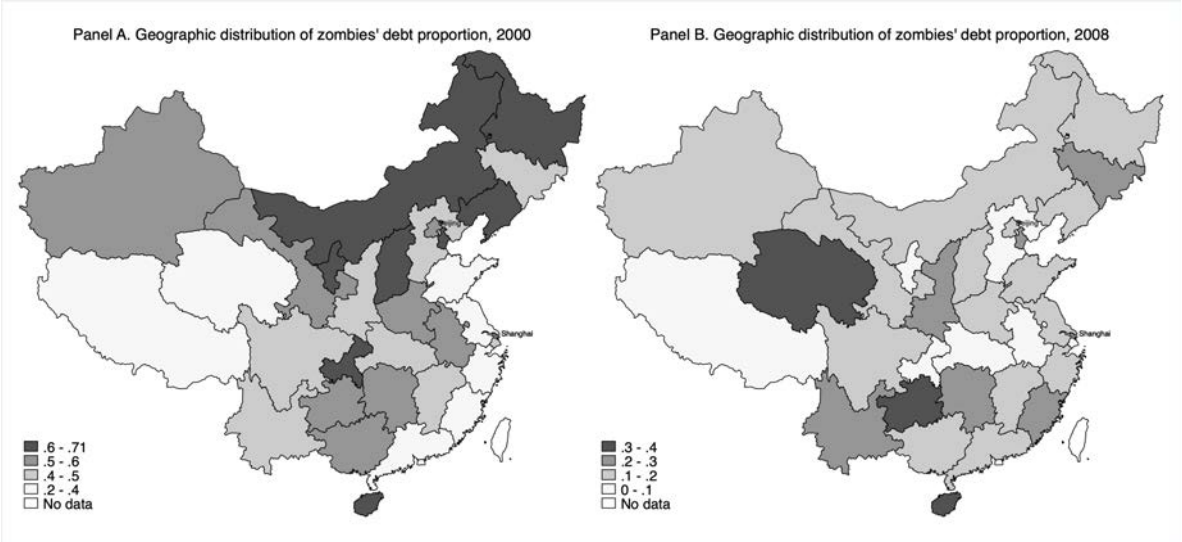

Figure 4: Geographic distribution of zombie debt as a proportion of total SOE debt

Note: Calculated by the authors using the ASIF dataset.

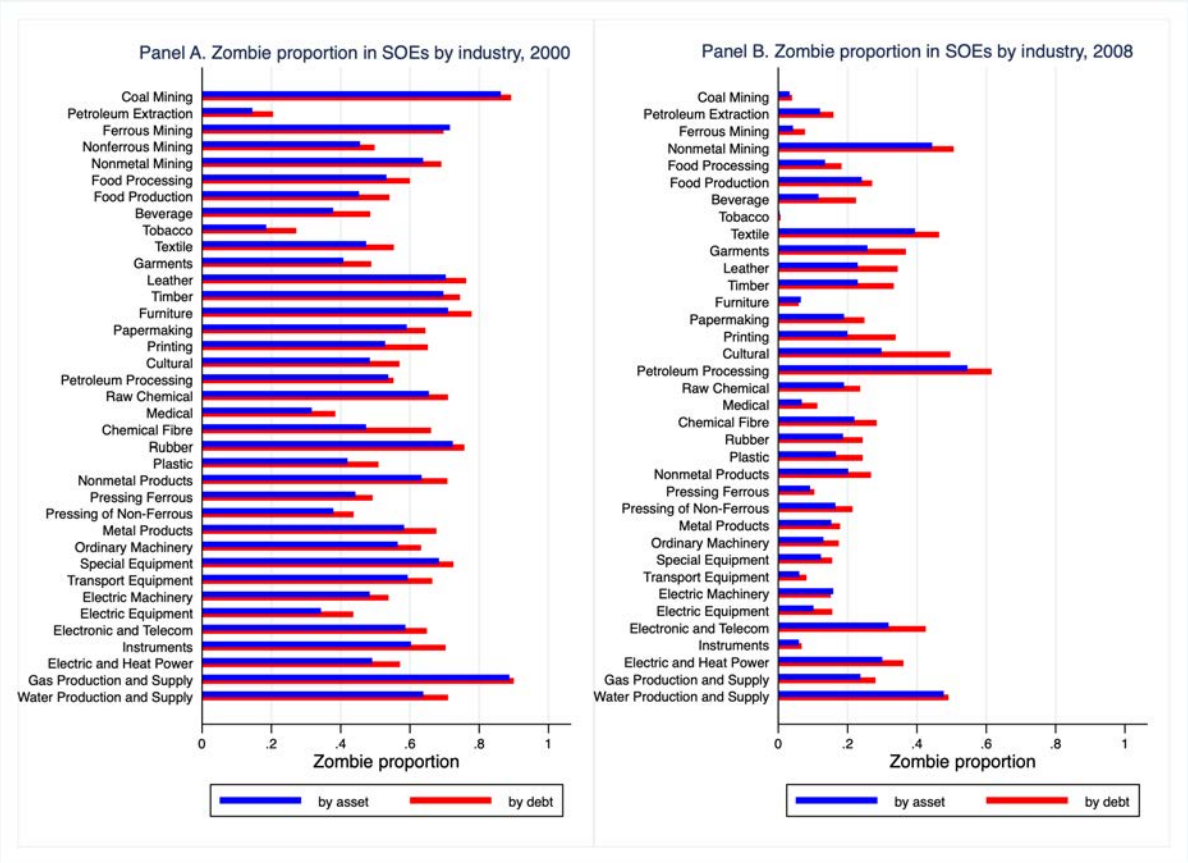

Figure 5: Industry distribution of zombie SOEs as a proportion of all SOEs

Note: Calculated by the authors using the ASIF dataset.

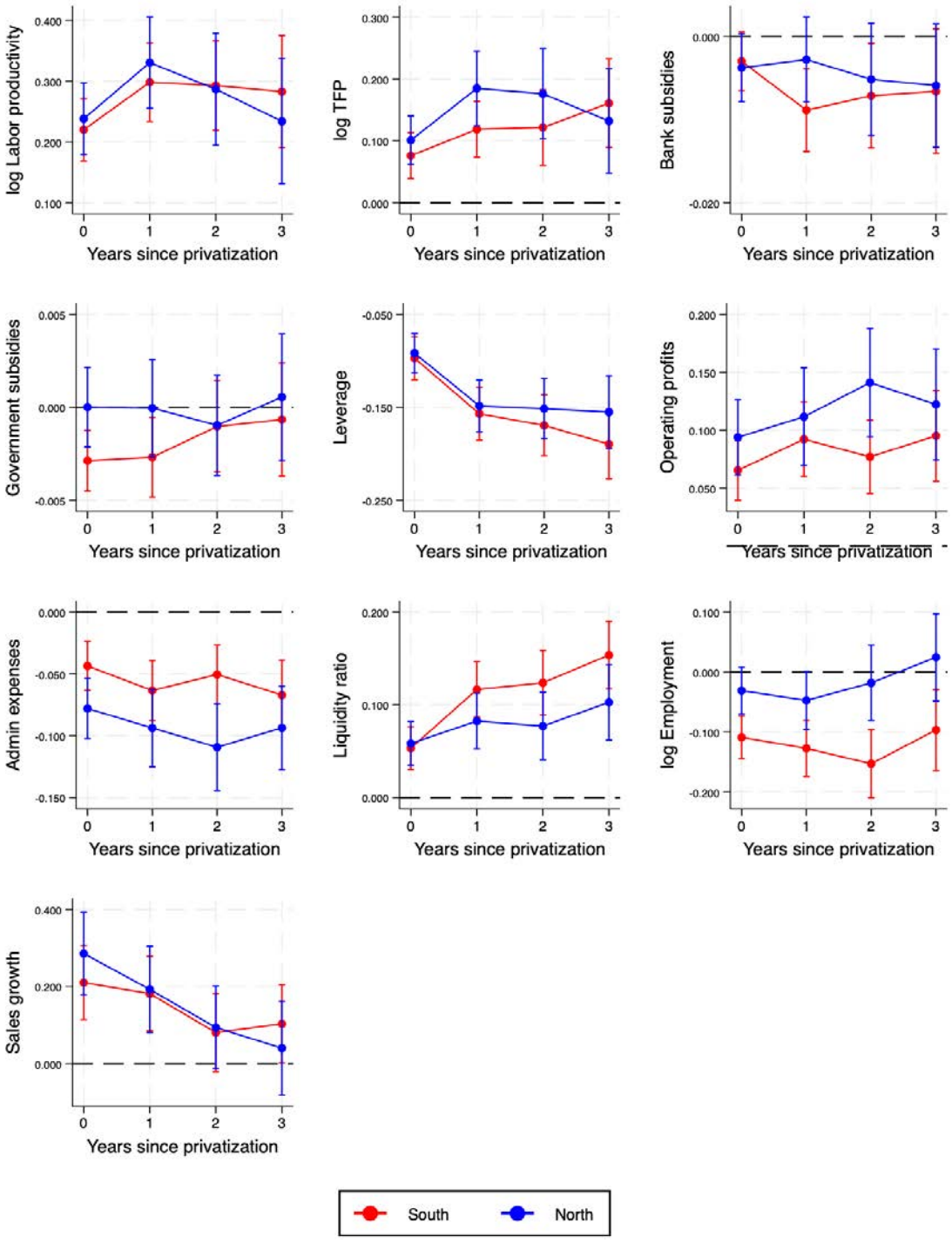

Figure 6: Effects of privatization in South versus North China among zombie SOEs

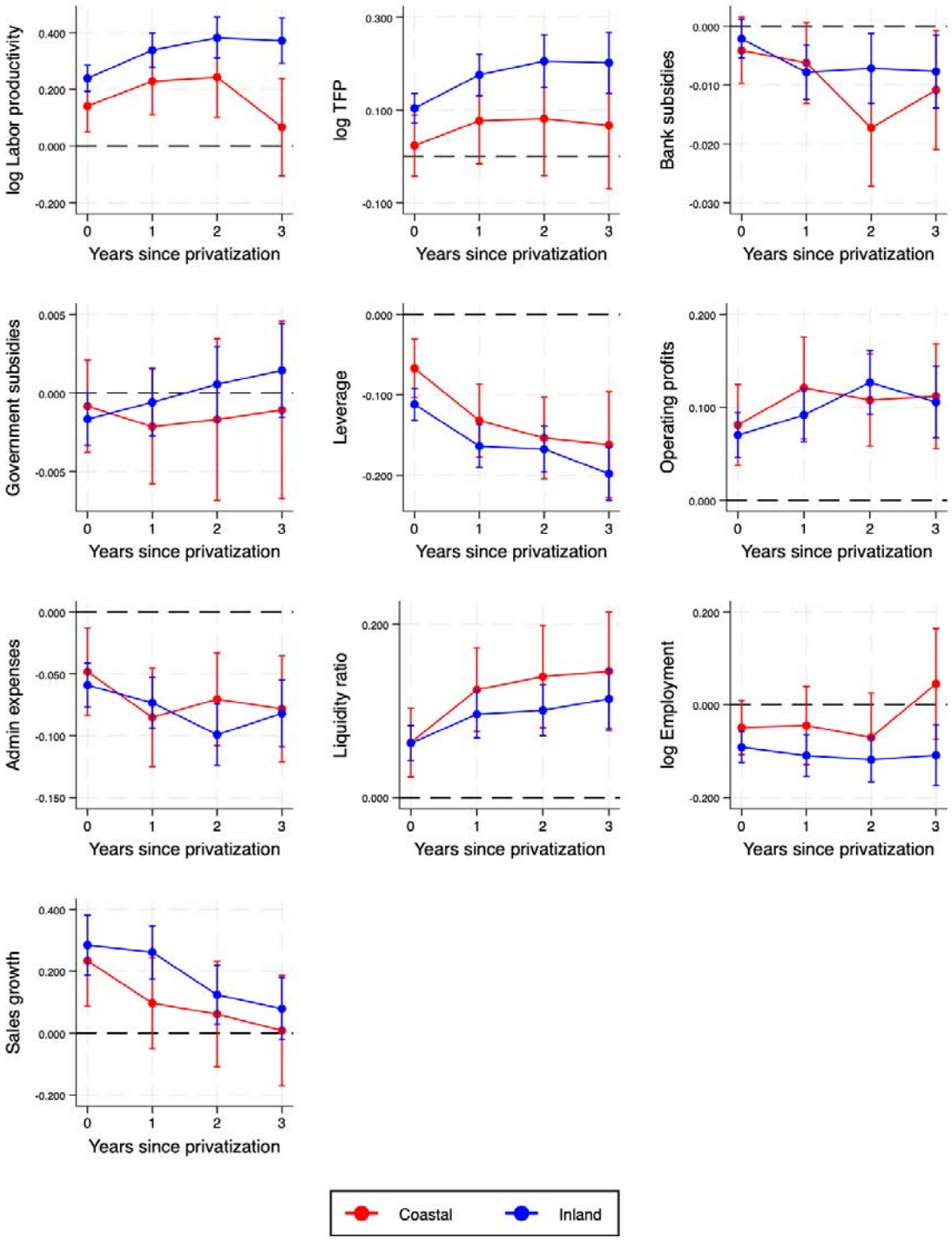

Figure 7: Effects of privatization in Coastal versus Inland regions among zombie SOEs

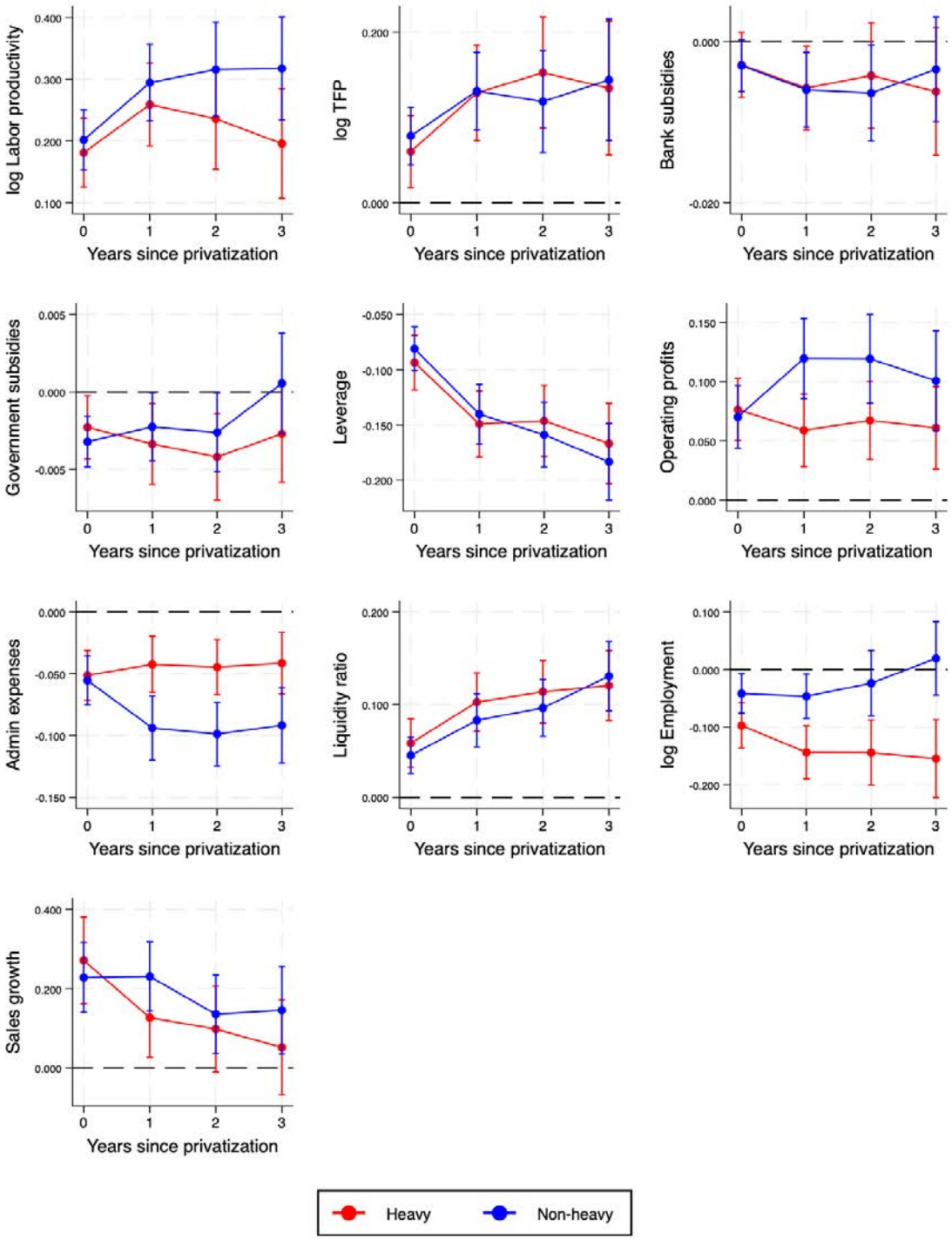

Figure 8: Effects of privatization in heavy versus light industries among zombie SOEs

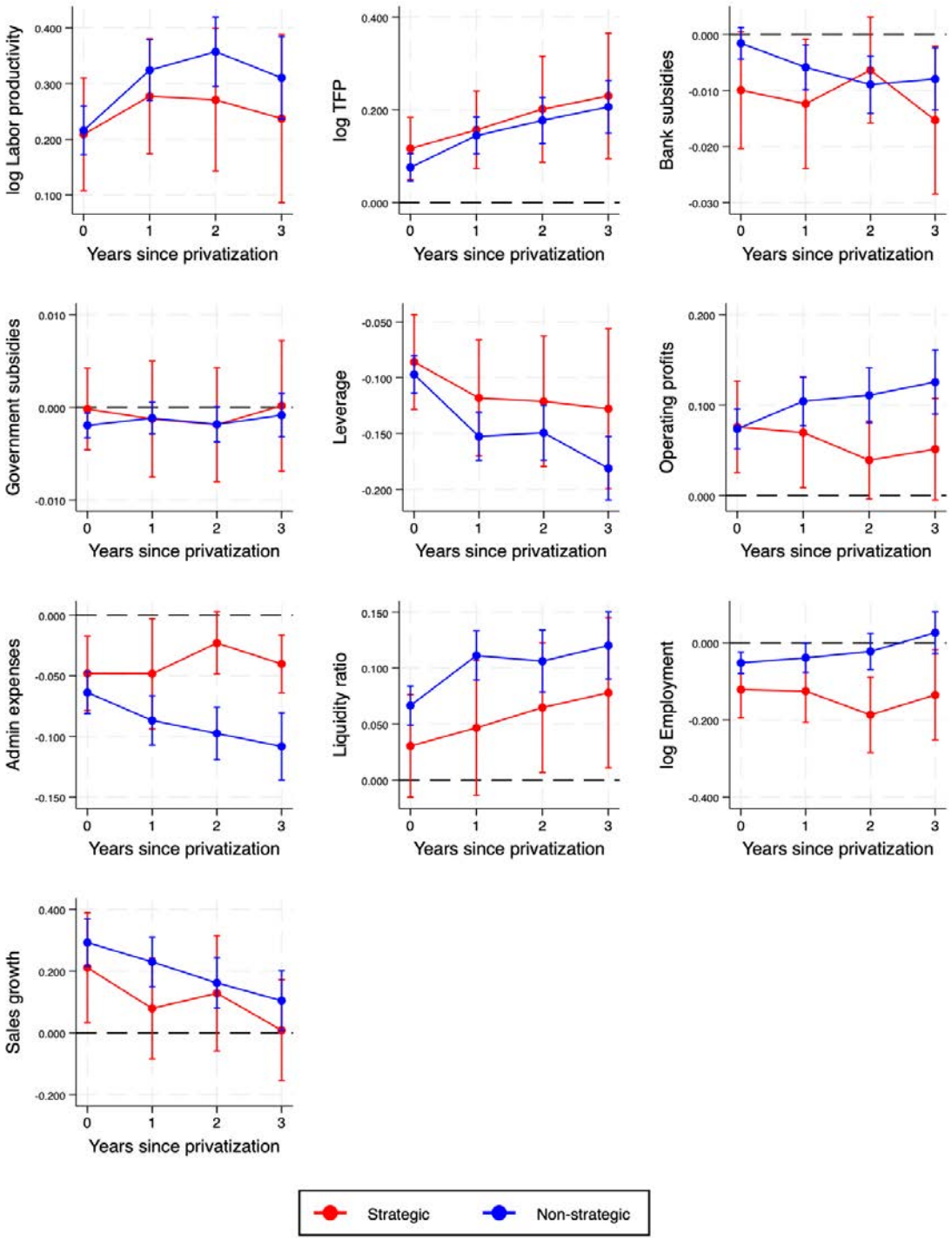

Figure 9: Effects of privatization in strategic versus non-strategic industries among zombie SOEs

Table 1: Comparison between healthy and zombie initial SOEs (1999-2008)

Variables	(1) Healthy	(2) ZB	(3) Diff
Operating profits	0.027	-0.184	0.211***
Net profits	0.019	-0.152	0.171***
Government subsidies	0.005	0.011	-0.006***
Interest rate paid	0.053	0.020	0.033***
Interest rate subsidies	-0.020	0.019	-0.039***
Leverage	0.575	0.806	-0.231***
Age	22.53	26.79	-4.253***
log TFP	2.196	1.786	0.410***
log Labor productivity	4.833	3.979	0.854***
log Output	10.36	9.376	0.981***
log Employment	5.520	5.393	0.127***
log Average wage	2.467	2.092	0.375***
log Capital intensity	4.298	4.194	0.104***
Liquidity ratio	0.026	-0.167	0.193***
Export status	0.201	0.133	0.068***
Fixed investment	0.078	0.054	0.024***
Observations	106567	88610	

Notes: This table compares the mean of firm fundamentals between zombie and healthy SOEs. "Healthy" stands for healthy firms, "ZB" stands for zombie firms, and "Diff" stands for difference. All variables are defined in Appendix Table D.1. "Capital intensity" is defined as the capital-labor ratio. Initial SOEs are firms that were originally state-owned in the sample during 1999-2008 (i.e., SOEs that appeared for the first time in the sample). In this table, we apply our criterion to classify zombie firms. Column (3) shows the difference in means of each variable between the two groups, and *** denotes statistical significance at the 1% level.

Table 2: Number of privatizations by year and region

Year	(1) # of privatized	(2) # of remaining SOEs	Region	(3) # of privatized	(4) # of initial SOEs
1999	2,885	50,541	Northeast	1,652	7,786
2000	2,255	44,153	Northern coast	2,859	12,200
2001	2,151	38,060	Eastern coast	3,144	8,738
2002	1,713	33,488	Southern coast	1,610	6,863
2003	1,736	27,715	Middle of Yellow River	2,015	8,624
2004	2,252	24,134	Middle of Yangtze River	2,648	11,320
2005	1,065	21,183	Southwest	1,714	9,335
2006	940	19,830	Northwest	756	4,156
2007	646	16,261			
2008	755	15,593			
Total	16,398		Total	16,398	69,022

Notes: This table shows the distribution of privatizations and SOEs by year and region. Columns (2) and (3) show the number of privatized SOEs and remaining SOEs in each year, while columns (4) and (5) show the number of privatized SOEs and initial SOEs in each region in China during 1999-2008. Provinces are categorized into eight regions based on the NBS as follows: *Northeast*: Heilongjiang, Jilin, and Liaoning; *Northern Coast*: Beijing, Tianjin, Hebei, and Shandong; *Eastern Coast*: Shanghai, Jiangsu, and Zhejiang; *Southern Coast*: Fujian, Guangdong, and Hainan; *Middle of Yellow River*: Shanxi, Inner Mongolia, Henan, and Shaanxi; *Middle of Yangtze River*: Anhui, Jiangxi, Hubei, and Hunan; *Southwest*: Guangxi, Chongqing, Sichuan, Guizhou, and Yunnan; *Northwest*: Tibet, Ningxia, Gansu, Qinghai, and Xinjiang.

Table 3: Number of privatizations and SOEs by year and zombie status in the previous year

	# of privatized (treated)		# of SOEs (controls)	
	Zombie status in $t-1$		Zombie status in $t-1$	
Year (t)	Zombie (1)	Healthy (2)	Zombie (3)	Healthy (4)
2000	631	657	15,082	8,599
2001	633	646	12,928	7,639
2002	513	422	11,162	6,856
2003	550	544	9,130	6,589
2004	469	585	6,433	6,061
2005	196	229	6,053	6,647
2006	209	363	5,733	7,428
2007	134	200	3,845	6,406
2008	131	244	3,011	6,258
Total	3,466	3,890	73,377	62,213

Notes: This table presents the yearly distribution of privatized SOEs (treated) and non-privatized SOEs (controls) with their zombie status in the preceding year. The privatization studied here excludes firms that reverted back to SOEs within three years after privatization. In our econometric method, each privatized SOE is matched with an SOE observation with the same zombie status in the previous year, i.e., column (2) matched with column (3), and column (2) matched with column (4).

Table 4: Effects of privatization on the efficiency of zombie and non-zombie SOEs prior to privatization

	(1) Privatization year	(2) 1 year after	(3) 2 years after	(4) 3 years after
Panel A. Zombie SOEs				
log Labor productivity	0.206***	0.275***	0.310***	0.272***
	(0.019)	(0.022)	(0.028)	(0.030)
Observations	6256	4737	3810	3178
log TFP	0.085***	0.135***	0.156***	0.166***
	(0.013)	(0.017)	(0.023)	(0.027)
Observations	5733	4058	3059	2362
Panel B. Healthy SOEs				
	(1) Privatization year	(2) 1 year after	(3) 2 years after	(4) 3 years after
log Labor productivity	0.050***	0.103***	0.113***	0.057**
	(0.012)	(0.016)	(0.020)	(0.024)
Observations	7898	6667	5813	5140
log TFP	0.017*	0.051***	0.073***	0.067***
	(0.010)	(0.014)	(0.017)	(0.022)
Observations	7019	5339	4230	3364

Notes: This table presents the estimated impacts of privatization on the efficiency of zombie SOEs (Panel A) and healthy SOEs (Panel B). Each privatized SOE is matched with a never-privatized SOE with the same pre-privatization zombie status, in the same two-digit industry, and in the same year. Each result is estimated from a separate regression, where the dependent variable is expressed as the difference between $t-1$ (i.e., the year prior to privatization) and year $t+s$ (the sth year after privatization, $s = 0, 1, 2, 3$). Standard errors using 500 bootstrap replications are reported in parentheses. Superscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5: Effects of privatization on a broad array of firms' financial indicators

	(1) Privatization year	(2) 1 year after	(3) 2 years after	(4) 3 years after
Panel A. Zombie SOEs				
Interest rate charged	0.002	0.004**	0.004**	0.006**
	(0.001)	(0.002)	(0.002)	(0.002)
Observations	6140	4633	3680	3067
Interest rate subsidies	−0.002	−0.005***	−0.006***	−0.008***
	(0.001)	(0.002)	(0.002)	(0.002)
Observations	6140	4633	3680	3067
Government subsidies	−0.002***	−0.001*	−0.003***	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	6277	4749	3830	3203
Leverage	−0.097***	−0.149***	−0.161***	−0.185***
	(0.007)	(0.010)	(0.012)	(0.013)
Observations	6333	4806	3869	3224
Operating profits	0.077***	0.093***	0.107***	0.098***
	(0.010)	(0.011)	(0.012)	(0.014)
Observations	6276	4752	3829	3200
Liquidity ratio	0.064***	0.100***	0.115***	0.139***
	(0.008)	(0.010)	(0.011)	(0.014)
Observations	6333	4806	3867	3218
Administrative expenses	−0.057***	−0.078***	−0.091***	−0.086***
	(0.007)	(0.008)	(0.009)	(0.010)
Observations	6276	4752	3831	3198
Panel B. Healthy SOEs				
	(1) Privatization year	(2) 1 year after	(3) 2 years after	(4) 3 years after
Interest rate charged	0.001	0.002	0.000	0.000
	(0.002)	(0.003)	(0.003)	(0.003)
Observations	7750	6559	5644	4964
Interest rate subsidies	−0.002	−0.005**	−0.001	−0.002
	(0.002)	(0.003)	(0.003)	(0.003)
Observations	7750	6559	5644	4964
Government subsidies	−0.001	−0.000	−0.001**	−0.000
	(0.000)	(0.001)	(0.001)	(0.001)
Observations	7906	6676	5862	5183
Leverage	−0.006	−0.021***	−0.038***	−0.039***
	(0.005)	(0.006)	(0.007)	(0.007)
Observations	7915	6691	5884	5199
Operating profits	0.025***	0.042***	0.047***	0.041***
	(0.005)	(0.005)	(0.006)	(0.006)
Observations	7896	6667	5871	5186
Liquidity ratio	0.010*	0.011	0.032***	0.032***
	(0.006)	(0.007)	(0.008)	(0.008)
Observations	7915	6691	5882	5192
Administrative expenses	−0.013***	−0.027***	−0.035***	−0.026***
	(0.003)	(0.004)	(0.004)	(0.004)
Observations	7896	6667	5870	5182

Notes: Standard errors using 500 bootstrap replications are reported in parentheses. Superscripts ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Table 6: Effects of privatization on sales growth, employment, and other firm fundamentals

	(1) Privatization year	(2) 1 year after	(3) 2 years after	(4) 3 years after
Panel A. Zombie SOEs				
log Employment	−0.077***	−0.084***	−0.099***	−0.098***
	(0.014)	(0.018)	(0.020)	(0.024)
Observations	6344	4814	3859	3206
log Average wage	0.013	0.005	0.024	0.048*
	(0.014)	(0.018)	(0.020)	(0.025)
Observations	6344	4814	3859	3206
Sales growth	0.260***	0.187***	0.132***	0.035
	(0.036)	(0.034)	(0.033)	(0.039)
Observations	6342	4787	3773	3122
Fixed investment	0.030***	0.036***	0.042***	0.019**
	(0.006)	(0.007)	(0.007)	(0.008)
Observations	6344	4813	3790	3130
Panel B. Healthy SOEs				
	(1) Privatization year	(2) 1 year after	(3) 2 years after	(4) 3 years after
log Employment	−0.045***	−0.060***	−0.038**	−0.017
	(0.009)	(0.012)	(0.015)	(0.018)
Observations	7923	6697	5840	5161
log Average wage	−0.021*	−0.028**	−0.061***	−0.108***
	(0.011)	(0.013)	(0.015)	(0.018)
Observations	7923	6697	5840	5161
Sales growth	0.030	0.087***	0.058**	0.031
	(0.023)	(0.024)	(0.026)	(0.026)
Observations	7920	6692	5771	5086
Fixed investment	0.030***	0.022***	0.023***	0.008
	(0.006)	(0.006)	(0.006)	(0.007)
Observations	7923	6697	5778	5089

Notes: This table presents the estimated impacts of privatization on sales growth, employment, wages, and investment of zombie SOEs (Panel A) and healthy SOEs (Panel B). Each privatized SOE is matched with a never-privatized SOE with the same pre-privatization zombie status, in the same two-digit industry, and in the same year. Each result is estimated from a separate regression, where the dependent variable is expressed as the difference between $t-1$ (i.e., the year prior to privatization) and year $t+s$ (the sth year after privatization, $s = 0, 1, 2, 3$). Standard errors using 500 bootstrap replications are reported in parentheses. Superscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 7: Effects of renationalization

	(1) Renationalization year	(2) 1 year after	(3) 2 years after	(4) 3 years after
log Labor productivity	−0.085***	−0.106***	−0.115***	−0.179***
	(0.019)	(0.023)	(0.029)	(0.036)
Observations	3997	3291	2756	2474
log TFP	−0.068***	−0.110***	−0.100***	−0.188***
	(0.015)	(0.022)	(0.031)	(0.042)
Observations	3372	2438	1625	1116
Interest rate subsidies	−0.002	0.003	0.001	0.007*
	(0.003)	(0.003)	(0.004)	(0.004)
Observations	3927	3236	2654	2353
Government subsidies	0.000	−0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	4002	3293	2789	2495
Leverage	0.020***	0.028***	0.047***	0.064***
	(0.007)	(0.009)	(0.010)	(0.012)
Observations	4013	3299	2793	2504
Operating profits	−0.034***	−0.036***	−0.029***	−0.031***
	(0.008)	(0.009)	(0.011)	(0.010)
Observations	3999	3294	2786	2498
Administrative expenses	0.017***	0.021***	0.027***	0.021***
	(0.005)	(0.006)	(0.008)	(0.006)
Observations	3999	3294	2788	2499
Liquidity ratio	−0.020**	−0.040***	−0.034***	−0.040***
	(0.008)	(0.010)	(0.012)	(0.014)
Observations	4013	3299	2787	2494
log Employment	0.000	0.018	0.007	0.028
	(0.013)	(0.016)	(0.024)	(0.029)
Observations	4022	3301	2766	2483
Sales growth	−0.097***	−0.114***	−0.108***	−0.171***
	(0.035)	(0.038)	(0.036)	(0.043)
Observations	4022	3297	2729	2423

Notes: This table shows the effect of renationalization, i.e., the reversal of privatization, on firms' financial and real variables. Each renationalized firm is matched with a privatized SOE in the same two-digit industry and the same year. Each result is estimated from a separate regression, where the dependent variable is expressed as the difference between $t-1$ (i.e., the year prior to privatization) and year $t+s$ (the sth year after renationalization, $s = 0, 1, 2, 3$). Standard errors using 500 bootstrap replications are reported in parentheses. Superscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Appendix A. Estimating the propensity score

To estimate the causal effect of privatization on zombie SOEs by PSM-DID, we first estimate the probability of being privatized using a logit selection model to obtain the propensity score, separately for zombie SOEs and non-zombie SOEs in the pre-privatization period. We believe that observable characteristics serve as a good starting point since private acquirers rely heavily on the basic firm-level observable information to screen the potential target SOEs. The estimation results of the logit selection models for SOEs are presented in Table A.1 (the first two columns for the zombie SOEs and the last two for the non-zombie SOEs). As shown in Table A.1, the coefficients on interest rate and government subsidies are negative and statistically significant, suggesting that hardening budget constraints facilitates SOE privatization (consistent with Guo and Yao (2005) and Tong (2009)). Similarly, SOEs with slower debt growth rates are more likely to be privatized. Leverage and squared leverage display an inverse U-shaped relationship with privatization, as do log employment and log squared employment. This aligns with the inverse U-shaped relationship found by Hsieh and Song (2015). In contrast, the U-shaped relationship between age and privatization indicates that middle-aged SOEs are more likely to undergo privatization.

The results also suggest that SOEs exporting to foreign markets, operating on a larger scale, and those investing more in fixed assets (specifically within the zombie subsample) have a significantly higher probability of being privatized. Notably, operating profits, TFP, and TFP growth are not statistically significant determinants of privatization, suggesting that debt and subsidies play a more dominant role. As expected, SOEs affiliated with lower-level governments or unaffiliated SOEs are more likely to be privatized than those affiliated with central or provincial governments, as the latter are often larger firms in strategic sectors. Finally, among macroeconomic variables, SOEs operating in more developed cities and more concentrated industries are less likely to be privatized. Importantly, our evidence indicates that the government did not prioritize TFP (either in levels or growth) or profits in privatization decisions, suggesting that selection bias related to unobservable firm "quality" factors should not significantly affect our results.

Table A.1: The Logit model for the propensity score: zombie versus healthy SOE

	Pre-privatization: Zombies		Pre-privatization: Non-zombies	
	Coef		SE	
Operating profits	0.169**	(0.072)	0.048	(0.115)
Bank subsidies	−2.721***	(0.670)	−0.935***	(0.247)
Government subsidies	−2.459***	(0.812)	−2.405**	(1.112)
Age	−0.085***	(0.006)	−0.047***	(0.005)
Age^2	0.001***	(0.000)	0.000***	(0.000)
log Employment	1.702***	(0.144)	1.739***	(0.120)
log Employment^2	−0.099***	(0.019)	−0.040***	(0.015)
Leverage	1.189***	(0.217)	1.025***	(0.207)
Leverage^2	−0.463***	(0.102)	−0.538***	(0.125)
Liquidity ratio	0.091	(0.085)	−0.321***	(0.097)
log Real capital intensity	−0.157***	(0.037)	−0.126***	(0.033)
log Real capital intensity × Age	−0.000	(0.001)	0.003***	(0.001)
log Real wage	−0.187***	(0.055)	0.086*	(0.049)
log Real wage × Age	0.011***	(0.002)	−0.002	(0.002)
Export status	0.147**	(0.063)	0.390***	(0.052)
log Output	0.837***	(0.098)	0.952***	(0.083)
log Output × log Employment	−0.087***	(0.016)	−0.139***	(0.013)
Fixed investment rate	0.378**	(0.149)	0.122	(0.123)
log TFP	−0.171**	(0.075)	−0.012	(0.072)
Debt growth	−0.529***	(0.087)	−0.181**	(0.072)
TFP growth	−0.010	(0.051)	0.008	(0.048)
log GDP pc	−0.198***	(0.044)	−0.237***	(0.041)
GDP growth	1.112**	(0.535)	1.178**	(0.543)
HHI	−11.061***	(2.340)	−8.879***	(2.025)
Medium-level Affiliation	1.494***	(0.072)	1.442***	(0.057)
Low-level Affiliation	2.359***	(0.200)	2.178***	(0.134)
No Affiliation	1.405***	(0.132)	1.184***	(0.092)
Constant	−10.154***	(0.739)	−11.281***	(0.662)
Observations	61258		60124	
Pseudo R^2	0.19		0.20	

Notes: This table shows the results of the logit selection model for zombie SOEs with a dummy indicating privatization as the dependent variable. Province dummies are also included in the model but not reported for brevity. All the independent variables are lagged one year relative to the dependent variable. Employment, average wage, capital intensity, TFP and GDP per capita are in logarithms. Profits and government subsidies are scaled by sales and output, respectively. ***, ** and * denote significance levels at the 1%, 5% and 10%, respectively.

Appendix B. Heterogeneity

B.1 By types of ownership

The survey of the privatization literature by Estrin et al. (2009) finds that the effects of privatization vary considerably depending on the countries, the types of owners to whom the control is given (e.g., insiders vs. outsiders, domestic vs. foreign) as well as the concentration of private ownership, among others. They generally find privatization to outsider, rather than insider, owners has significant performance effects and the effect of privatization to foreign owners is larger than that to domestic owners. Due to data limitations, we are unable to distinguish between outsider and insider owners. Besides, because of the strict restrictions on foreign capitals during the sample period, the number of privatization to foreign owners is very small, making it infeasible to differentiate the privatizations to foreign owners from those to domestic owners. However, in our data, a nonnegligible proportion of SOEs have been taken over by collective owners. Theoretically, collective firms certainly differ from private firms in that the former involves the community government, in a sense similar to SOEs (Perotti, Sun, and Zou 1999). However, collective ownership proves to be very successful in boosting efficiency and growth, and as a result, township and village enterprises (TVEs), the primary form of collective firms, are found to outperform SOEs by a large margin (Dong and Putterman 1997; Perotti, Sun, and Zou 1999; Fu and Balasubramanyam 2003). In this part, we try to examine whether the effects of privatization we investigated above exhibit significant heterogeneity depending on the types of post-privatization owners. In this section, we only focus on the privatization of previously zombie SOEs.

The estimated effects of privatization on selected outcomes to private owners and to collective owners for former zombie SOEs are presented together in Figure B.1. Our results suggest that, overall, zombie SOEs experience larger gains from pure privatization than from collectivization. For example, the labor productivity of privatized SOEs increases by around 40 percent in the first and second years after privatization, while the increase is only about 15 percent for collectivized SOEs, though the gap has been largely closed by the third year. Besides, pure privatization appears to be more effective in reducing administrative expenses and enhancing liquidity than collectivization, and the gap does not narrow down by the third year. Moreover, privatization is found to significantly reduce interest rate subsidies and government subsidies whereas collectivization appears to exert little impact on the soft budget constraints of SOEs. As TVEs are under the *de facto* control of the community government, it's not difficult to imagine that they can still get easy access to subsidies from their local governments and banks. Finally, while private owners have engaged in significant labor shedding, this is not the case for collective owners, reflecting the incentive of the community government to maintain employment (Perotti, Sun, and Zou 1999).

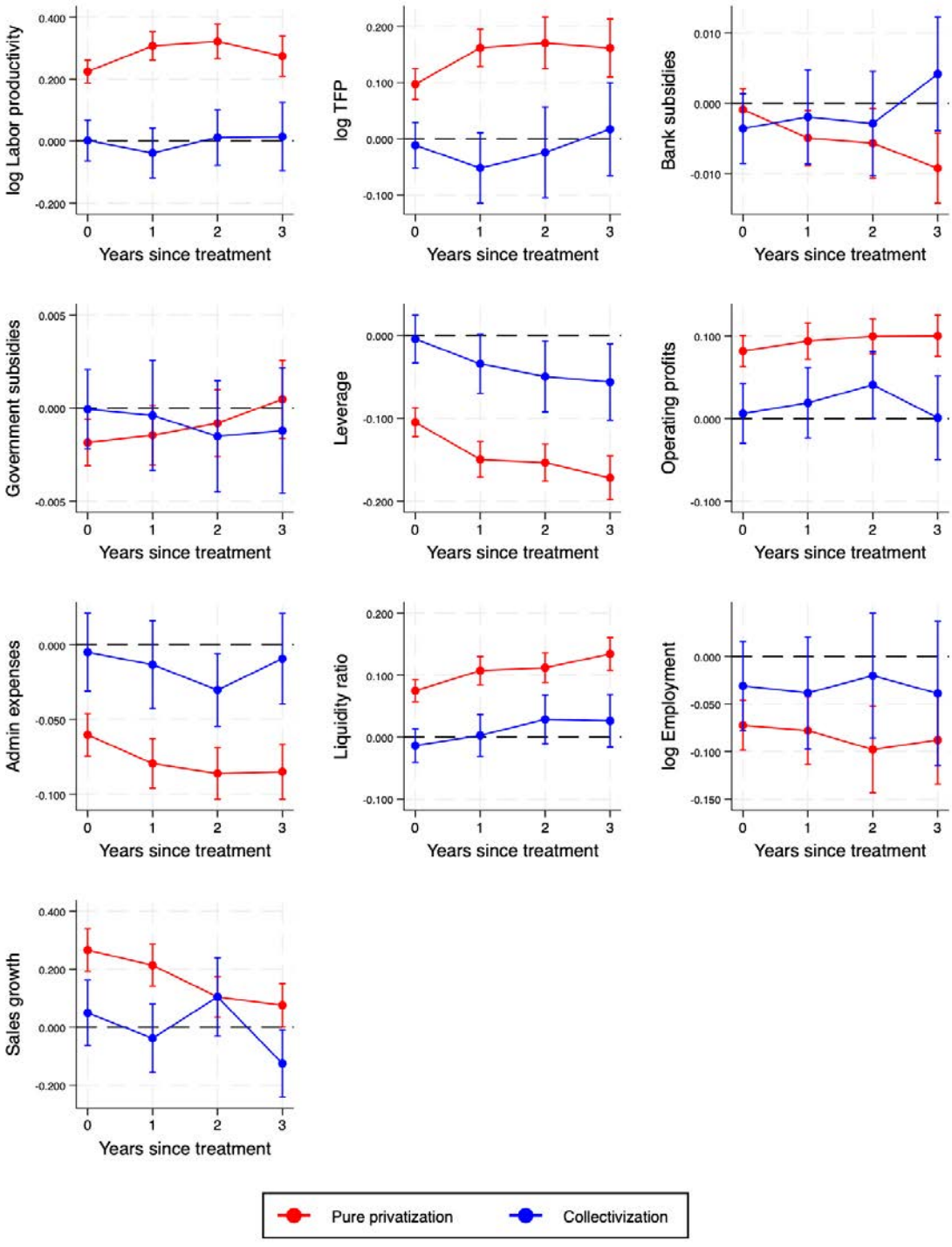

Figure B.1: Effects of pure private vs collective ownership

Appendix C. Using the "actual profits" criterion to identify zombies

On top of the standard approach, we propose a modified approach that fits the Chinese setting as detailed above, which explicitly focuses on firms' profitability while at the same time taking into account subsidies granted by both governments and banks. The *actual profit* is defined as a firm's net profits after subtracting both government subsidies and interest rate subsidies. We then smooth the above actual profit by calculating its moving sum up to the current year as in Eq. (C.1) below, a negative value of which indicates bad real performance, thus very probably a zombie.

$$\sum_{j=0}^{T} Actual\,profit_{i,t-j} = \sum_{j=0}^{T} Net\,profit_{i,t-j} - (Gov.\,Sub_{i,t-j} + Bank\,Sub_{i,t-j}) < 0, \qquad \text{(C.1)}$$

where where $R^*_{i,t}$ and $R_{i,t}$ are defined in the same way as in the main text. In our condition (C.1), the government subsidy, as a part of the non-operating profit, is subtracted to exclude the financial support provided by the government. Importantly, for zombie firms whose interest rate subsidies are generally positive by construction, the deduction of these interest rate subsidies from net profits in Eq. (C.1) amounts to increasing the financial expenses by the amount that falls short of the hypothetical minimum so that each firm's debt is subject to the same risk-free lending rates. We let T be 1 to preserve more observations identifiable using this method. That is to say, firms with a negative sum of the current year and last year's actual profits are identified as zombies in the current year. The conclusions of this paper remain unaffected if we assign a value of 2 to T, i.e., a 3-year moving sum.

Table C.1 and C.2 show the results using the "actual profits" approach and those using a combined approach where an SOE is classified as a zombie if either the standard approach or "actual profits" approach identifies it as a zombie. As shown in these two tables, our results are robust to using these alternative definitions.

Table C.1: Robustness checks: using the actual profit criterion to identify zombies

	(1) Privatization year	(2) 1 year after	(3) 2 years after	(4) 3 years after
log Labor productivity	0.190***	0.300***	0.293***	0.209***
	(0.019)	(0.024)	(0.028)	(0.033)
Observations	5648	4391	3580	2953
log TFP	0.073***	0.157***	0.153***	0.112***
	(0.014)	(0.019)	(0.024)	(0.029)
Observations	5041	3462	2558	1926
Interest rate subsidies	−0.001	−0.006***	−0.006**	−0.003
	(0.002)	(0.002)	(0.003)	(0.003)
Observations	5565	4324	3487	2876
Government subsidies	−0.002***	−0.002**	−0.003***	−0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	5668	4402	3612	2998
Leverage	−0.087***	−0.135***	−0.158***	−0.169***
	(0.009)	(0.011)	(0.012)	(0.014)
Observations	5713	4432	3630	3008
Operating profits	0.085***	0.101***	0.107***	0.112***
	(0.009)	(0.011)	(0.012)	(0.013)
Observations	5662	4397	3608	2996
Administrative expenses	−0.063***	−0.073***	−0.073***	−0.085***
	(0.007)	(0.008)	(0.008)	(0.010)
Observations	5662	4397	3610	2996
Liquidity ratio	0.074***	0.103***	0.121***	0.131***
	(0.009)	(0.011)	(0.012)	(0.014)
Observations	5713	4432	3629	2998
log Employment	−0.096***	−0.131***	−0.131***	−0.104***
	(0.013)	(0.016)	(0.020)	(0.025)
Observations	5716	4438	3609	2976
Sales growth	0.241***	0.198***	0.054*	0.049
	(0.037)	(0.034)	(0.033)	(0.036)
Observations	5715	4427	3552	2930

Notes: This table shows the effect of privatization on selected outcomes using PSM-DID for zombie SOEs where a firm is classified as a zombie if it is identified as a zombie by the actual profit criterion. Each privatized SOE is matched with a never privatized SOE with the same pre-privatization zombie status in the same two-digit industry and year based on the propensity score estimated using the lagged values of (logged if appropriate) variables in Table A.1. Each cell represents a separate regression where the dependent variable is expressed as the difference between $t-1$ (i.e., the year prior to privatization) and year $t+s$ (the sth year after privatization, $s = 0, 1, 2, 3$). Bootstrapped standard errors using 500 replications are listed in parentheses. ***, ** and * denote significance levels at the 1%, 5% and 10%, respectively.

Table C.2: Robustness checks: using a combined approach to identify zombies

	(1) Privatization year	(2) 1 year after	(3) 2 years after	(4) 3 years after
log Labor productivity	0.188***	0.282***	0.276***	0.240***
	(0.017)	(0.021)	(0.024)	(0.028)
Observations	7869	6062	4963	4146
log TFP	0.072***	0.141***	0.153***	0.157***
	(0.012)	(0.016)	(0.019)	(0.024)
Observations	7148	5038	3789	2886
Interest rate subsidies	−0.001	−0.005***	−0.007***	−0.007***
	(0.001)	(0.002)	(0.002)	(0.002)
Observations	7716	5958	4805	4027
Government subsidies	−0.002***	−0.001	−0.002**	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	7887	6071	4989	4194
Leverage	−0.086***	−0.131***	−0.152***	−0.157***
	(0.007)	(0.009)	(0.010)	(0.012)
Observations	7941	6132	5032	4225
Operating profits	0.071***	0.097***	0.102***	0.096***
	(0.009)	(0.010)	(0.011)	(0.011)
Observations	7876	6081	5003	4200
Administrative expenses	−0.048***	−0.069***	−0.069***	−0.078***
	(0.006)	(0.007)	(0.008)	(0.008)
Observations	7876	6081	5004	4198
Liquidity ratio	0.062***	0.099***	0.119***	0.127***
	(0.007)	(0.009)	(0.010)	(0.011)
Observations	7941	6132	5030	4217
log Employment	−0.104***	−0.132***	−0.124***	−0.107***
	(0.012)	(0.015)	(0.018)	(0.021)
Observations	7956	6137	5019	4183
Sales growth	0.220***	0.167***	0.094***	0.082***
	(0.030)	(0.031)	(0.028)	(0.032)
Observations	7954	6113	4920	4105

Notes: This table shows the effect of privatization on selected outcomes using PSM-DID for zombie SOEs where a firm is classified as a zombie if it is identified as a zombie by either of the two criteria. Each privatized SOE is matched with a never privatized SOE with the same pre-privatization zombie status in the same two-digit industry and year based on the propensity score estimated using the lagged values of (logged if appropriate) variables in Table A.1. Each cell represents a separate regression where the dependent variable is expressed as the difference between $t-1$ (i.e., the year prior to privatization) and year $t+s$ (the sth year after privatization, $s = 0, 1, 2, 3$). Bootstrapped standard errors using 500 replications are listed in parentheses. ***, ** and * denote significance levels at the 1%, 5% and 10%, respectively.

Appendix D. Complementary Figures and Tables (not for publication)

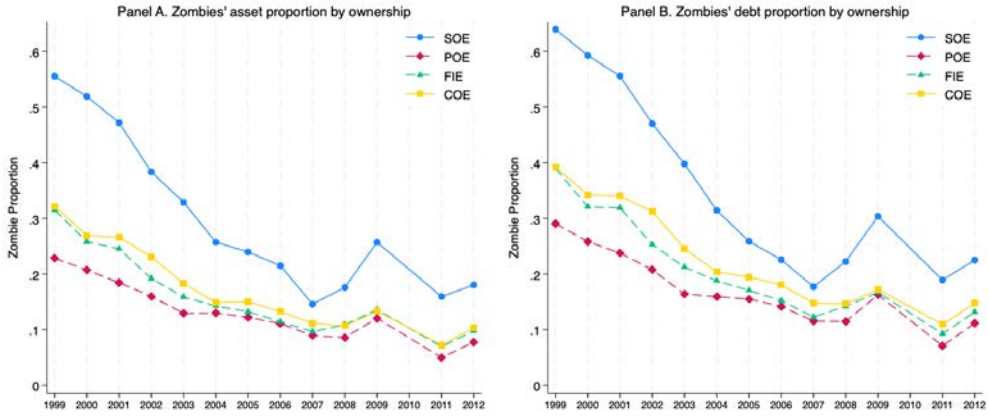

Figure D.1: Time trends of zombies' proportion by ownership

Note: Calculated by the authors using the ASIF dataset.

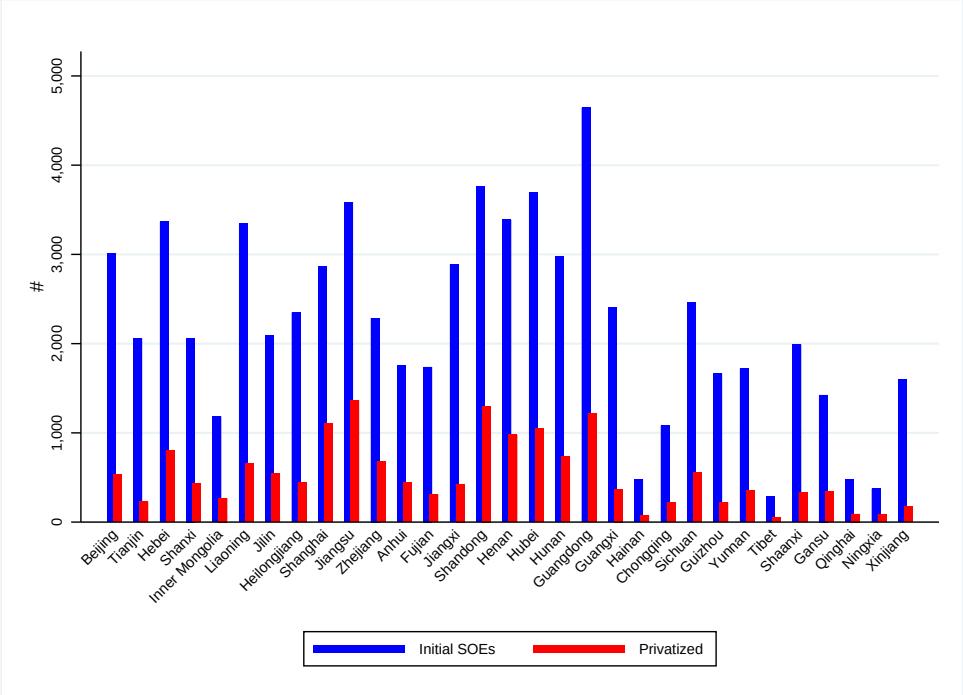

Figure D.2: Number of privatization and initial SOEs during 1999-2008 across provinces

Note: Calculated by the authors using the ASIF dataset.

Table D.1: Definition and summary statistics of key variables

Variable	Definition	Mean	SD	Min	p50	Max
log TFP	Logarith of total factor productivity using the ACF method	2.017	1.413	-1.342	2.323	4.576
log Labor productivity	Logarithm of real output per worker	4.550	1.440	0.857	4.532	8.389
log Output	Logarithm of real output	9.878	2.067	4.919	9.867	15.19
Operating profits	Operating profits scaled by sales	-0.112	0.486	-3.412	0.002	0.414
Net profits	Net profits scaled by sales	-0.101	0.454	-3.219	0.003	0.385
Government subsidies	Government subsidies scaled by output	0.008	0.029	0	0	0.207
Interest rate paid	Interest payments scaled by lagged debt	0.041	0.076	-0.256	0.028	0.541
Interest rate subsidies	$R^*_{i,t} - R_{i,t}$ scaled by lagged debt	-0.007	0.077	-0.510	0.005	0.283
Admin expenses	Administrative expenses divided by sales	0.212	0.371	0	0.112	2.759
Leverage	Total liability divided by total assets	0.687	0.361	0.027	0.672	2.066
Sales growths	Sales growth rates	0.196	0.874	-0.993	0.058	5.899
Age	Current year minus the year the firm opened	23.56	17.78	0	18.92	87.25
log Employment	Logarithm of the number of employees	5.291	1.370	2.485	5.247	8.942
log Average wage	Logarithm of average real wages	2.384	0.863	0.054	2.365	4.991
log Capital intensity	Logarithm of capital-labor ratio	4.335	1.323	1.010	4.260	8.468
Liquidity ratio	Difference between current assets and current liability scaled by total assets	-0.072	0.359	-1.386	-0.027	0.711
Export status	A dummy indicating whether the firm exports in that year	0.150	0.357	0	0	1
Fixed investment	Investment in fixed assets scaled by lagged total assets	0.071	0.192	-0.01	0.004	1.349

Table D.2: Balance test of the covariates

		Pre-privatization: Zombie SOEs				Pre-privatization: Non-Zombie SOEs			
		Mean				Mean			
Variable	Sample	Treated	Control	% Bias	p	Treated	Control	% Bias	p
Operating profits	Unmatched	-0.127	-0.199	18.20	0.000	0.023	0.018	2.500	0.171
	Matched	-0.136	-0.122	-3.500	0.201	0.022	0.025	-1.200	0.563
Interest rate subsidies	Unmatched	0.018	0.020	-6.600	0.005	-0.021	-0.016	-7.800	0.000
	Matched	0.018	0.018	2.200	0.537	-0.020	-0.020	0.100	0.966
Government subsidies	Unmatched	0.007	0.014	-19.80	0.000	0.003	0.005	-10.20	0.000
	Matched	0.008	0.007	2.700	0.306	0.004	0.004	-0.500	0.806
Age	Unmatched	23.53	30.54	-40.20	0.000	19.14	26.08	-39.80	0.000
	Matched	24.83	24.78	0.300	0.941	19.80	19.40	2.300	0.313
log Employment	Unmatched	5.449	5.434	1.200	0.649	5.457	5.571	-8.400	0.000
	Matched	5.455	5.467	-1.000	0.751	5.464	5.442	1.700	0.419
Leverage	Unmatched	0.872	0.811	17.10	0.000	0.646	0.559	31.00	0.000
	Matched	0.871	0.866	1.600	0.638	0.641	0.636	1.700	0.446
Debt growth	Unmatched	0.001	0.042	-14.60	0.000	0.070	0.072	-0.900	0.574
	Matched	0.010	0.013	-1.100	0.747	0.067	0.062	1.800	0.425
log TFP	Unmatched	2.279	1.540	59.60	0.000	2.741	1.800	68.80	0.000
	Matched	2.238	2.251	-1.000	0.718	2.719	2.697	1.600	0.389
TFP growth	Unmatched	-0.052	-0.053	0.300	0.891	0.025	-0.003	7.300	0.000
	Matched	-0.059	-0.050	-2.100	0.563	0.022	0.016	1.500	0.536
Liquidity ratio	Unmatched	-0.198	-0.175	-6.600	0.006	-0.016	0.023	-13.70	0.000
	Matched	-0.204	-0.194	-2.800	0.421	-0.016	-0.009	-2.200	0.364
log Capital intensity	Unmatched	4.087	4.278	-18.20	0.000	4.063	4.408	-29.70	0.000
	Matched	4.102	4.081	1.900	0.570	4.085	4.072	1.100	0.623
log Average wage	Unmatched	2.090	2.176	-12.50	0.000	2.381	2.536	-22.20	0.000
	Matched	2.082	2.065	2.400	0.480	2.381	2.367	2.000	0.394
Export status	Unmatched	0.162	0.116	13.30	0.000	0.235	0.154	20.50	0.000
	Matched	0.148	0.161	-3.600	0.322	0.223	0.229	-1.400	0.557
log Output	Unmatched	9.686	9.361	20.00	0.000	10.40	10.31	4.900	0.010
	Matched	9.636	9.665	-1.800	0.545	10.377	10.32	3.000	0.118
Fixed investment	Unmatched	0.040	0.053	-8.800	0.001	0.064	0.076	-6.900	0.000
	Matched	0.041	0.042	-0.700	0.832	0.063	0.065	-1.200	0.576
log GDP pc	Unmatched	9.199	9.144	7.400	0.002	9.365	9.338	3.600	0.028
	Matched	9.176	9.191	-2.000	0.546	9.360	9.357	0.300	0.892
GDP growth	Unmatched	0.113	0.113	-0.900	0.723	0.114	0.118	-8.800	0.000
	Matched	0.112	0.113	-2.800	0.431	0.114	0.113	1.300	0.577
HHI	Unmatched	0.010	0.012	-15.20	0.000	0.011	0.014	-23.40	0.000
	Matched	0.010	0.010	-2.900	0.460	0.011	0.011	-0.400	0.828

Notes: This table examines the balancing property of covariates both before and after matching. Columns 5 and 9 report the standardized bias, defined as the difference in means between the two groups divided by the square root of the sum of the variances(multiplied by 100%). Columns 6 and 10 report the p value of the difference in mean.

Table D.3: Robustness checks: using a balanced panel of former zombie SOEs

	(1) Privatization year	(2) 1 year after	(3) 2 years after	(4) 3 years after
log Labor productivity	0.164***	0.214***	0.292***	0.298***
	(0.032)	(0.036)	(0.039)	(0.045)
Observations	1563	1563	1563	1563
log TFP	0.013	0.054	0.087**	0.097**
	(0.027)	(0.033)	(0.038)	(0.045)
Observations	864	864	864	864
Interest rate subsidies	−0.005*	−0.009***	−0.008**	−0.010***
	(0.002)	(0.003)	(0.003)	(0.003)
Observations	1463	1463	1463	1463
Government subsidies	−0.001	−0.002	−0.001	0.001
	(0.001)	(0.002)	(0.001)	(0.002)
Observations	1573	1573	1573	1573
Leverage	−0.104***	−0.149***	−0.179***	−0.177***
	(0.014)	(0.016)	(0.017)	(0.019)
Observations	1566	1566	1566	1566
Operating profits	0.065***	0.080***	0.101***	0.095***
	(0.013)	(0.016)	(0.017)	(0.018)
Observations	1559	1559	1559	1559
Administrative expenses	−0.064***	−0.070***	−0.086***	−0.099***
	(0.010)	(0.012)	(0.012)	(0.014)
Observations	1577	1577	1577	1577
Liquidity ratio	0.066***	0.097***	0.117***	0.125***
	(0.014)	(0.016)	(0.018)	(0.019)
Observations	1591	1591	1591	1591
log Employment	−0.055**	−0.048*	−0.032	−0.004
	(0.022)	(0.025)	(0.030)	(0.034)
Observations	1549	1549	1549	1549
Sales growth	0.338***	0.166***	0.160***	0.083
	(0.068)	(0.053)	(0.051)	(0.052)
Observations	1594	1594	1594	1594

Notes: This table shows the effect of privatization on selected key outcomes using PSM-DID on a balanced panel of former zombie SOEs. Each privatized SOE is matched with a never privatized SOE with the same pre-privatization zombie status in the same two-digit industry and year based on the propensity score estimated using the lagged values of (logged if appropriate) variables in Table A.1. Each cell represents a separate regression where the dependent variable is expressed as the difference between $t-1$ (i.e., the year prior to privatization) and year $t+s$ (the sth year after privatization, $s=0,1,2,3$). Bootstrapped standard errors are listed in parentheses. ***, ** and * denote significance levels at the 1%, 5% and 10%, respectively.

Table D.4: Robustness checks: using a 30% cutoff in state shares to identify SOEs

	(1) Privatization year	(2) 1 year after	(3) 2 years after	(4) 3 years after
log Labor productivity	0.218***	0.316***	0.310***	0.200***
	(0.023)	(0.031)	(0.036)	(0.038)
Observations	3920	2927	2351	1939
log TFP	0.094***	0.171***	0.188***	0.157***
	(0.016)	(0.024)	(0.029)	(0.034)
Observations	3515	2370	1739	1332
Interest rate subsidies	−0.003**	−0.009***	−0.009***	−0.007**
	(0.002)	(0.002)	(0.003)	(0.003)
Observations	3882	2879	2270	1879
Government subsidies	−0.002**	−0.001	−0.002	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	3942	2936	2362	1966
Leverage	−0.119***	−0.164***	−0.191***	−0.207***
	(0.010)	(0.013)	(0.015)	(0.018)
Observations	3974	2965	2379	1972
Operating profits	0.101***	0.110***	0.119***	0.103***
	(0.011)	(0.014)	(0.014)	(0.016)
Observations	3925	2931	2359	1961
Administrative expenses	−0.074***	−0.087***	−0.083***	−0.086***
	(0.009)	(0.011)	(0.012)	(0.012)
Observations	3925	2931	2361	1961
Liquidity ratio	0.087***	0.117***	0.135***	0.142***
	(0.010)	(0.013)	(0.014)	(0.017)
Observations	3974	2965	2378	1969
log Employment	−0.079***	−0.074***	−0.102***	−0.056*
	(0.016)	(0.021)	(0.025)	(0.030)
Observations	3981	2969	2376	1953
Sales growth	0.299***	0.166***	0.037	0.078*
	(0.045)	(0.042)	(0.038)	(0.040)
Observations	3980	2952	2319	1911

Notes: This table shows the effect of privatization on selected key outcomes using PSM-DID for zombie SOEs where the cutoff in state shares for SOEs is set at 30%. Each privatized SOE is matched with a never privatized SOE with the same pre-privatization zombie status in the same two-digit industry and year based on the propensity score estimated using the lagged values of (logged if appropriate) variables in Table A.1. Each cell represents a separate regression where the dependent variable is expressed as the difference between $t-1$ (i.e., the year prior to privatization) and year $t+s$ (the sth year after privatization, $s = 0, 1, 2, 3$). Bootstrapped standard errors using 500 replications are listed in parentheses. ***, ** and * denote significance levels at the 1%, 5% and 10%, respectively.

Table D.5: Robustness checks: dropping all the privatized SOEs that reverted to SOEs

	(1) Privatization year	(2) 1 year after	(3) 2 years after	(4) 3 years after
log Labor productivity	0.240***	0.335***	0.333***	0.244***
	(0.022)	(0.030)	(0.037)	(0.042)
Observations	3719	2812	2256	1888
log TFP	0.106***	0.175***	0.157***	0.136***
	(0.017)	(0.024)	(0.031)	(0.034)
Observations	3358	2276	1670	1311
Interest rate subsidies	−0.002	−0.007***	−0.007**	−0.010***
	(0.002)	(0.002)	(0.003)	(0.003)
Observations	3681	2761	2190	1828
Government subsidies	−0.001	−0.003**	−0.003**	−0.001
	(0.001)	(0.001)	(0.001)	(0.002)
Observations	3740	2820	2269	1902
Leverage	−0.109***	−0.161***	−0.186***	−0.198***
	(0.011)	(0.013)	(0.014)	(0.017)
Observations	3781	2844	2286	1912
Operating profits	0.106***	0.109***	0.127***	0.114***
	(0.012)	(0.016)	(0.016)	(0.016)
Observations	3730	2819	2269	1900
Administrative expenses	−0.081***	−0.088***	−0.092***	−0.084***
	(0.009)	(0.012)	(0.012)	(0.012)
Observations	3730	2819	2270	1899
Liquidity ratio	0.078***	0.111***	0.115***	0.129***
	(0.010)	(0.013)	(0.015)	(0.017)
Observations	3781	2844	2285	1909
log Employment	−0.098***	−0.100***	−0.101***	−0.070**
	(0.018)	(0.022)	(0.026)	(0.030)
Observations	3784	2847	2279	1901
Sales growth	0.316***	0.161***	0.121***	0.054
	(0.046)	(0.042)	(0.042)	(0.040)
Observations	3782	2831	2239	1851

Notes: This table shows the effect of privatization on selected key outcomes using PSM-DID for zombie SOEs with all the privatized SOEs that reverted to SOEs dropped. Each privatized SOE is matched with a never privatized SOE with the same pre-privatization zombie status in the same two-digit industry and year based on the propensity score estimated using the lagged values of (logged if appropriate) variables in Table A.1. Each cell represents a separate regression where the dependent variable is expressed as the difference between $t-1$ (i.e., the year prior to privatization) and year $t+s$ (the sth year after privatization, $s = 0, 1, 2, 3$). Bootstrapped standard errors using 500 replications are listed in parentheses. ***, ** and * denote significance levels at the 1%, 5% and 10%, respectively.

Table D.6: Robustness checks: using one-to-three nearest neighbor matching on former zombie SOEs

	(1) Privatization year	(2) 1 year after	(3) 2 years after	(4) 3 years after
log Labor productivity	0.251***	0.362***	0.368***	0.300***
	(0.021)	(0.028)	(0.032)	(0.034)
Observations	5802	4303	3322	2688
log TFP	0.110***	0.181***	0.173***	0.170***
	(0.016)	(0.022)	(0.027)	(0.030)
Observations	5176	3478	2490	1837
Interest rate subsidies	−0.004***	−0.009***	−0.007***	−0.011***
	(0.001)	(0.002)	(0.003)	(0.003)
Observations	5771	4246	3238	2601
Government subsidies	−0.002**	−0.002*	−0.003***	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	5834	4316	3347	2713
Leverage	−0.118***	−0.171***	−0.199***	−0.210***
	(0.010)	(0.012)	(0.014)	(0.016)
Observations	5908	4362	3374	2725
Operating profits	0.100***	0.117***	0.129***	0.103***
	(0.011)	(0.013)	(0.015)	(0.016)
Observations	5824	4307	3352	2711
Administrative expenses	−0.076***	−0.093***	−0.096***	−0.086***
	(0.009)	(0.010)	(0.010)	(0.012)
Observations	5824	4307	3353	2710
Liquidity ratio	0.085***	0.112***	0.125***	0.137***
	(0.010)	(0.012)	(0.015)	(0.015)
Observations	5908	4362	3371	2719
log Employment	−0.068***	−0.073***	−0.077***	−0.054*
	(0.015)	(0.020)	(0.024)	(0.028)
Observations	5918	4370	3365	2707
Sales growth	0.321***	0.224***	0.147***	0.095**
	(0.040)	(0.037)	(0.037)	(0.040)
Observations	5917	4340	3305	2641

Notes: This table shows the effect of privatization on selected key outcomes using PSM-DID with one-to-three nearest neighbor matching on former zombie SOEs. Each privatized SOE is matched with a never privatized SOE with the same pre-privatization zombie status in the same two-digit industry and year based on the propensity score estimated using the lagged values of (logged if appropriate) variables in Table A.1. Each cell represents a separate regression where the dependent variable is expressed as the difference between $t-1$ (i.e., the year prior to privatization) and year $t+s$ (the sth year after privatization, $s = 0, 1, 2, 3$). Bootstrapped standard errors using 500 replications are listed in parentheses. ***, ** and * denote significance levels at the 1%, 5% and 10%, respectively.

Table D.7: Robustness checks: using kernel matching on former zombie SOEs

	(1) Privatization year	(2) 1 year after	(3) 2 years after	(4) 3 years after
log Labor productivity	0.240***	0.336***	0.364***	0.317***
	(0.021)	(0.025)	(0.028)	(0.032)
Observations	36808	29123	23105	18637
log TFP	0.098***	0.179***	0.204***	0.199***
	(0.015)	(0.019)	(0.023)	(0.027)
Observations	32907	23654	17222	12283
Interest rate subsidies	−0.004**	−0.009***	−0.009***	−0.011***
	(0.002)	(0.002)	(0.003)	(0.003)
Observations	36655	29063	22855	18394
Government subsidies	−0.001**	−0.002**	−0.002**	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	36929	29256	23345	18889
Leverage	−0.119***	−0.175***	−0.193***	−0.209***
	(0.009)	(0.012)	(0.014)	(0.014)
Observations	37398	29743	23716	19142
Operating profits	0.093***	0.111***	0.118***	0.102***
	(0.009)	(0.012)	(0.011)	(0.012)
Observations	36938	29318	23382	18871
Administrative expenses	−0.076***	−0.092***	−0.096***	−0.095***
	(0.007)	(0.008)	(0.008)	(0.008)
Observations	36938	29318	23378	18859
Liquidity ratio	0.084***	0.119***	0.124***	0.136***
	(0.010)	(0.012)	(0.013)	(0.014)
Observations	37398	29743	23709	19112
log Employment	−0.063***	−0.059***	−0.053**	−0.002
	(0.015)	(0.019)	(0.023)	(0.025)
Observations	37482	29797	23639	19033
Sales growth	0.317***	0.241***	0.173***	0.185***
	(0.043)	(0.041)	(0.046)	(0.061)
Observations	37475	29606	23193	18525

Notes: This table shows the effect of privatization on selected key outcomes using PSM-DID using kernel matching with the epanechnikov kernel on zombie SOEs. Each cell represents a separate regression where the dependent variable is expressed as the difference between $t-1$ (i.e., the year prior to privatization) and year $t+s$ (the sth year after privatization, $s = 0, 1, 2, 3$) and the regression is estimated by weighted least squares using the kernel weight. Robust standard errors are listed in parentheses. ***, ** and * denote significance levels at the 1%, 5% and 10%, respectively.

Table D.8: Robustness checks: using Mahalanobis matching on former zombie SOEs

	(1) Privatization year	(2) 1 year after	(3) 2 years after	(4) 3 years after
log Labor productivity	0.207***	0.275***	0.294***	0.295***
	(0.021)	(0.028)	(0.033)	(0.038)
Observations	4169	3284	2677	2244
log TFP	0.094***	0.152***	0.171***	0.204***
	(0.015)	(0.021)	(0.027)	(0.031)
Observations	3745	2769	2103	1646
Interest rate subsidies	−0.002*	−0.007***	−0.004*	−0.008***
	(0.001)	(0.002)	(0.002)	(0.003)
Observations	4117	3224	2584	2164
Government subsidies	−0.002*	−0.002	−0.003**	−0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	4185	3296	2694	2268
Leverage	−0.101***	−0.130***	−0.154***	−0.162***
	(0.008)	(0.010)	(0.013)	(0.015)
Observations	4210	3324	2711	2278
Operating profits	0.079***	0.098***	0.108***	0.103***
	(0.009)	(0.013)	(0.015)	(0.013)
Observations	4184	3300	2690	2266
Administrative expenses	−0.048***	−0.077***	−0.079***	−0.072***
	(0.007)	(0.010)	(0.013)	(0.010)
Observations	4184	3300	2694	2266
Liquidity ratio	0.076***	0.091***	0.108***	0.127***
	(0.009)	(0.011)	(0.013)	(0.015)
Observations	4210	3324	2710	2275
log Employment	−0.069***	−0.068***	−0.058**	−0.018
	(0.014)	(0.018)	(0.024)	(0.029)
Observations	4216	3327	2704	2260
Sales growth	0.173***	0.119***	0.052	0.078*
	(0.037)	(0.034)	(0.038)	(0.040)
Observations	4213	3314	2641	2194

Notes: This table shows the effect of privatization on selected key outcomes using DID combined with Mahalanobis matching on former zombie SOEs. Each privatized SOE is matched with a never privatized SOE with the same pre-privatization zombie status in the same year based on the Mahalanobis distance estimated using the lagged values of (logged if appropriate) variables in Table A.1. Each cell represents a separate regression where the dependent variable is expressed as the difference between $t-1$ (i.e., the year prior to privatization) and year $t+s$ (the sth year after privatization, $s=0,1,2,3$). Bootstrapped standard errors using 500 replications are listed in parentheses. ***, ** and * denote significance levels at the 1%, 5% and 10%, respectively.

Table D.9: Robustness checks: using CEM on former zombie SOEs

	(1) Privatization year	(2) 1 year after	(3) 2 years after	(4) 3 years after
log Labor productivity	0.227***	0.329***	0.397***	0.386***
	(0.032)	(0.040)	(0.050)	(0.058)
Observations	2652	2102	1748	1464
log TFP	0.097***	0.155***	0.215***	0.215***
	(0.022)	(0.029)	(0.040)	(0.048)
Observations	2472	1789	1411	1107
Interest rate subsidies	−0.002	−0.009***	−0.010***	−0.018***
	(0.002)	(0.003)	(0.004)	(0.004)
Observations	2617	2073	1712	1454
Government subsidies	−0.002**	−0.001	−0.004**	−0.003
	(0.001)	(0.001)	(0.002)	(0.002)
Observations	2660	2111	1755	1481
Leverage	−0.101***	−0.148***	−0.195***	−0.211***
	(0.013)	(0.016)	(0.020)	(0.022)
Observations	2682	2137	1770	1492
Operating profits	0.097***	0.109***	0.151***	0.117***
	(0.013)	(0.019)	(0.023)	(0.021)
Observations	2658	2117	1756	1482
Administrative expenses	−0.073***	−0.084***	−0.125***	−0.113***
	(0.010)	(0.015)	(0.017)	(0.017)
Observations	2658	2117	1756	1481
Liquidity ratio	0.068***	0.107***	0.114***	0.154***
	(0.013)	(0.017)	(0.020)	(0.022)
Observations	2682	2137	1770	1492
log Employment	−0.109***	−0.121***	−0.095***	−0.080**
	(0.023)	(0.027)	(0.035)	(0.038)
Observations	2686	2139	1767	1480
Sales growth	0.190***	0.142***	0.106**	0.106**
	(0.054)	(0.046)	(0.050)	(0.050)
Observations	2684	2130	1741	1462

Notes: This table shows the effect of privatization on selected key outcomes using coarsened exact matching (CEM) on former zombie SOEs. Each privatized SOE is matched with one or more never privatized SOEs with the same pre-privatization zombie status in the same two-digit industry and year based on the imbalance measure estimated using the lagged values of (logged if appropriate) a subset of variables in Table A.1. Each cell represents a separate regression where the dependent variable is expressed as the difference between $t-1$ (i.e., the year prior to privatization) and year $t+s$ (the sth year after privatization, $s = 0, 1, 2, 3$). Robust standard errors are listed in parentheses. ***, ** and * denote significance levels at the 1%, 5% and 10%, respectively.

Appendix E. Procedures to classify zombies

In this appendix, we describe in detail the procedures we use to classify zombies using the ASIF dataset. The procedures discussed in this subsection closely follow Tan, Huang, and Woo (2016) and Tan et al. (2017) and are applied to the ASIF dataset.

We summarize the procedures into five steps. First of all, we calculate the minimum required interest payments based on the following formula similar to Eq. (**??**):

$$R^*_{i,t} = rs_{t-1}BS_{i,t-1} + \left(\frac{1}{5}\sum_{j=1}^{5} rl_{t-j}\right) BL_{i,t-1} \tag{E.2}$$

The meanings of the notations are identical to those in the main text. However, one problem is that the ASIF dataset does not contain information on the amount of bank loans. Given the data availability, we thus impute the amount of short-term bank loans by subtracting accounts payable, VAT payable, income tax payable, payroll payable and employee benefits payable from short-term liabilities while viewing long-term liabilities equivalent to long-term bank loans.[25] The second problem we met is that we only have data on net interest payments rather than total interest payments. This requires us to impute the interest income from bank deposits, which is calculated as:

$$RB_{i,t} = (CA_{i,t-1} - AR_{i,t-1} - INV_{i,t-1}) * rd_t \tag{E.3}$$

where $CA_{i,t}$, $AR_{i,t}$ and $INV_{i,t}$ stand for current assets, accounts receivable and inventory in year t respectively and rd_t denotes the one-year deposit rates in year t.

In the third step, we add back the interest income, compare the actual interest payments with the hypothetical lower bound for interest payments and normalize the difference with one-year lagged total borrowings:

$$Gap_{i,t} = [RC_{i,t} - (R^*_{i,t} - RB_{i,t})]/B_{i,t-1} \tag{E.4}$$

Based on our criterion, a firm is categorized as a zombie if $Gap_{i,t} < 0$ and vice versa. The criterion developed by Fukuda and Nakamura (2011) further introduce two additional criteria, i.e., the "profitability criterion" and the "evergreen leading criterion". According to the former, firms whose earnings before interest and tax (EBIT) exceed the minimum required interest payment should be excluded from being categorized into zombies. Therefore, in the fourth step, we proceed to calculate the adjusted gap as:

[25] We subtract these payables from the short-term liabilities because they are interest-free as operating liabilities. Missing data on certain variables in some years are interpolated by available data in other years or predicted from other relevant variables using OLS by industry. Another related issue is that except for the accounts payable, all these payable items in our dataset are accumulative values rather than balances at the end of the year. Since income tax is paid quarterly and the other three are paid monthly, we take one-fourth of the value of income tax payable, and one-twelfth of the other three payables as balances at the end of the year when imputing the short-term bank loans.

$$Gapadj_{i,t} = [EBIT_{i,t} - (R^*_{i,t} - RB_{i,t})]/B_{i,t-1} \tag{E.5}$$

Firms whose $Gapadj_{i,t} > 0$ and are categorized as zombies under our criterion are recategorized into the non-zombie group. In the last step, we apply the "evergreen lending criterion" and identify firms whose EBIT is less than the hypothetical lower bound for interest payments $R^*_{i,t}$ in year t, total external debt accounts for more than half of the total assets in year $t-1$ and keeps growing in year t as zombies. Note that we only use the operating profit to calculate EBIT to exclude government subsidies and revenues from other non-business-related activities.

Another important issue worth discussing at length is the selection of interest rates. Prime rates are the interest rates only the most credit-worthy borrowers can enjoy, thus the risk-free market lending rates. In China, all the benchmark interest rates are set by the People's Bank of China (PBC) and are available in the Statistical Yearbook of China. However, the benchmark rates may be changed by the PBC during a year, sometimes even several times, leading to the existence of several benchmark rates in one year. We choose the minimum rates among them as the prime rates to construct a conservative measure of zombies.[26] All the results in the paper remain qualitatively unchanged if we use the weighted average benchmark rates with the weight being the length of the spell for each benchmark rate in the year.

There are several types of loan rates based on the length of terms. For short-term loans (term equal to or less than one year), we assume the loan term of the borrower follows a uniform distribution, and then calculate the annualized average short-term interest rate based on one-year and half-year loan rates. For long-term loans (more than one year), we just take the average of three types of long-term benchmark rates available, i.e., interest rates with loan terms being 1–3 years, 3–5 years and longer than 5 years.

[26] We actually take 0.9 times the minimum rates as the prime rates because commercial banks in China are allowed to issue loans at a rate of 10% lower than the benchmark during our sample period.