Zombie Firms and the Crowding-Out of Private Investment in China*

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Abstract
From a data set of Chinese firms in the 2005–07 period, we find that government investment boosted the performance of zombie firms and crowded out the growth of private firms; we also found that the higher the concentration of state banks (and of state-owned enterprises), the more conducive is the environment for nurturing zombie firms. With the exit of zombie firms, (a) the industrial output growth rate would be higher by 2.12 percentage points, (b) the capital accumulation rate would be higher by 1.4 percentage points, (c) the employment growth rate would be higher by 0.84 percentage points, and (d) the rate total factor productivity growth would be higher by 1.06 percentage points. Our results support a radical change in the way that government investment has been carried out, and support comprehensive reform of the state sector, but they do not necessarily argue against government investment in large infrastructure projects and strategically-critical areas.

1. Introduction

On 14 September 2015, the *China Daily* reported on its front page that:[1]

> China's economic growth failed to rebound in August as expecting, signaling that the central government may have to introduce more support measures.

* We are grateful to Gou Qin, Ji Yang, Li Yue, Peter Petri, Tan Zhibo, Wang Daili, Xie Peichu, Yao Yang, Yu Miaojie, and participants in seminars and conferences for useful comments and helpful discussions.

1 "Growth Rate May Spur More Support." *China Daily* 14 September 2015.

Asian Economic Papers 15:3
doi:10.1162/ASEP_a_00474

> The National Bureau of Statistics said on Sunday that industrial output, the main monthly growth measure, rose to 6.1 percent year-on-year last month, up from 6 percent in July, but short of expectations of 6.5 percent.
>
> On Friday, Premier Li Keqiang sent a message to the world at the "Summer Davos" forum in Dalian, Liaoning Province, that a slower growth rate is acceptable unless there is turbulence in the job market. Measures introduced to date are sufficient to prevent an economic "hard landing."
>
> In an attempt to inject long-term growth momentum into large state-owned enterprises, the State Council, or Cabinet, has released a guideline on further reforming their ownership and stimulating market vitality.

We support the present policy preference for undertaking supply-side structural reform to generate growth over using demand-side macro-stimulus via fiscal or monetary policies to keep growth on target. Our support for this cautious policy stance is based on the fact that macro-stimulus in China generally took the form of state-directed investments during the 2003–13 period of the Hu-Wen administration, and that these state-led investments had (a) crowded out private sector growth and (b) served as an important lifeline for the inefficient "zombie firms."[2]

We are, of course, aware from experience that macro-stimulus is fast-acting and that structural reforms are slower in implementation and could also involve the risk of output contraction in the short run. Nevertheless, in China's case, these two instruments could turn out to represent the choice between short-run growth stability and long-run stagnation on one hand, and below-target growth in the short-run and avoidance of the middle-income trap in the long-run on the other hand.[3]

In this paper, we use a large data set of Chinese enterprises over 2004–07 to investigate the size of the "zombie sector" and the effects of government investment. "Zombie firms" are insolvent firms that stay in operation because of subsidies in the form of continual bank loans and/or in the form of overpriced projects awarded by the state. To anticipate our results, we find that government investment distributes capital in favor of zombie firms. While government investment raises the performance of zombie firms in output

2 Herrala and Jia (2015) analyzed the "credit availability of listed firms in China between 2003 and 2011", and found "that favoritism of state-owned firms in access to credit grew continuously more pronounced until at least 2011, that is, even after the accommodative policies in response to the first phase of the 2008–09 global financial crisis had abated." They hence hypothesized "that political influence on banks' credit policies contributed to an increase in economic growth in the short run above its long-run potential, . . . [explaining why growth] remained resilient even during episodes of significant international economic headwinds."

3 See Zhang and Woo (2010) for details. Yiping Huang (2013) has characterized the three key pillars of the economic policy framework of the present government, the Xi-Li administration (i.e., *Likonomics*), to be (a) no stimulus, (b) financial deleveraging, and (3) structural reform.

growth, job creation, and productivity improvements, it inhibits the performance of non-zombie firms. Our calculations suggest that the exit of zombie firms could increase annual output growth of non-zombie firms by as much as 2.12 percentage points. We want to emphasize that we are not arguing either against government investment in strategically critical areas, or against counter-cyclical policies that are not implemented through the zombie firms.

The paper is organized as follows. Section 2 describes government investment–led growth in China. Section 3 discusses the data and identifies the zombie firms. Section 4 specifies the empirical model, and Section 5 examines the impact of government investment on zombie firms and non-zombie firms. Section 6 calculates the efficiency gain from the exit of zombie firms exit the market, and Section 7 concludes.

2. Government investment-led growth

When Chinese growth decelerated rapidly during the Asian financial crisis of 1997 and the global financial crisis of 2008, the government quickly adopted sizable stimulus measures, mainly through increases in infrastructure investment (Fardoust, Lin, and Luo 2012). In both cases, GDP growth rebounded sharply. In these two episodes of macro-stabilization, the government was able to mobilize not just the efforts of the Ministry of Finance and the People's Bank of China, but also the enthusiasm of state-controlled commercial banks, local governments, and the state-owned enterprises (SOEs). Local officials had strong incentives to boost economic growth in their areas because post-1978 regional decentralization has promoted yardstick competition (i.e., relative performance evaluation) for career advancement.

Analysts have presented a number of competing perspectives on the consequences of state-led investment on economic growth in China. On the positive side, Wen and Wu (2014) found that the 2009–10 stimulus package helped to sustain economic growth during the global financial crisis. Fardoust et al. (2012) attributed the success of the macro-stimulus to investments in bottleneck-easing infrastructure projects, but they also emphasized importance of public investment quality.

On the other hand, Qin et al. (2006) found in their simulations of a macro-econometric model that, although growth of government investment promoted employment, it also raised the capital–output ratio and worsened the over-investment problem.[4] Wu (2013) found that total factor productivity (TFP) growth in China's industrial sectors from 1980 to 2010 was far worse than in other Asian economies at their similar stage of development, and that the worst TFP growth (0.3 percent) was in the aftermath of

4 Another way of analyzing the inefficiency of government-led investment is to compare capital returns among different ownership, industry, and regional groups (e.g., Knight and Ding 2010).

the 2009–10 stimulus package. TFP was in fact stagnant in the industries with higher government investment.[5]

A zombie firm is an insolvent firm that continues to operate because of continued access to financing. For example, the bank not only rolls over the loan when the zombie firm is unable to service the loan but also extends new loans to enable the zombie firm to make interest payments and to continue operating. Another way is to improve the sales of the zombie firm by awarding this firm a large-scale project. In fact, with government support, the unprofitable zombie firm could enlarge its capacity to undertake the large project, and might even take over well-performing enterprises in order to quickly increase its capacity. For example, loss-making Shandong Iron & Steel Group took over profitable Rizhao Steel Holding Group in 2009, with support from the local government.[6] This case is in line with the finding by liu, Liming, and Zhang (2013) that firms with political connections had a greater probability of engaging in mergers and acquisitions (M&As) and tended to engage in larger-scale M&As.

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5 In testimony to a Congressional Commission in February 2009, Wing Thye Woo (2009) had predicted the following:

> My opinion is that, unless the global economy weakens significantly, China's growth in 2009 is likely to lie closer to Premier Wen's 8 percent target than to the IMF's projection of 6.7 percent, say, 7.5 percent in 2009 and 2010. The state-owned banks (SOBs) will be happy to obey the command to increase lending because they cannot now be held responsible for future nonperforming loans. The local governments and the state-owned enterprises (SOEs) can now satisfy more of their voracious hunger for investment motivated by the soft-budget constraint situation where the profits would be privatized and the losses socialized. The stimulus package will work well because of the collusion between the managers of the SOBs and SOEs to transfer public assets to themselves. In January 2009, the banks extended 1,620 billion yuan in new loans, more than double the 806 billion yuan extended in January 2008, and the 772 billion extended in December 2009.
>
> Also, under the cover of economic emergency, the local governments will now ignore the recently-strengthened laws on environmental protection, worker safety, and medical insurance in order to encourage investment. The price of the 7.5 percent growth in the midst of a global recession will be paid later by the recapitalization of the SOBs and a more depleted natural environment.

Although it is politically desirable that Woo's prediction of continued high growth turned out to be true, it is unfortunate economically that the predicted emergence of bad debt caused by local government borrowing and the predicted damage to the environment have also been borne out.

6 This case is described in a SOE performance report, from the Unirule Institute of Economics (2011):

> Since 2007, Shandong local government wanted to push the local steel mills to create bigger companies, and invest in more advanced steel production lines, to compete against overseas rivals and help improve bargaining power for raw materials. So the local government started to urge Shandong Iron & Steel Group, the largest state-owned steel company in the province, to take over Rizhao Steel Holding Group, a well-performed private steel firm. Though Rizhao posted a profit of 1.8 billion yuan in the first half year of 2009, while Shandong Steel had a loss of 1.29 billion yuan, with the support of the local government, in September 2009, Shandong Iron & Steel Group took over Rizhao Steel Holding Group by acquiring two-thirds of a new venture between the two steelmakers.

3. Data and identification of zombie firms

3.1 Firm-level data and provincial variables

Our data set is compiled by the National Bureau of Statistics through annual surveys of all industrial firms (SOEs and non-SOEs) with annual sales of more than 5 million yuan in 1998–2007. Because of the unavailability of financial information needed for the zombie measure and of the unavailability of some provincial data, however, we use only 2004–07 data. After deleting outliers following Feenstra, Li, and Yu (2014), we obtain a total sample of 1,163,169 observations, which accounts for 97.77 percent of the original data set. The number of firms increased from 269,000 in 2004 to 332,000 in 2007, with a substantial number of exits and entries in each year. A total of 411,810 distinct enterprises were seen during the 2004–07 period, distributed over 31 provinces.[7]

Data on fixed-asset investment are available for individual provinces.[8] The financing of provincial fixed-asset investment is disaggregated into five categories: state budgetary fund, domestic loan, foreign investment, self-financing, and other sources. Clearly, "state budgetary fund" is a direct policy variable, and it includes infrastructure funding and renovation grants from the state budget, local finance, and entrusted bank loans. Because the government investment plan is usually based on the level of funds in previous year, we use the growth rate of state budget funds on investment (*g_investG*) to measure the extent of each province's policy to stimulate the local economy.

We rank the 31 provinces by their average growth rates of provincial government investment in 2005–07, and we use the mean value (0.18) to partition of the group. The high-stimulus group consists of the following 17 provinces: Shanxi, Liaoning, Jilin, Heilongjiang, Shanghai, Anhui, Fujian, Jiangxi, Hubei, Hunan, Hainan, Chongqing, Guizhou, Yunnan, Tibet, Shaanxi, and Qinghai. The low-stimulus group consists of Beijing, Tianjin, Hebei, Inner Mongolia, Jiangsu, Zhejiang, Shandong, Henan, Guangdong, Guangxi, Sichuan, Gansu, Ningxia, and Xinjiang. The *t*-test of the difference in the means of between the two groups (0.26 versus 0.08) is significant ($t = 4.24$).[9]

7 We delete observations that fail any one of the following criteria: (1) key financial variables cannot be missing or negative (such as total assets, gross value of industrial output, employment, net fixed assets, sales); (2) the General Accepted Accounting Principles must be observed—that is, the value of an item like the liquid assets, the total fixed assets, and the net value of the fixed assets cannot exceed the value of total assets; (3) the employment must not be less than ten people (because the financial reports of these enterprises are not so reliable); and (4) a firm's identification number cannot be missing and must be unique.

8 Data are dawn from the CEIC database.

9 The range for the high-stimulus group is 0.18 to 0.39, and the mean is 0.26. The range for the low-stimulus group is −0.17 to 0.17, and the mean is 0.08.

3.2 Zombie firms in China

The word "zombie" was first used in economics by Kane (1989) to describe an insolvent bank that was kept alive during the Savings & Loan Crisis in the United States in the 1980s. This term is best known for describing the economic situation in Japan in the 1990s after the bursting of the asset bubble—hopelessly insolvent firms that kept receiving new loans. We classify a firm as a "zombie" by combining two criteria (1) the Caballero, Hoshi, and K. Kashyap (2008) criteria of the firm receiving subsidized credit; and (2) the Fukuda and Nakamura (2011) criteria of the firm's profits being smaller that the interest subsidy. The result is a four-step procedure in the identification of zombie firms.

Step 1: Let x_t be the value of x at the end of period t. The minimum required interest payment of firm i in year t, $RA_{i,t}$, is defined as:

$$RA_{i,t} = rs_{t-1} BS_{i,t-1} + \left(\frac{1}{5} \sum_{j=1}^{5} rl_{t-j} \right) BL_{(i,t-1)},$$

where $BS_{i,t}$ denotes short-term liabilities minus accounts payable, taxes payable, and other payable items to measure the short-term bank debt, and $BL_{i,t}$ denotes long-term liabilities. rs_t and rl_t are, respectively, the average short-term and long-term prime rate in year t.[10]

Step 2: Firm i's interest income from bank deposits in year t is estimated as follows:

$$RB_{i,t} = (AT_{i,t-1} - AR_{i,t-1} - AI_{i,t-1}) * rd_t,$$

where $AT_{i,t}$, $AR_{i,t}$, $AI_{i,t}$ are, respectively, firm i's liquid assets, accounts receivable, and inventory for year t, and rd_t is the one-year bank deposit rate.

Step 3: Comparing the actual net interest payment of firm i ($RC_{i,t}$) and the minimum required net interest payment ($RA_{i,t} - RB_{i,t}$), and standardizing it with loans in the previous period ($B_{i,t-1} = BS_{i,t-1} + BL_{i,t-1}$), the interest rate gap is:

$$gap_{i,t} = (RC_{i,t} - (RA_{i,t} - RB_{i,t})) / B_{i,t-1}.$$

Following Caballero, Hoshi, and Kashyap (2008), if $gap_{i,t} < 0$, firm i has received a subsidy, and its zombie index is 1; otherwise its zombie index is 0.

10 The People's Bank of China has set the lower limit of lending rate as 0.9 times the benchmark rate until 2012, which is the prime rate.

Table 1. Proportion of zombie firms by year

Year	Total	Zombies	Proportion (Equally Weighted)	Proportion (Weighted Assets)	Proportion (Weighted Debts)
2005	229,627	38,317	16.69%	16.05%	20.49%
2006	243,592	37,197	15.27%	14.11%	17.73%
2007	271,596	32,915	12.12%	10.70%	13.42%

***Source**: Authors' estimation.*

Step 4: Because our firm debt information is not very specific, and because there is a possibility that we misclassify the non-zombies as zombies because they perform well and have a relatively low interest cost,[11] we follow Fukuda and Nakamura (2011) and further adjust firms' zombie index based on their profitability: if firm *i's* profit is greater than the gap between the minimum required net interest and actual net interest payment ($Profit_{i,t} + RC_{i,t} > RA_{i,t} - RB_{i,t}$), then firm *i* is reclassified as a non-zombie.

By applying this to the Chinese enterprise data set, we find that the overall percentage of zombies was actually quite high, although it declined from 16.7 percent in 2005 to 12.1 percent in 2007 (Table 1).[12] The asset-weighted version decreased from 16.1 percent to 10.7 percent; and the debt-weighted version (which captures the implied bad debt ratio) decreased from 20.5 percent to 13.4 percent. The official measure of the bad debt ratio also decreased in the same period, from 12.4 percent to 6.17 percent.[13]

Figures 1 and 2 show the proportion of zombie firms by ownership and by region, respectively. The SOEs had the highest proportion of zombies, and foreign firms had the lowest proportion. (Figure 1). The Northeast regions had the highest proportion of zombies and the Southeast region had the lowest proportion (Figure 2). We also calculate proportion of zombie firms for every two-digit level industry (see Appendix Table A.1). The industry with the highest proportion of zombie firms, 45.53 percent, is water production and supply. The industry with the lowest proportion, 0.89 percent, is the tobacco industry.

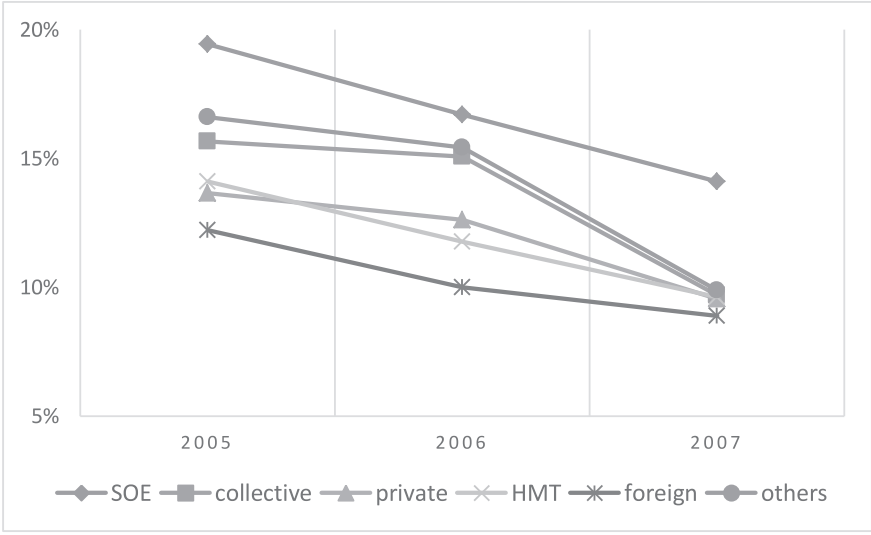
Because of the conceptual difficulties in defining and identifying zombie firms, we check the robustness of these measures. One major difficulty is getting information on evergreen loans (i.e., loans where the bank is subsidizing a firm by continually rolling over the loan at the normal interest rate). To control for this, we provide a modification: after the four-step procedure, if a firm's debt ratio is over 50 percent and debt is still increasing in year *t*,

11 When we regress firm profitability on the zombie index we measured in Step (3), controlling year and firm fixed effect, the coefficient estimate is negative, and significant at 1 percent level. It indicates that most of the firms with extremely low interest payment do not have better performance.

12 Because of data unavailability or because the firm did not exist in the previous year, we excluded 418,354 observations (268,652 in 2004 and 149,702 in the other three years) in our analysis, leaving 744,815 observations in the sample.

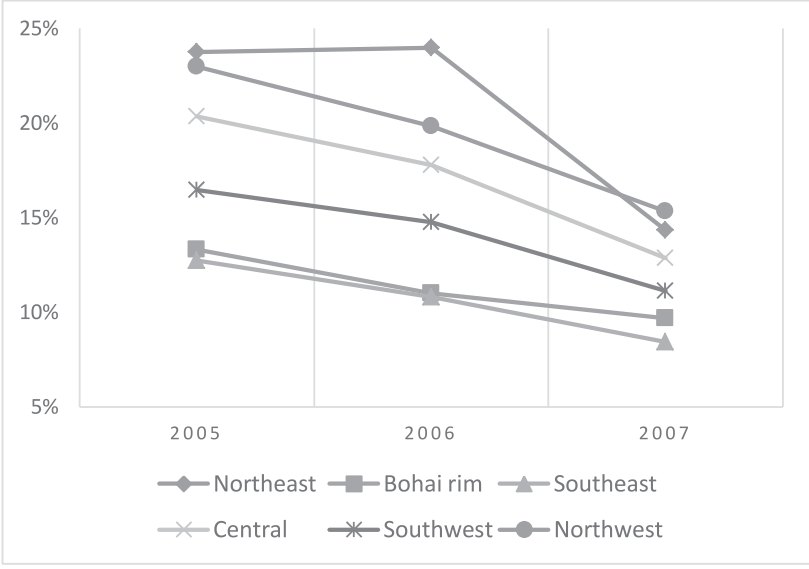
13 The data are from the Web site of China's Bank Regulatory Commission.

Figure 1. Proportion of zombie firms by ownership (asset-weighted)



Source: *Authors' estimation.*

Figure 2. Proportion of zombie firms by region (asset-weighted)



Source: *Authors' estimation.*

Table 2. Correlation between different zombie indexes

	Zombie	Z1	Z2	Z3
Zombie	1			
Z1	0.9191	1		
Z2	0.8435	0.8081	1	
Z3	0.9782	0.898	0.8284	1

Source: *Authors' estimation.*

then the firm is reclassified as zombie in year *t*. We will call the original zombie measure "Zombie" and this alternative zombie measure "Z1."

Some good firms may be mistakenly identified as zombies because they repay loans early. Here, we introduce the second modification by using two-year moving average (year *t* and lagged year *t–1*) firm debt to calculate minimum interest payment in year *t* (zombie measure Z2). And a final concern is that firms' profit already includes a direct subsidy or tax refund from the government. So the final modification is to extract subsidy from profit (zombie measure Z3).

Table 2 tests for robustness of our four zombie measures by calculating the correlations among them. The correlations range from 0.81 to 0.98, indicating that these four measures are close substitutes for each other.

3.3 Indication of government support for zombie firms

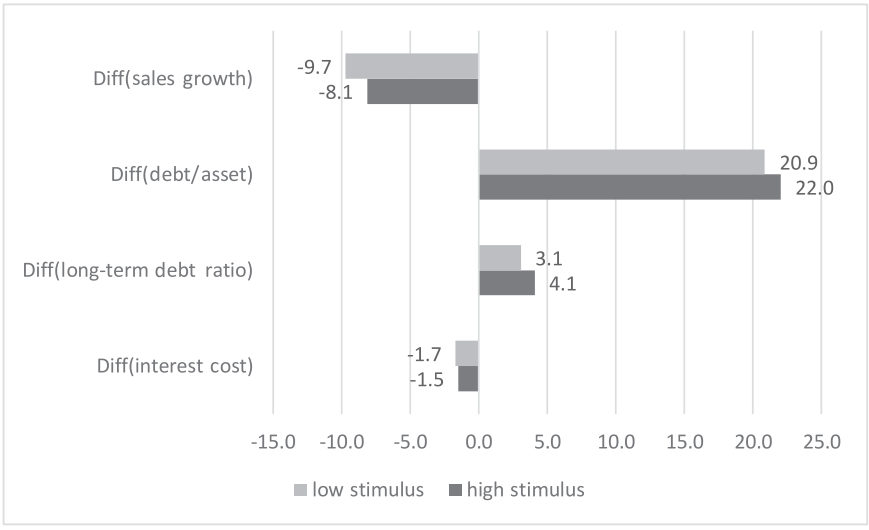
The government uses four main ways to support zombie firms. The first way is to boost the sales of zombie firms through government procurement for investment projects. The second way is to extend more loans to them, resulting in a higher leverage ratio for zombie firms. The third way is to favor them in the disbursement of long-term loans. The fourth way is to lower the interest rate that zombie firms pay.

We construct an indicator for each of these four methods for two types of firms in each province, zombie firms and non-zombie (normal) firms:

1. Sales Growth: Measured as the difference of firm total sales in logarithm term
2. Debt Ratio: Leverage of the firm that is (total debt)/asset
3. Long-term Debt Ratio: Long-term debt of the firm as a proportion of total debt of the firm
4. Interest Cost: Measured as net interest payment divided by total debt of the firm

For each indicator, we compute the respective mean value of all the zombie firms in the high-stimulus group of 17 provinces and the mean value of all the non-zombie firms in the high-stimulus group. Using IZH and InZH to denote the respective values, we

Figure 3. Zombie – non-zombie differences in high stimulus and low stimulus province groups



Source: *Authors' estimation.*

Note: *By the average provincial government investment growth rate during years 2005–07, we divide provinces into high stimulus group and low stimulus group. Diff(x) denotes difference of zombie and non-zombie on x ($x_z - x_{nonz}$), where x could be Interest Cost, Long-term Debt Ratio, Debt/Asset, or Sales Growth. Interest Cost is measured as firm net interest payment divided by firm total debt; Long-term Debt Ratio is long-term debt divided by total debt; Debt Ratio (Debt/Asset) is the ratio of total debt and total asset; Sales Growth is measured as difference of firm total sales in logarithm term.*

compute the difference between them (IZH – InZH). The differences between zombie firms and non-zombie firms on these four indicators indicate the degree of distortion between these two kinds of firms in high-stimulus provinces.

We repeat this set of calculations for zombie firms and non-zombie firms in the low-stimulus group of 14 provinces.

Figure 3 compares the differences in (zombie/non-zombie) sales growth, debt ratio, long-term debt ratio, and financing cost between the high-stimulus and low-stimulus groups. Zombie firms had lower interest cost, higher long-term debt ratio, higher debt ratio, and lower sales growth in both province groups. Comparing the results of the two province groups, the interest cost difference is narrower in the high-stimulus group, which means that governments in high-stimulus provinces do not use financing costs more aggressively to support their zombie firms.

The differences on long-term debt ratio and debt asset ratio become larger in the high-stimulus group (Figure 3), indicating that government stimulus supports zombie

firms by allocating more loans, especially long-term loans. The absolute size of the negative gap in sales growth between zombies and non-zombies decreases in the high-stimulus group, indicating that zombie firms get more sales opportunity with government-related projects.

4. Econometric strategy

4.1 Empirical specification

The first type of effect we try to detect is a direct effect, that is, whether or not growth of government-funded investment exerts a positive effect on capital accumulation (investment rate) of zombie firms. Our hypothesis is that the zombie firms have an advantage in competing for a government investment fund.

Moreover, there could be several possible indirect effects on different types of firms (zombies versus non-zombies):

1. Government investment could improve output and increase employment, which are the aims of government stimulus. So we will test its influence on firms' output and employment growth.
2. Possible misallocation and inefficiency would be reflected in TFP if the impacts are different between zombies and non-zombies.
3. Government stimulus might have extensive marginal effect on the prevalence of zombie firms in the province.

To see which type of firm is favored by government investment through the direct effect and through the first two indirect effects, we adapt the following reduced form specification from Cabellero, Hoshi, and Kashyap (2008):

$$\begin{aligned}\text{Activities}_{irt} = {} & \gamma_1 g\_investG_{rt} + \gamma_2 zombie\_initial_i \times g\_investG_{rt} \\ & + \gamma_3 zombie\_initial_i + \alpha C_{it} + DInd + Dyear + Dreg + \varepsilon_{it}, \end{aligned} \tag{1}$$

where the four proxies for Activities are (1) investment rate, (2) output growth rate, (3) job creation, and (4) productivity (TFP) growth.

The investment rate (I/K) is defined as changes in fixed assets plus depreciation divided by lagged fixed assets,[14] and output, job, and productivity growth are all in the form of log difference: value-added growth ($D.lnY$); job creation ($D.lnL$) and total factor

14 The investment rate is approximately equal to capital growth. It differs by including the renewal of the depreciated part.

Table 3. Summary statistics of variables, full sample

Variables	N	Mean	SD	Min	Max
I/K	744805	0.54	1.54	−0.79	11.13
D.lnY	725414	0.20	0.73	−1.99	2.61
D.lnL	744815	0.03	0.35	−1.19	1.36
D.lnTFP	725414	0.15	0.74	−2.03	2.53
zombie_initial	744815	0.13	0.34	0	1
g_investG	744815	0.19	0.26	−0.32	0.71
StateFinan	744815	0.23	0.12	0.04	0.98
PPI	744682	1.03	0.02	0.99	1.17
SOE	744815	0.05	0.23	0	1
Collective	744815	0.07	0.26	0	1
HMT	744815	0.11	0.31	0	1
Foreign	744815	0.10	0.31	0	1
Others	744815	0.18	0.39	0	1
Expdummy	744815	0.28	0.45	0	1
Kintensity	744815	3.72	1.36	−6.77[a]	14.39
Size	744815	9.92	1.43	2.48	20.15
Age	744763	10.46	9.92	1	218[b]
IndusConcen	744815	0.23	0.15	0.05	1

Source: *Authors' estimation.*

Note: *a. Capital intensity is measured as ratio of fixed asset to number of employees in logarithm term; that is why the minimum value is negative.*
b. Very few observations have extremely large values on age. Because age is a control variable, we did not delete it so as to save more observations. But we checked those firms with large age value—the large maximum is not a mistake, but due to a few "time-honored brands" or long-standing enterprises.

productivity improvement (*D.lnTFP*), where TFP is computed using the OP methodology (Olley and Pakes 1996)[15] and all the variables are winsorized at fraction 1 percent.[16]

$g\_investG_{rt}$ is the government stimulus variable, the growth rate of government investment in the province where the firm is located. $zomibie\_initial_i$ is the zombie index in 2005. Because the government stimulus might impact the formation of zombies, we use the zombie index in the first regression year (2005) to represent the zombie group to avoid an endogeneity problem here. *DInd, Dyear, Dreg*, respectively, are controls for two-digit industry, year, and province fixed effects.

Table 3 shows the large number of control variables in C_{it} : (1) type of firm ownership, including *SOE, collective, foreign, HMT and others*;[17] (2) other firm characteristics, including export firm dummy (firms with positive export value, denoted as *Expdummy*), capital intensity (ratio of fixed asset to number of employees, denoted as *Kintensity*), size (natural

15 We use two factor inputs, employment and net fixed asset, and the output is value added; the depreciation rate is set to 15 percent. Net fixed assets and outputs are deflated by capital and producer price index, respectively. Price index data are from the National Bureau of Statistics.

16 "Winsorize at fraction 1 percent" means it takes the non-missing values of a variable x ordered and generates a new variable y identical to x except that the 1 percent highest and 1 percent lowest values are replaced by the next value counting inwards from the extremes.

17 "Private" dummy is deleted in the regressions as ownership benchmark.

logarithm of total assets), age, and industry concentration (sales proportion of ten largest companies in the four-digit industries, denoted as *IndusConcen*); and (3) provincial features, including concentration of state-owned banks (which is reversal linear transformed from the financial industry competitive index constructed by Fan, Wang, and Zhu [2009], denoted by *StateFinan*) and producer price index. We tested the correlation coefficients of all the including independent variables and did not find a multicollinearity problem.

Our main interest is on the coefficients y_1 and y_2. If a disproportionate amount of government investment fund is allocated to zombie firms, we expect to see it shows a better impact on zombie firms' production activities than others (positive y_2), and resource constraint would crowd out the non-zombie firms (negative y_1).

When firms enter and exit the market freely, we might see both coefficients being of the same sign when the government resources prefer the non-zombies, however. The mechanism is that more zombie firms would be crowded out by non-zombies and close their business, and more non-zombie firms would established, which would increase the average productivity of zombies in the market while lowering it for non-zombies. To control for this disturbing effect, we limit the sample to firms that survived the whole period of 2004–07, but we also re-estimate the effects for the whole sample as a robustness check.

4.2 Clustering issue

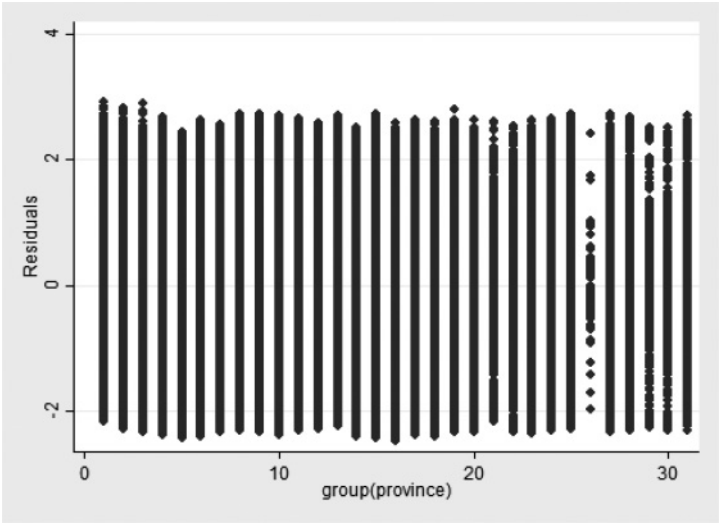
Because our key regressor $g\_investG_{rt}$ is a provincial-level variable, though we focus on its interaction effect with a firm-level variable, we still checked whether the firm observations should be clustered at the provincial level. It indicates that all the firms in the same province are correlated, which is equivalent to adjusting heteroskedasticity among provinces. From Figure 3 we can find that distribution of the residuals from our basic regression is quite similar among most of the provinces (except Tibet, because of fewer observations), which supports the claim that there is no obvious heteroskedasticity problem among provinces. Besides, when there are few clusters in the sample (in our case, 31 clusters with more than one million observations), there is no consensus in the literature on a truly satisfactory solution, and clustered standard errors can suffer from few-cluster bias and over-reject significant coefficients (Cameron and Miller 2013). Therefore, we assume correlation among firms' performance in different years and cluster our regression at the firm level.

5. Effects of government investment

5.1 Baseline results

The lower half of Table 4 compares the performance of zombie firms and non-zombie firms on growth in output, capital stock, jobs, and TFP. The non-zombie firms perform significantly better on all four fronts.

Figure 4. Distribution of residuals by province from basic regression



Source: *Authors' estimation.*

Table 4. Production activity comparison between zombies and non-zombies

	lnY	lnK	lnL	lnTFP	N
Non-zombies	9.0357	8.4207	4.7804	3.9127	630298
Zombies	8.4415	8.6599	4.7515	3.2547	104644
Difference	0.5942***	−0.2391***	0.0289***	0.6580***	
	(0.0044)	(0.0054)	(0.0035)	(0.0011)	
	D.lnY	**I/K**	**D.lnL**	**D.lnTFP**	**N**
Non-zombies	0.2255	0.5769	0.0419	0.1642	623904
Zombies	0.0455	0.3244	−0.0320	0.0652	101510
Difference	0.1800***	0.2525***	0.0739***	0.0991***	
	(0.0025)	(0.0051)	(0.0011)	(0.0025)	

Source: *Authors' estimation.*

We estimate equation (1) using weighted least squares regression with the number of enterprises in each province as the weight. As a precaution against omitted firm heterogeneity, we also apply a panel data fixed-effect method to compare. Table 5 reports the impact of government investment on the investment rate. We find a negative impact of government investment on investment rate of the whole sample, possibly pointing to the inefficiency problem of government spending (columns [1] and [2] of Table 5). When the cross-term of government stimulus and zombie index is included in the estimation, however, we find that government stimulus actually only lifts zombies' investment ratio, and lowers the investment ratio of non-zombies (columns [3] and [4]). The significantly

Table 5. Impact of government investment on firm investment: Basic results

Dependent variable: I/K	(1) WLS	(2) FE	(3) WLS	(4) FE
g_investG	−0.016*	−0.016*	−0.029***	−0.037***
	(0.009)	(0.009)	(0.010)	(0.010)
zombie_initial*g_investG			0.100***	0.167***
			(0.020)	(0.021)
zombie_initial			−0.139***	
			(0.007)	
Controls	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	No	Yes	No
Province fixed effect	Yes	No	Yes	No
Firm fixed effect	No	Yes	No	Yes
Observations	579,672	579,672	579,672	579,672
R^2	0.024	0.057	0.024	0.057

Source: *Authors' estimation.*

Note: *Each column reports the coefficient estimates and their robust standard errors (in parentheses), all of which are displayed to three decimal places. All the coefficient estimates of control variables and fixed effect dummies are not reported. FE = fixed effects.*

****Statistically significant at the 1% level; **statistically significant at the 5% level; *statistically significant at the 10% level.*

Table 6. The impact of government investment on production outcomes: Basic results

	(1) D.lnY	(2)	(3)	(4) D.lnL	(5)	(6)	(7) D.lnTFP	(8)	(9)
	WLS	WLS	FE	WLS	WLS	FE	WLS	WLS	FE
g_investG	−0.055***	−0.065***	−0.063***	0.019***	0.020***	0.020***	−0.065***	−0.074***	−0.072***
	(0.005)	(0.005)	(0.005)	(0.002)	(0.003)	(0.003)	(0.005)	(0.005)	(0.005)
zombie_initial*		0.084***	0.082***		−0.008	−0.008		0.073***	0.059***
g_investG		(0.013)	(0.014)		(0.006)	(0.006)		(0.013)	(0.014)
zombie_initial		−0.049***			−0.034***			−0.001	
		(0.004)			(0.002)			(0.004)	
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
Province FE	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
Firm FE	No	No	Yes	No	No	Yes	No	No	Yes
Observations	566,271	566,271	566,271	579,678	579,678	579,678	566,271	566,271	566,271
R^2	0.020	0.020	0.014	0.017	0.018	0.012	0.010	0.011	0.012

Source: *Authors' estimation.*

Note: *Each column reports the coefficient estimates and their robust standard errors (in the parentheses), all of which are displayed to three decimal places. All the coefficient estimates of control variables and fixed effect dummies are not reported. WLS = weighted least squares; FE = fixed effects.*

****Statistically significant at the 1% level; **statistically significant at the 5% level; *statistically significant at the 10% level.*

positive effect is even greater when we control firm-level fixed effects. Specifically, if government investment growth increases by 1 percent, the investment ratio goes up by 0.167 percent (column [4]). Therefore, we conclude that zombies and non-zombies are not equally treated when they compete for government investment projects.

Table 6 reports the impact of government investment on growth in output, jobs, and productivity. We limit our discussion to columns (2), (3), (5), (6), (8), and (9) where the cross-term (of government investment growth and zombie) is included. The coefficient of

g_investG is negative for growth in output and TFP but positive for growth in jobs. The coefficient for *zombie_initial*g_investG* is positive and statistically significant in regressions for output growth and TFP growth. Interestingly, column (5) actually suggests that zombie-hood might actually be bad for job creation within the zombie firm.

5.2 Robustness check

A main concern about the regressions in Tables 5 and 6 is that government investment growth is not exogenously determined—for example, when local economic conditions turn sour, the provincial governments might respond by implementing an economic stimulus. We address this endogeneity issue in two ways. The first way is to replace government investment with the first order lag of government investment in the regressions.

The second way is to use the distance between the provincial capital and Beijing as the instrument for government stimulus. A stronger stimulus might happen in a more distant province, away from the eyes of the central government. This means, however, that we are not able to control for either province fixed effects or firm fixed effects in the regression. It might cause some new biases. That is why we put the instrumental variable estimation as one of the robust check instead of main regression.[18]

The first four columns in Table 7 shows that the use of first-order lag of government investment growth only reduces the positive effect on job creation of zombie firms, the other results remain almost the same. The remaining four columns report the coefficient estimates of the two-stage least squares regression.[19] All estimates for key regressors are significant;[20] our basic conclusions therefore remain unchanged.[21]

5.3 How did government stimulus affect the prevalence of zombies?

To study the marginal effect of government stimulus on the prevalence of zombies in the province, we apply the following nonlinear probit model:

$$\Pr(zombie_{it} = 1) = \beta g\_investG_{rt} + \alpha C_{it} + DInd + Dyear + Dreg + \varepsilon_{it}, \qquad (2)$$

18 The cross-term of the zombie index and government investment growth would also be endogenous when the government investment variable is endogenous. So we use distance and the cross-term of the zombie index and distance to instrument for *g_investG* and the cross-term.

19 The Durbin-Wu-Hausman test shows that government investment growth is endogenous, and our instrument is valid confirmed by the first-stage *F* statistic.

20 Another instrument we tried is the number of local members in the Central Committee of the Chinese Communist Party, and it shows similar results as using distance.

21 We did some more tests: (1) test the measure error by replacing the standard zombie indicator with all the alternatives (Z1, Z2, Z3) we discussed in Section 3; (2) include firms that enter or exit during this period; (3) replace the government stimulus measure with total government investment, instead of growth rate. The regression results do not change our main conclusions. Results are not reported but available from the authors upon request.

Table 7. Testing the robustness of the impact of government investment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Lagged government investment				Instrumental variable estimation			
	I/K	D.lnY	D.lnL	D.lnTFP	I/K	D.lnY	D.lnL	D.lnTFP
g_investG	−0.081***	−0.040***	0.018***	−0.043***	−0.146	−0.979***	0.211***	−1.007***
	(0.015)	(0.007)	(0.004)	(0.008)	(0.169)	(0.064)	(0.033)	(0.062)
zombie*	0.002	0.046***	−0.013*	0.039**	2.409***	2.347***	0.897***	1.979***
g_investG	(0.027)	(0.016)	(0.007)	(0.016)	(0.511)	(0.214)	(0.110)	(0.206)
zombie	−0.071***	0.022***	−0.058***	0.063***	−0.516***	−0.422***	−0.184***	−0.314***
	(0.007)	(0.004)	(0.002)	(0.004)	(0.083)	(0.035)	(0.018)	(0.034)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	No	No	No	No
Observations	386,474	378,487	386,480	378,487	579,672	566,271	579,678	566,271
R^2	0.016	0.011	0.012	0.007	-	-	-	-
DWH test					25.085	228.471	243.980	241.161
(p value)					(0.000)	(0.000)	(0.000)	(0.000)
First-stage F					717.07	709.616	716.929	709.616

Source: *Authors' estimation.*

Note: *Each column reports the coefficient estimates and their robust standard errors (in parentheses), all of which are displayed to three decimal places. All the coefficient estimates of control variables and fixed effect dummies are not reported.* R^2 *has no statistical meaning in the context of 2SLS. The null hypothesis of Durbin-Wu-Hausman test is the instrumented government stimulus and cross-term are exogenous, which is rejected when* $p = 0$*. First-stage F statistic confirms that the instrument variables are not weak.*

****Statistically significant at the 1% level; **statistically significant at the 5% level; *statistically significant at the 10% level.*

where $zombie_{it}$ is the zombie index (later we also substitute it with Z1, Z2, and Z3 as robustness checks); all other variables are as in Equation (1). The coefficient of $g\_investG_{rt}$, which is our central focus, reflects the within-province impact of the government investment growth on formation of zombies.

Because we found that government investment helped improve the performance of zombie firms, we expect that some zombie firms might to turn into non-zombies with the help of government stimulus. Estimation results in Table 8 confirm this speculation, which suggests that government stimulus, through government investment expansion, has significant negative effect on zombies. The effect is quite small, however. Taking column (1) as an example, the marginal effect of government investment expansion on zombie firms is only −0.008. The results in columns (2), (3), and (4), which used alternative zombie measures, confirm the finding.

The concentration of SOBs has a significant impact on new zombies—the higher the degree of concentration, the more zombie firms in the province. Comparing the estimated magnitude of marginal effects, we see that concentration of state-owned banks and SOEs are two main factors contributing to the zombie phenomenon.

Most of the firm-level control variables also have expected effects. One, SOEs are more likely than any other forms of ownership to become zombies. The literature already established that the state sector receives better credit support (Ferri and Liu 2010; Herrala and

Table 8. Determinants of zombie-hood

Variables	(1) Zombie	(2) Z1	(3) Z2	(4) Z3
g_investG	−0.008***	−0.007***	−0.008***	−0.008***
	(0.002)	(0.002)	(0.002)	(0.002)
StateFinan	0.284***	0.317***	0.295***	0.290***
	(0.026)	(0.028)	(0.026)	(0.026)
PPI	−0.019	0.012	−0.005	−0.022
	(0.027)	(0.029)	(0.026)	(0.028)
SOE	0.166***	0.177***	0.160***	0.177***
	(0.005)	(0.005)	(0.005)	(0.005)
collective	0.017***	0.016***	0.011***	0.026***
	(0.003)	(0.003)	(0.003)	(0.003)
HMT	0.029***	0.039***	0.020***	0.029***
	(0.002)	(0.003)	(0.002)	(0.002)
foreign	0.008***	0.020***	0.000	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)
others	0.046***	0.050***	0.040***	0.049***
	(0.002)	(0.002)	(0.002)	(0.002)
expdummy	−0.032***	−0.027***	−0.036***	−0.034***
	(0.001)	(0.002)	(0.001)	(0.001)
Kintensity	0.010***	0.006***	0.009***	0.010***
	(0.001)	(0.001)	(0.001)	(0.001)
size	−0.002***	−0.000	0.005***	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)
age	0.002***	0.002***	0.001***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
IndusConcen	0.009*	0.010*	0.010*	0.005
	(0.005)	(0.005)	(0.005)	(0.005)
Obervations	579,678	579,678	579,678	579,678
Pseudo R^2	0.065	0.060	0.064	0.067

Source: *Authors' estimation.*

Note: *Each column reports the marginal effect coefficient estimates and their robust standard errors (in parentheses) for a probit model of determinants of zombies, all of which are displayed to three decimal places. The regression also includes year, industry, and province dummies as well as a constant term, the coefficient estimates of which are not reported. Variables are defined as before.*

****Statistically significant at the 1% level; **statistically significant at the 5% level; *statistically significant at the 10% level.*

Jia 2015). Two, export firms are less likely to become zombies, which is consistent with the finding that more efficient enterprises often choose to export rather than serving domestic market (Helpman, Melitz, and Yeaple 2004). Three, capital-intensive and older enterprises have greater possibility of obtaining zombie lending.

5.4 Zombies, political connection, and firm ownership

In Table 9, we run the regressions on the SOE and non-SOE subsamples separately. If SOEs have a closer relationship with the government, then the zombie versus non-zombie difference should be greater among non-SOEs than among SOEs. The coefficient estimates for government investment expansion using the SOE subsample are opposite to what we obtain from the non-SOE sample (columns [1], [2], and [4] vs. columns [5], [6], and [8]). Indeed, they show a greater difference in policy effects on zombies and non-zombies in the non-SOE sample, except for the coefficients in the employment regression.

Table 9. The impact of government investment on production outcomes in SOEs and Non-SOEs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Subsample: SOEs				Subsample: Non-SOEs			
VARIABLES	I/K	D.lnY	D.lnL	D.lnTFP	I/K	D.lnY	D.lnL	D.lnTFP
g_investG	0.017	0.048	0.016	0.033	−0.027***	−0.066***	0.021***	−0.076***
	(0.052)	(0.029)	(0.012)	(0.029)	(0.010)	(0.005)	(0.003)	(0.005)
zombie_initial*	−0.062	−0.133***	−0.031	−0.094*	0.104***	0.091***	−0.007	0.078***
g_investG	(0.070)	(0.048)	(0.021)	(0.048)	(0.020)	(0.013)	(0.006)	(0.014)
zombie_initial	−0.065***	0.006	−0.023***	0.031**	−0.142***	−0.049***	−0.034***	−0.003
	(0.022)	(0.013)	(0.005)	(0.013)	(0.007)	(0.004)	(0.002)	(0.004)
controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
IndustryFE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	29,302	27,931	29,302	27,931	550,370	538,340	550,376	538,340
R-squared	0.015	0.011	0.013	0.008	0.025	0.021	0.018	0.010

Source: *Authors' estimation.*

Note: *Each column reports the coefficient estimates and their robust standard errors (in parentheses), all of which are displayed to three decimal places. All the coefficient estimates of control variables and fixed effect dummies are not reported.*

****Statistically significant at the 1% level; **statistically significant at the 5% level; *statistically significant at the 10% level.*

The crowding-out effect on non-zombies does not exist in the SOE sample. This suggests that zombies have no advantage when all the firms have political connections.

6. Potential consequences of reallocation and zombie exit

In this section, we calculate the potential gains from factor reallocation and exit of the zombies. We assume that total industrial output is produced by non-zombies (n) and zombies (z):

$$Y = Y_n(K_n, L_n) + Y_z(K_z, L_z), \tag{3}$$

where K_n, L_n, K_z, L_z denote levels of capital stock and employment in the non-zombies and zombies, respectively. We further assume the economy's total capital stock K, total labor force L, and capital–labor share in non-zombies are respectively λ_k and λ_l, that is,

$$K_n = \lambda_k K, L_n = \lambda_l L. \tag{4}$$

If China's capital resources no longer misallocate toward zombie firms, the return of factors of non-zombies and zombies should equalize. Assuming the Cobb-Douglas production function: $Y_i = A_i K_i^{\alpha} L_i^{\beta}$, and giving the productivity parameter of non-zombies and zombies as, respectively, A_n, A_z, the equalization of capital and labor marginal returns would be:

$$\begin{cases} A_n K_n^{\alpha-1} L_n^{\beta} = A_z K_z^{\alpha-1} L_z^{\beta} \\ A_n K_n^{\alpha} L_n^{\beta-1} = A_z K_z^{\alpha} L_z^{\beta-1}. \end{cases} \tag{5}$$

Solving equations (4) and (5), we can obtain the capital and labor share in non-zombies after factor reallocation:

$$\lambda_k^* = \lambda_l^* = 1 - \frac{1}{(\frac{A_n}{A_z})^{\frac{1}{1-\alpha-\beta}} + 1}. \tag{6}$$

Given $\log(A_n) - \log(A_z) = 0.6580$ in Table 4, we calibrate the TFP ratio A_n/A_z as $e^{0.6580}$. The sum of capital and labor elasticities is usually assumed to be 1 (constant returns to scale); if we make this assumption, then the optimal share in non-zombies would be 1, so all the zombies should exit the market.

Conservatively, if we use the capital and labor elasticities from our estimation of TFP using the OP method, where α is estimated as 0.34 and β is estimated as 0.473, then the optimal capital and labor share in non-zombie firms without friction would be 0.97. Under the decreasing returns to scale production in our firm database, the tolerance of low productive firm percentage is about 3 percent compared with the actual percentage of more than 10 percent. When zombie firms and non-zombie firms compete fairly, about 8 percent of capital and labor in the whole economy (industrial market in the dataset) would be reallocated to non-zombie firms.

Note, however, that the adjustment process to the exit of zombie firms could be painful in the short term. If the exit takes the form of M&As, then capital and labor may be retained and the negative impact could be relatively small. If the exit takes the form of closing down, there would be a much bigger unemployment problem.

According to Du and Dong (2009), the average unemployment duration in the three years prior to 2003 were about 18 months for the entire sample, 13 months for the re-employed, and 21 months for those still unemployed. Given this consideration, we take 6 months as one period, and assume that the zombies would withdraw gradually in N periods (i.e., during each period *1/N* of the zombie firms will exit the market). Another assumption is that capital can be redistributed instantaneously to other non-zombie enterprises, but re-employment after being laid off is lagged for three periods (18 months). So output in period t ($t = 1, \ldots, N$) can be expressed as:

$$\begin{aligned} Y_t = \Bigg\{ & A_n \left[\lambda_k + \frac{\min\{t, N\}}{N} \times (\lambda_k^* - \lambda_k)\right]^{\alpha} \left[\lambda_l + \frac{\max\{0, t-3\}}{N} \times (\lambda_l^* - \lambda_l)\right]^{\beta} \\ & + A_z \left[1 - \lambda_k - \frac{\min\{t, N\}}{N} \times (\lambda_k^* - \lambda_k)\right]^{\alpha} \left[1 - \lambda_l - \frac{\min\{t, N\}}{N} \times (\lambda_l^* - \lambda_l)\right]^{\beta} \Bigg\} K^{\alpha} L^{\beta}. \end{aligned} \tag{7}$$

Table 10. Calculations of efficiency gain during reallocation of factors Annual growth rate of output caused by reallocation, %

t	N = 4	N = 8	N = 16
1	−1.27	−0.60	−0.29
2	−0.67	−0.18	−0.06
3	2.02	0.24	0.17
4	0.98	0.10	0.15
5	-	0.99	0.13
6	-	0.48	0.10
7	-	-	0.07
8	-	-	0.03
9	-	-	0.49
10	-	-	0.24
Overall	1.03	1.03	1.03

Source: *Authors' estimation.*

Table 11. The efficiency gains after the exit of zombie firms (%)

	Output growth	Capital growth	Job creation	TFP improvement
Non-zombies	25.80	9.59	3.91	19.63
Zombies	6.56	−3.15	−3.76	9.95
Difference	19.24	12.74	7.67	9.68
Growth change of the whole economy				
89% healthy	23.68	8.19	3.07	18.57
100% healthy	25.80	9.59	3.91	19.63
Growth gain	2.12	1.40	0.84	1.06

Source: *Authors' estimation.*

The annual growth rate in output is: $\%\Delta Y_{t/2} = Y_t / Y_{t-2} - 1$, where t is even and starts from the second period.

To estimate the percentage change in total output, we need five parameters:

(1) Non-zombies' shares of capital and labor $\lambda_k = 0.885$, $\lambda_1 = 0890$ (derived from 2007 data);
(2) The optimal shares of capital and labor in non-zombies $\lambda_k^* = \lambda_l^* = 0.97$ (obtain from equation [6]);
(3) Period $N = 4$, 8, and 16 (temporary annual unemployment rate close to 4 percent, 2 percent, and 1 percent, respectively);
(4) TFP ratio $A_n/A_Z = e^{0.6580}$ (given $\log(A_n) - \log(A_z) = 0.6580$ in Table 4); and
(5) Capital and labor elasticities $\alpha = 0.34$, $\beta = 0.473$ (derived from TFP estimation).

Table 10 reports the efficiency gain during the reallocation of labor and capital. The total increase industrial output would be 1.03 percent after short-term reallocation.

Overall, after the exit of the zombie firms, annual output growth could be lifted by 2.12 percentage points. Capital growth would increase by 1.4 percent. Growth of employment would rise by 0.84 percentage point a year, which means the short-term stress in the labor market can actually lead to a lower unemployment rate in long run. And, finally, TFP growth may be lifted by 1.06 percentage points a year.

7. Concluding remarks

We would like to emphasize three points. First, an increase in government investment reduces the investment rate of non-zombie firms and raises that of the zombie firm. The overall investment rate is lower because of the "crowding out" of non-zombie firms, which comprise the bulk of the firms. Second, although government investment raises employment growth in all firms, it is likely that even more jobs would have been created if the zombie firms were absent. There would have been a higher growth rate of output and hence a higher rate of job creation. The higher overall productivity growth in the absence of zombie firms would also have meant higher wages for the workers. Third, when a province has a higher degree of concentration of state-owned commercial banks, the firms in this province are more likely to become zombies. This is also true when the concentration of SOEs is higher in a province. The reform of the state sector is hence fundamental to the elimination of zombie firms.

It cannot be overemphasized that we are not saying that all government investment is negative. The undeniable fact is that government investment is an efficient instrument for economic management, when properly used. Because China is a developing country and an economy in transition away from central planning, government investment in large physical infrastructure projects and human capital formation programs (e.g., public health and education) can accelerate economic development. Government investment in strategically critical industries (e.g., defense industries) are also necessary, but there should be strict oversight over the cost and scope of the investment. Finally, government investment is a good instrument for macro-stabilization when there are shovel-ready projects available, and when it is not implemented through zombie firms.

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Table A.1. Proportion of zombie firms by industry, 2007

Code	Industry	Proportion	Code	Industry	Proportion
46	Production and Distribution of Water	45.53%	26	Manufacture of Raw Chemical Materials and Chemical Products	10.22%
45	Production and Distribution of Gas	22.90%	6	Mining and Washing of Coal	10.17%
25	Processing of Petroleum, Coking, Processing of Nuclear Fuel	17.94%	24	Manufacture of Articles For Culture, Education and Sport Activity	10.12%
28	Manufacture of Chemical Fibers	16.98%	20	Processing of Timber, Manufacture of Wood, Bamboo, Rattan, Palm, and Straw Products	10.11%
11	Mining of Other Ores	16.87%	21	Manufacture of Furniture	10.03%
10	Mining and Processing of Nonmetal Ores	16.35%	40	Manufacture of Communication Equipment, Computers and Other Electronic Equipment	9.72%
23	Printing, Reproduction of Recording Media	15.03%	34	Manufacture of Metal Products	9.46%
42	Manufacture of Artwork and other Manufacturing	14.85%	22	Manufacture of Paper and Paper Products	8.84%
31	Manufacture of Non-metallic Mineral Products	13.26%	13	Processing of Food from Agricultural Products	8.66%
8	Mining and Processing of Ferrous Metal Ores	12.88%	18	Manufacture of Textile Wearing Apparel, Footwear, and Caps	8.40%
15	Manufacture of Beverages	12.67%	39	Manufacture of Electrical Machinery and Equipment	7.09%
37	Manufacture of Transport Equipment	12.54%	33	Smelting and Pressing of Non-ferrous Metals	6.93%
17	Manufacture of Textile	12.08%	41	Manufacture of Measuring Instruments and Machinery for Cultural Activity and Office Work	6.92%
36	Manufacture of Special Purpose Machinery	12.06%	32	Smelting and Pressing of Ferrous Metals	6.24%
44	Production and Distribution of Electric Power and Heat Power	11.73%	19	Manufacture of Leather, Fur, Feather and Related Products	5.82%
35	Manufacture of General Purpose Machinery	11.64%	43	Recycling and Disposal of Waste	5.50%
30	Manufacture of Plastics	11.53%	9	Mining and Processing of Non-Ferrous Metal Ores	4.64%
29	Manufacture of Rubber	11.05%	7	Extraction of Petroleum, Natural Gas	3.24%
27	Manufacture of Medicines	10.67%	16	Manufacture of Tobacco	0.89%
14	Manufacture of Foods	10.30%			