Zombie Firm Dynamics and China's Monetary Policy

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Preliminary and Please Do Not Circulate

Abstract

By examining dynamics of zombie firms with respect to both the intensive margin and extensive margin, we study the distributional effects of monetary policy on firm performance and reallocation dynamics in China. Based on China Industrial Enterprise database from 1998 to 2013, this paper documents the evidence of two competing forces arising from China's monetary policy practices. First, monetary expansion leads to an improvement upon the extensive margin of Chinese firm dynamics by selecting good firms out of the bad league of "zombie" firms that are marked by negative profits and subsidized borrowing. Simultaneously, conditional on staying as zombies, these firms are associated with greater resource misallocations, thus an deterioration at the intensive margin. Precisely, we show why zombie firms exits: monetary stimulus brings forth improved revenue without further distorting the borrowing cost of these firms. For very persistent zombie firms, leverage went up and revenue was down in spite of increasingly subsidized borrowings. We then build a heterogeneous-firm model to study zombie firm dynamics.

JEL codes: E22, E44, E52, G32, O47

Key Words: Zombie Status, Firm Dynamics, Asymmetric Response, Monetary Policy

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1 Introduction

This paper, by highlighting the heterogeneous responses of capital investment and borrowing to monetary policy changes across firms, examines the distributional effects of monetary policy and its transmission mechanism through lens of production heterogeneities. We find centralized monetary policy moves not only affect the firm performance conditional on the firm distribution, but shift the distribution by altering the resource reallocations across firms.

We address the heterogeneous effects of monetary policy across firms by studying the firm dynamics in China. First, past 30 years of fast-growing experience exhibits that China is heavily indebted to the toolkits of monetary policy to boost its economy and to manage economic fluctuations (Chen et al., 2016a,b). In particular, aggregate capital investment consistently takes a share of 40 % of its total GDP as the largest contributor to China's robust growth. Studying firm dynamics and Chinese monetary policy has general implications by providing estimates of the transmission mechanism of monetary policy attributed to its distributional effects through firms performance. Second, as highlighted in Restuccia and Rogerson (2008) and Hsieh and Klenow (2009), China is marked by a great magnitude of capital and labor misllocations among firms that drive down its aggregate productivity. To what extent an accommodating monetary policy may affect the degree of resource misallocation by triggering heterogeneous firm responses at the micro-level? What are the *aggregated* effects of monetary policy associated with investment channel when both financial frictions and policy distortions are present at the firm level? Answering these questions are particularly important to understand the effectiveness of monetary policy.

We follow Chen et al. (2017) to identify Chinese monetary policy shocks using the M2 growth rate as policy instrument. Alternatively, using residuals from estimates of interest rate rules as rate shocks, the distributional effects of monetary policy on firm performance are found to be robust. Using a large panel data based on China Annual Surveys of Industrial Firms (CASIF) covering years of 1998-2013, we show empirically a criterion of combining profitability and effective cost of borrowing is able to separate firms with capital and leverage reactions sensitive to monetary policy shocks from those whose responses are muted. This criterion happens to be overlapped with the identification of *zombie* firms that are associated with low profitability and subsidized borrowing extensively studied in the literature of zombie firm lending (Caballero et al., 2008; Kwon et al., 2015).

Importantly, we highlight that in terms of both sign and magnitude, the identified heterogeneous responses of firms' investment, employment growth, and borrowings to China's monetary policy between zombie and non-zombie firms are not driven by differences in firm ownership, size, age, and leverage ratio.[1] While sizable resource misllocations are associated with zombie firms dynamics, heterogeneous firm-level responses along this dimension suggests that the aggregate impacts of China's monetary policy depends on how its distributional effects are carried out. We then build a model of firm heterogeneity to deliver the differed firm-level responses to monetary policy between zombies and non-zombies along with the reallocation dynamics among firms.

Our empirical results are twofold. First, zombie firms are found to be strongly expanding in response to the monetary policy lax, while non-zombie firms are contracting that contrast the intended effects of positive shocks. It implies that at the intensive margin, the transmission of China's monetary policy is through providing stimulus to those "bad" firms associated with low profits and engineered low cost of borrowings. Second, monetary policy stimulus "selects" firms with improved profitability and less distorted borrowing cost to exit the zombie firm league. At such extensive margin, monetary expansion in China helps these selected firms improve their debt positions by deleveraging.

These two offsetting effects at intensive and expensive margin suggest a trade-off between reinforcing the resource misallocation to zombie firms and selecting well-stimulated firms as a result of monetary expansion. Our quantitative model, by calibrating to the right moments of Chinese firm dynamics, gives that former effect dominates through aggregation. An im-

[1](State-Owned-Enterprises) SOE firms are often considered having preferential access to formal credits of bank lending, see Song et al. (2011), Chang et al. (2016), and Liu et al. (2017)

portant policy implications of this paper arises: given the capital formation and employment growth in response to positive monetary policy shocks are largely driven by zombie expansions, mechanically forcing the zombie firms to exit may attenuate the overall effectiveness of China's monetary policy.

Related Literature. This paper is related to three strands of literature. First, this paper aligns itself with the stream of works that explores the heterogeneous effects of monetary policy. Kaplan et al. (2018) highlight the differences in the elasticity of households' consumption and savings to changes of monetary policy stances. They argue that the distributional affects of monetary policy across heterogeneous households are non-trivial and are overlooked in the conventional transmission mechanism based on a representative agent New Keynesian model. Focusing on labor income risk and search-match frictions, Gornemann et al. (2016) find that contractionary monetary shocks generate greater inequality across households with respect to wealth, income and consumption, which renders greater aggregate consumption responsiveness to monetary policy shocks. While most of the work is on the household side of heterogeneities, our paper contributes to the literature by exploring the implications of firm heterogeneity for monetary policy transmission. The contemporaneous work by Ottonello and Winberry (2018) studies investment responses of U.S. public firms to identified monetary policy shocks. Our paper, however, differs in that we examine the performance of both listed and unlisted firms, while delve into the connections between reallocation dynamics among firms and the effectiveness of monetary policy.

Second, this paper joins the works that study capital and credit misallocations among firms that lead to lower aggregate productivity dated from (Hsieh and Klenow, 2009; Restuccia and Rogerson, 2008). For the case of China, while SOE firms are argued to be more tightly connected to formal bank lending (Chang et al., 2016; Cong et al., 2018; Liu et al., 2017; Song et al., 2011), this paper is the first to compliment the literature by documenting that zombie vs. non-zombie firms is another important dimension to study credit misallocations. We show that zombie firms are the ones that build leverage and expand in case of monetary policy lax regardless of whether or not this firm is SOE.

Third, a rich literature has documented the causes of zombie firm formation and their distortionary consequences for the economy. Distortions brought by zombie firms on other "healthy" firms are studied mainly in the context of Japanese economy for period of 1990s (Caballero et al., 2008; Peek and Rosengren, 2005). These studies have focused on forbearance lending which helped inefficient firms as the main reason for zombie firms to be kept alive. Recently the development and implications of zombie firms have been examined for a number of other countries, including Korea (Bank of Korea, 2013), the U.K. (Bank of England, 2013), Southern Europe (Acharya et al., 2017), and OECD countries (Adalet McGowan et al., 2017). Our paper is the first one that emphasizes the critical role of zombie firms to better understand the relationship between dynamic resource reallocation among Chinese firms and heterogeneous responses of monetary policy.

The rest of the paper is structured as follows. Section 2 describes the identification of Chinese monetary policy shocks and the firm-level data employed for empirical analysis. Descriptive evidence of zombie firms statics and transition dynamics are also provided. Section 3 discusses the dynamics of zombie firms and provides estimates of the differential responsiveness of zombie firms and non-zombie firms to monetary policy shocks. Section 4 presents the details of a quantitative model of firm heterogeneity with financial frictions. Section 5 concludes.

2 Monetary Policy Shocks and Zombie Firm Dynamics

This section discusses how we identify monetary policy shocks in China. Then we present a simple criterion based on firm profits and effective cost of borrowing to identify zombie firms. We discuss the time series properties of zombie firms vis-a-vis non-zombie firms transition dynamics as preparations to examine firms' heterogeneous responses to monetary policy shocks.

2.1 Monetary Policy Shocks in China

We follow the identification strategies of monetary policy shocks in China à la Chen et al. (2017). Accordingly, our baseline monetary policy instrument is year-over-year (YOY) M2 growth rate ΔM_t, which largely reflects that the central bank of China, People's Bank of China (PBOC) sets official targets for monetary growth.[2] We estimate the following regime switching monetary policy equation such that

$$\Delta M_t = a + \rho \Delta M_{t-1} + \phi_\pi(\pi_{t-1} - \pi^*) + \phi_{Y,t}(\Delta Y_t - \Delta Y^*_{t-1}) + \sigma_{M,t}\epsilon_{M,t} \tag{1}$$

This specification allows the response of M2 growth rate to the gap of GDP growth rate: *de facto* number in year t relative to the official target set one year ahead, $\phi_{Y,t}$ to depend on regime j such that $\phi_{Y,t} = \phi_{Y,j}$ with $j = \{1, 0\}$. Regime j differs from the other when the GDP growth rate gap is positive ($j = 1$) or non-positive ($j = 0$). Similarly, the standard deviation of monetary policy shocks $\epsilon_{M,t}$ may also differ across regimes $\sigma_{M,t} = \sigma_{M,j}$. By contrast, the PBOC's monetary policy response to the actual inflation relative to some specified inflation target ϕ_π is regime-invariant.

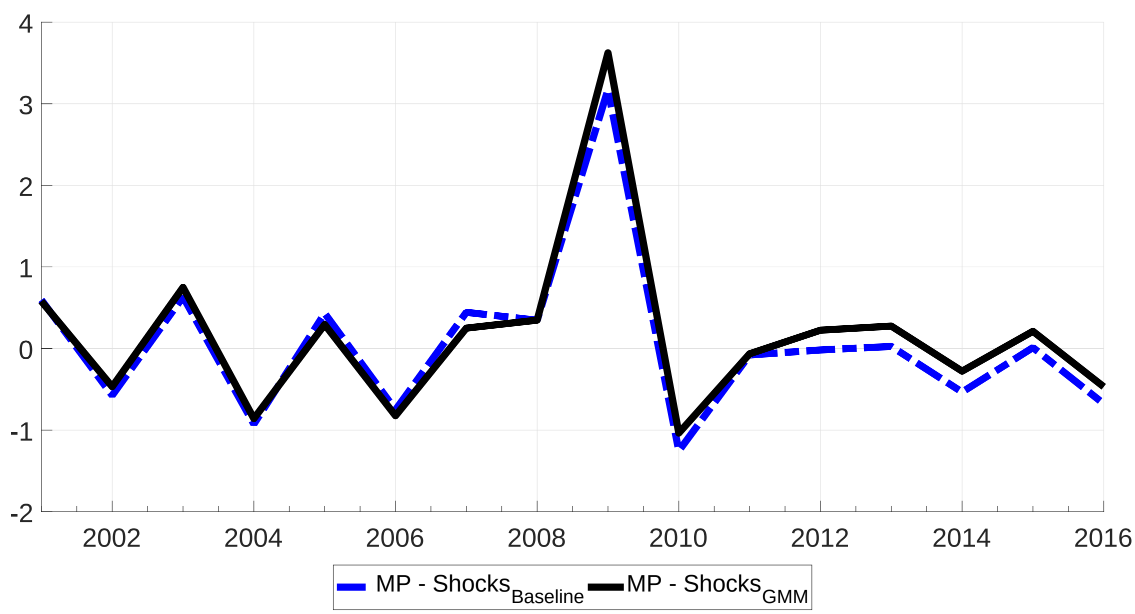
By parsing out the endogenous reactions of M2 growth responses to major variable shortfalls expressed in gaps, we are left with estimated monetary policy shock series of $\epsilon_{M,t}$. We call a positive number of it an expansionary monetary policy shock. Our Markov-Switching estimation is based on quarterly data ranging from 1999Q1 to 2016Q4. For robustness, we also estimated a standard Taylor-type M2 growth reaction function to these inflation and GDP target shortfall gaps using GMM following Clarida et al. (2000). For concerns with the alternative monetary policy instrument, we apply the same GMM estiamtion procedures using 3-month Chinese Government Bond Yield in place of M2 growth rate. We relegate Appendix XXX for a discussion of the estimation details. In sum, our estimates of the

[2]The monetary policy instrument in China is considered mostly quantity-based though a trend to rate-based adjustment is ongoing. Since 2007, PBOC dropped the official target for M1 growth rate but left with M2 target only.

asymmetric monetary policy rule regarding M2 growth rate suggest that monetary growth in China can be pro-growth when the GDP growth falls short the national target whereas the growth rate is lower when the GDP gap is widened, i.e. $\phi_{Y,1} > 0$ and $\phi_{Y,0} < 0$.

In Figure 1, we plot the identified monetary policy shocks against the M2 growth rates over time. It suggests that the shock series is extremely close to each other using either Markov-Switching or GMM structure of estimations. In particular, we see a spike of expansionary monetary shocks occurring in the first two quarters of 2009. Consequently, in the end of 2010Q2, the central bank triggered contractionary shocks. Over time, we see great variations of $\epsilon_{M,t}$. They are then aggregated to yearly numbers matched annual data of firms in order to examine firm-level performance.

Figure 1: Identified China Monetary Policy Shocks (Quarterly)



Notes: Estimations based on quarterly data from 1999Q1 to 2016Q4. Shocks $\epsilon_{M,t} > 0$ denote monetary expansion in terms of M2 Growth. Blue dashed line and black solid line respectively denote the series of monetary policy shocks estimated based on Markov-Switching estimation and GMM estimation. Red-dotted line marks the year-over-year M2 growth rate.

2.2 Firm-level Data

To examine firms' responses to monetary policy shocks, we employ a panel data of Chinese firms based on China Annual Surveys of Industrial Firms (CASIF) for years of 1998 to 2013.

These surveys are conducted by the Chinese government's National Bureau of Statistics. CASIF is a (truncated) census of all non-state manufacturing firms with more than 5 million yuan in revenue (about $700,000) plus all state-owned firms. The revenue cutoff threshold increases to 20 million yuan (about $2.8 million) in later years after 2007. The raw data consists of 100,000 - 150,000 firms before 2004 and the coverage grows to 200,000 - 300,000 firms in the years after 2004.

While this data set has been widely used in studies of Chinese firms ending in 2007,[3] this paper is among the very few to use the newly released firm-level data for years of 2008 to 2013. Concerning the measurement and data issues highlighted in Brandt et al. (2014), we match firms and pick the appropriate price deflators in consistent with Brandt et al. (2017). These treatments are very important to obtain good measures of firm-level real capital stock. For details of dataset construction, see Appendix XXX.

2.3 Firm Classifications: Zombie vs. Non-zombie Firms

We explore the responses of firms to monetary policy shocks in the dimension of zombie vs. non-zombie firms à la Caballero et al. (2008). The collocation term of "zombie firms" was coined to capture the firm characteristics of *low profitability* along with *subsidized* borrowing advantages. Presence of zombie firms are considered severe consequences of capital, labor and credit misallocation among firms. By looking into zombie firms' reactions to monetary policy shocks, we are able to examine effects of monetary policy practices on resource reallocation dynamics.

Numerous works have proposed ways for identifying zombie firms.[4] We start with the identification scheme of Caballero et al. (2008) by first locating those firms when their interest payments are lower than the counterfactual amount of "required" interest payments. Among

[3]For example, Hsieh and Klenow (2009) and Song et al. (2011) use the pre-2008 data to study resource reallocation and aggregate TFP growth. Park et al. (2010) examine the impacts of the Asian financial crisis on Chinese manufacturing firms. Brandt et al. (2017) document large productivity gain among manufacturing firms associated with China's entry into the WTO.

[4]For a summary of zombie firm identifications, see Kwon et al. (2015) for details.

them, we then label those with negative profits as zombie firms. We elaborate the two-step identification as followed.

Step 1: Construct the firm-specific "required" interest payment in year t, $R^*_{i,t}$ and the interest rate gap $Gap_{i,t}$. We lay out the definitions in the following.

$$R^*_{i,t} = r^{ST}_{t-1} SD_{i,t-1} + r^{LT}_{t-1} LD_{i,t-1} \tag{2}$$

where $SD_{i,t}$ and $LD_{i,t}$ denote the short-term and long-term liabilities respectively. r^{ST}_t and r^{LT}_t are the average short-term and long-term prime rates in year t. The former rate averages out the three-month, six-month and one-year prime rates. The long-term rate first takes the mean of prime rates of two-year, five-year, and ten-year lending and is then obtained by applying the five-year moving averages of the mean long term rates. Given that the bank lending rates were not liberalized yet considered in our sample,[5] we scaled the r^{ST}_t and r^{LT}_t by a factor of 0.9, a minimum lower limit that commercial banks can set on a prime lending rate, and our identified sample of zombie firms is insensitive to this treatment.

We further define the interest rate gap for firm i of year t as below:

$$Gap_{i,t} = (R^{Pay}_{i,t} - R^*_{i,t})/B_{i,t-1} \tag{3}$$

where $R^{Pay}_{i,t}$ captures the actual interest payment of firm i. The short interest payment relative to the required amount $R^{Pay}_{i,t} - R^*_{i,t}$ once scaled by the outstanding debt as of year $t-1$ such that $B_{i,t-1} = SD_{i,t-1} + LD_{i,t-1}$ gives the interest rate gap $Gap_{i,t}$. Caballero et al. (2008) argues that by $Gap_{i,t} < 0$, i.e. firm i has received subsidized borrowing, which is sufficient to denote firms with distorted debt advantages. However, a concern with this argument is that firms with low credit risk due to good productivity and sales may have relatively lower borrowing costs. We thus further refine this criterion by considering firm's profitability.

[5] In October 2015, the upper (lower) bounds of bank deposit (lending) rates set by PBOC were removed.

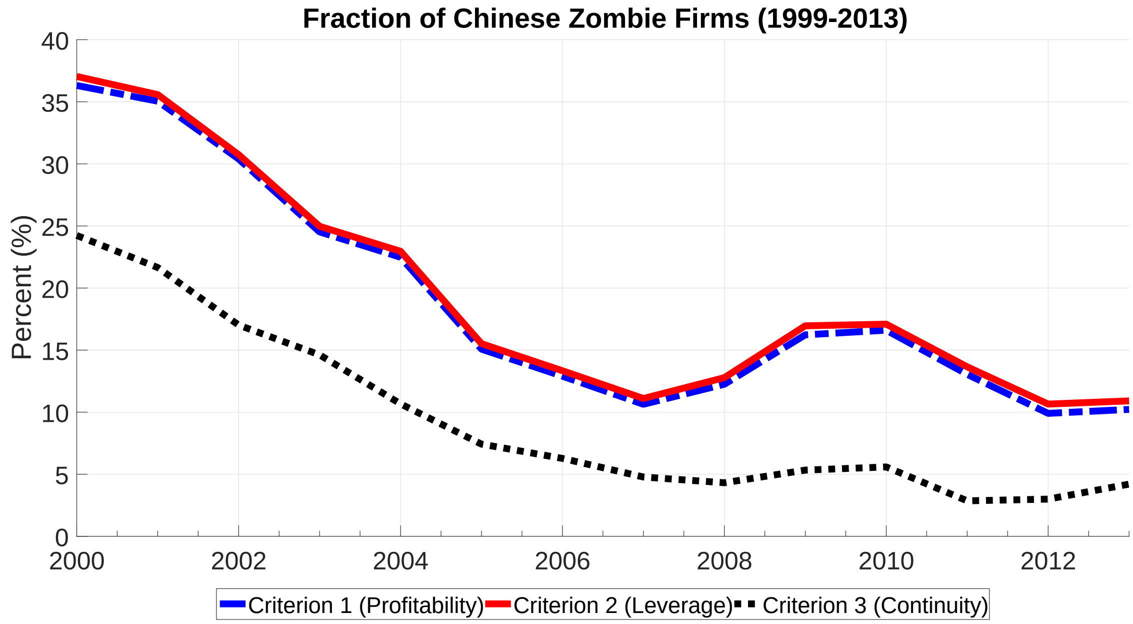
Step 2: Narrow the scope of firms of $Gap_{i,t} < 0$ to those with negative profits. In specific, conditional on a negative interest payment gap, if firm i has earned positive profit for year t, we discard these firms from the initial sample. Note the possibility that temporary profit shortfalls in year t may accidentally mis-classify some firms into zombies. We also used smoothed past two-year and three-year profits respectively in place of year t profit for refining zombie firm sample. It shows in Figure 6 that the group of identified zombie firms is robust to these alternates.[6]

2.4 Descriptive Statistics

In Figure 2, we plot the share of zombie firms and the share weighted by firm total asset in percent from 1999 to 2013. In general, the proportion of zombie firms declined over time regardless of whether or not the share is asset weighted. Throughout the post-crisis years of 2009-2010 when the package of monetary and fiscal stimulus were implemented, we see the share of zombie firms dropped continuously until it rebounded in 2012.

[6] Kwon et al. (2015) adopts a refining criterion upon Caballero et al. (2008) by restricting zombie firms in year t to those who are identified twice for two consecutive years since $t-1$ to t. We impose a two-year and three-year continuity restriction respectively on our two-step identified zombie sample. Our main results associated with heterogeneous responses of zombies relative to non-zombie firms to monetary policy shocks still hold. For the share of zombie firms identified using a two-year continuity criterion, see Figure 7

Figure 2: China: Proportion of Zombie Firms (1999-2013)



Notes: Zombie firms are the manufacturing firms with negative interest rate gap and negative profits. Blue solid line and black dashed line respectively denotes the unweighted and weighted share of zombie firms. Red-dotted line marks the year of 2009 where we identified the greatest positive monetary policy shocks.

Table 1 summarizes the key firm operation metrics for both groups of zombie and non-zombie firms. We report the mean along with their differences. Overall, all the differences are significant at 1 % level, suggesting differed firm characteristics across the two groups. In specific, zombie firms are on average less productive, borrowed more, and have higher leverage ratio. By construction, these firms are having negative thus lower profits. In addition, we see that zombie firms are not necessarily large firms (measured in total asset) though they are comparatively older. Importantly, note that though zombie firms are more likely to be SOEs (13 %) than non-zombie firms, we have more SOE firms in the non-zombie group accounting for the firm number differences. Conditional on being SOE firms, we calculated in our sample that around 50 % of them are zombies.

Table 1: Operation Metrics Comparisons: Zombie vs. Non-zombie Firms

Variables (Mean)	Non-Zombies	Zombies	diff
Employment (log)	5.08	4.96	0.11
Output (log)	10.70	9.97	0.73
Labor Productivity (log)	5.52	4.88	0.64
Capital/Labor (K/L ratio)	3.63	3.89	-0.26
Investment Rate	0.18	0.07	0.11
Short-term Debt (log)	9.17	9.60	-0.43
Long-term Debt (log)	2.45	3.42	-0.97
Debt/Asset (Leverage)	0.51	0.63	-0.12
SOE Share	0.03	0.13	-0.10
Profit Rate	0.06	-0.96	1.02
Firm Age (Years)	15.20	19.72	-4.52
No. Firms	393,635	71,209	

Notes: Sample: 1999 to 2013. All differences are statistically significant at 1 % level.

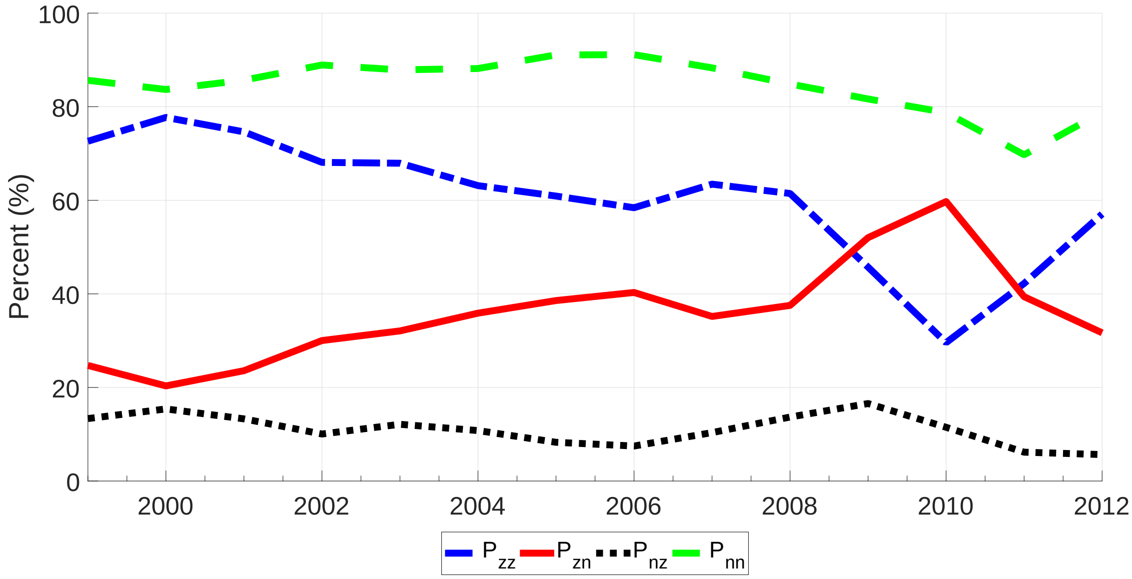
2.5 Zombie Firm Dynamics

Given the static differences of characteristics across zombie and non-zombie firm groups, we move on to examine the reshuffling of firms across groups. Time-variation in zombie vis-à-vis non-zombie transitions, i.e. zombie entries and exits, is an important facade of firm dynamics that is overlooked in the literature regarding Chinese zombie firms. It is important to look at not only the responses of firms to monetary policy shocks conditional on being zombie or non-zombie firms but also the impacts of monetary policy on resource reallocation as implied by zombie firm dynamics. We proceed by first computing the zombie and non-zombie transition probabilities over time and give a steady state estimate of zombie status transition matrix. Transition probabilities will be then taken into regression analysis to examine how the monetary policy may also affect the share of zombie firms and the overall distribution of heterogeneous firms.

We evaluate the likelihood of a firm to continue operating as zombie or non-zombie firm conditional on its status in the previous year, i.e. the transition probabilities of changing status of being zombies and non-zombies. In specific, we calculate the percent of identified zombie firms at year $t-1$ that entered year t as non-zombies $P_{zn,t}$ (zombie exits) along with the proportion of non-zombies that shifted their status to zombies in year t, $P_{nz,t}$ (zombie entries). Similarly, the probabilities of surviving status can be evaluated as well for $P_{zz,t}$ (zombie stays) and $P_{nn,t}$ (non-zombie stays).

We plot the four time series capturing the status transition probabilities for years of 2000 up to 2013 in Figure 3. Note that the probability of staying plus that of exiting a status ($P_{zn,t} + P_{zz,t}$ or $P_{nn,t} + P_{nz,t}$) is not equal to one due to the fact that some firm-year observations are missing when evaluating the consecutive status shifts. Two key insights can be drawn from the plot. First and foremost, the likelihood for a non-zombie firm to stay as non-zombie is high (around 82 %) and this probability goes stably over time. Similarly, the chance for a non-zombie firm to shift its status as a zombie entry firm is consistently low (below 15 %). However, focusing on zombie firm transitions, we see zombies are increasingly less likely to continue as zombies and the probability for them to enter as non-zombies is rising over time. Both of these two transition probabilities are moving at a constant rate before 2009. In addition, we see dramatically high reshuffling probabilities of zombie exits are taking places for periods of 2009-2011. As more zombie firms entered the next year as non-zombies, their profit conditions and/or subsidized borrowing status were improved by definition. What's more, we see non-zombie firms were less likely to stay as non-zombies for the same period. More interestingly, around the year of 2012, all these trends of transition dynamics were reversed.

Figure 3: Transition Probabilities of Zombie Dummy among Chinese Firms (2000-2013)



Notes: Conditional Transition Probabilities do not add up to 1 due to data missing. Red solid vertical line marks the peak of our identified positive monetary policy shocks.

Finally, we average the transition probabilities over time. Table 2 summarizes a steady state transition matrix of zombie vis-a-vis non-zombie status. The transition probability matrix has rows correspond to status of current year and columns that of the future year. With normalization, the conditional probabilities in a row sum up to one. The table suggests that non-zombie firms have trivial probabilities of falling into the league of zombie firms ($P_{nz} = 9\%$). However, on average, the zombie firms may have a decent chance of exiting and entering the next year as non-zombie firms ($P_{zn} = 43\%$) given improved profit and leverage conditions. The likelihood for a zombie firm to survive as zombies for continuously five years is about a scant of 6 %. Importantly, we see that the probability for a zombie firm to exit as non-zombie and re-enter as zombie is low due to the size of P_{nz}. It suggests that conditional upon improvement, newly exited zombie firms would be very much likely to persist as non-zombie firms.

Table 2: Transition Probability Matrix of Zombie Status

	Zombie Status	Non-Zombie Status
Zombie Status	0.57	0.43
Non-Zombie Status	0.09	0.91

Notes: Probabilities are averages of those over years of 2000 to 2013. Conditional transition probabilities are normalized such that each row adds up to 1 .

3 Empirics

In this section, we use the panel data constructed from China manufacturing census to explore the heterogeneous response to identified monetary shocks. In addition, we examine whether the monetary expansion also affects the share of zombie firms, which has great implications for the dynamics of resource reallocation.

3.1 Heterogeneous Responses of Firms to Monetary Policy Shocks

We examine if different types of firms, i.e. zombie and non-zombie firms are having differed responses to to given monetary policy shocks. We firstly estimate the following equation such that

$$y_{icst} = \delta_{cst} + \alpha_i + \beta LRatio_{icst} \times \epsilon_{M,t-1} + \gamma X_{icst} + \varepsilon_{icst} \tag{4}$$

where y_{icst} refers to a given firm-level outcome measure for firm i, in city c, in sector s and at year t. Here we include five performance variables: employment, output, short-term borrowing, long-term borrowing all expressed in annual growth rate and the investment-capital ratio, i.e. investment rate. We are interested in the estimation of this equation because the estimate of coefficient associated with the interaction term of leverage ratio and monetary policy shocks $LRatio_{icst} \times \epsilon_{M,t-1}$, β.[7] Firm-level controls X_{icst} include the age and

[7]We lag the monetary policy shocks by one year to explore the causal interpretations thereafter.

size (total asset) of the firm.

Importantly, a statistically different-than-zero coefficient suggests the *presence* of borrowing channel that is interacted with monetary policy so as to determine the effects of expansionary monetary policy of greater $\epsilon_{M,t-1}$ on firm performance. A greater estimate would mean higher leveraged firms are more sensitive to monetary policy shocks with respect to an outcome variable y_{icst}. Table 3 summarizes the key results regarding the selected variables. Columns (1) to (4) suggest that firms with higher leverage ratios are more responsive to monetary shocks when making employment, output and borrowing decisions. However, when it comes to investment decision, more leveraged firms are less inclined to accumulate capital conditional on positive monetary policy shocks according to the estimate of β in Column (5). Our result regarding firm-level investment is consistent with Ottonello and Winberry (2018) on U.S. public firms. The interpretation of this negative sign is that more leveraged firms are more financially constrained such that additional borrowing due to monetary stimulus incurs higher marginal cost of capital investment. Therefore, the impact of positive policy shocks reduces the firm-level investment.

Table 3: Responses to Monetary Policy Shocks Conditional on Firm Leverage

Dependent Variable	Δ Emp.	Δ Output	Δ ST Debt	Δ LT Debt	I_t/K_{t-1}
	(1)	(2)	(3)	(4)	(5)
$LRatio_{icst} \times \epsilon_{M,t-1}$	0.012***	0.011***	0.016***	0.049**	-0.015**
	(0.004)	(0.003)	(0.005)	(0.003)	(0.007)
City-Industry-Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
S.E. Clustered by	city	city	city	city	city
No. Obs.	2,340,055	2,340,055	2,340,055	2,340,055	1,619,678
Adj. R-squared	0.210	0.254	0.016	0.070	0.136

Notes: *LRatio* is defined as total debt of firm i divided by total assets. Monetary shocks $\epsilon_{M,t}$ are represented by the M2 growth rate shocks identified from the Markov-Switching framework à la Chen et al. (2017). ST debt and LT debt refer to the short-term and long-term debt on the firm's balance sheet. I_t/K_{t-1} refers to the investment rate, defined as changes in fixed assets plus depreciation divided by lagged fixed assets. Dependent variables are growth rates of employment, output, short-term debt and long-term debt in Columns (1)-(4). The outcome variable in Column (5) is the level of investment rate. Clustered standard errors (at city level) are reported in parentheses. Significance levels: $*$ (p<0.10), $**$ (p<0.05), $***$ (p<0.01).

We then estimate the following specification to examine heterogeneous responses of zombie and non-zombie firms controlling for firm leverages, age, and size. Our empirical strategy is specified as below:

$$y_{icst} = \delta_{cst} + \alpha_i + \beta Zombie_{icst} \times \epsilon_{M,t-1} + \gamma X_{icst} + \varepsilon_{icst} \tag{5}$$

where the dummy variable $Zombie_{icst}$ equals to 1 if firm i is a zombie firm. Firm controls X_{icst} now include firm leverage, age, and size. Our focus is on the coefficient associated with the interaction term β, to examine if zombie firms are having different responses to monetary policy shocks relative to benchmark response of non-zombie firms.

Table 4 presents the estimates of coefficients for different outcome variables per the specification of Equation (5). Per the 1 % exogenous increases in monetary growth, we find that zombie firms are more responsive with 1.8 percentage points (pp) more in employment growth relative to non-zombie firms. This excessive expansionary responses are also true for output and debt growth along with capital investment. In sum, across columns, positive monetary shocks provide excessive stimulus to zombie firms than non-zombie firms. These results has great implications for resource reallocation: an expansionary monetary policy has distortionary effects by promoting more capital, labor and credit misallocations to zombie firms that are already of low profits and subsidized borrowing advantages. Therefore, monetary lax is found to have unintended consequences by triggering heterogeneous firm responses across zombie and non-zombie firms.

Table 4: Responses to Monetary Policy Shocks: Zombie Firms Relative to Non-zombie Firms

	Δ Employment	Δ Output	Δ ST Debt	Δ LT Debt	I_t/K_{t-1}
	(1)	(2)	(3)	(4)	(5)
$Zombie_{icst} \times \epsilon_{M,t-1}$	0.018***	0.024***	0.008***	0.015***	0.009***
City-Industry-Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Clustered by	city	city	city	city	city

Notes: Monetary shocks $\epsilon_{M,t}$ are represented by the M2 growth rate shocks identified from the Markov-Switching framework à la Chen et al. (2017). ST debt and LT debt refer to the short-term and long-term debt on the firm's balance sheet. I_t/K_{t-1} refers to the investment rate, defined as changes in fixed assets plus depreciation divided by lagged fixed assets. Dependent variables are growth rates of employment, output, short-term debt and long-term debt in Columns (1)-(4). The outcome variable in Column (5) is the level of investment rate. Clustered standard errors (at city level) are reported in parentheses. Significance levels: $*$ (p<0.10), $**$ (p<0.05), $***$ (p<0.01).

Our baseline results suggest that zombie firms are more responsive to the monetary policy shocks relative to non-zombie firms. We address a critical concern that this result is driven by firm ownership as SOE firms are more likely to be zombie firms. We separate our samples into SOE and non-SOE firm groups and re-estimated Equation (5). As shown in Table 5, regardless of whether or not firms are SOEs, we see zombie firms are more response to monetary policy shocks in terms of all outcome variables except for the short-term debt in which the distinction in responses is due to non-SOE firms. In general, we are safe to maintain that the heterogeneous responses to monetary policy shocks are not driven by the differences in firm ownership.

Table 5: Responses to Monetary Policy Shocks: Zombie Firms vs. SOE Firms

Subsample: SOE=1	Employment	Output	ST Debt	LT Debt	I_t/K_{t-1}
$Zombie_{icst} \times \epsilon_{M,t-1}$	0.012***	0.015***	0.004	0.031***	0.005***
Subsample: SOE=0	ΔEmployment	ΔOutput	ΔST Debt	ΔLT Debt	I_t/K_{t-1}
$Zombie_{icst} \times \epsilon_{M,t-1}$	0.016***	0.025***	0.008***	0.013***	0.010***
City-Industry-Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Clustered by	city	city	city	city	city

Notes: Monetary shocks $\epsilon_{M,t}$ are represented by the M2 growth rate shocks identified from the Markov-Switching framework à la Chen et al. (2017). ST debt and LT debt refer to the short-term and long-term debt on the firm's balance sheet. I_t/K_{t-1} refers to the investment rate, defined as changes in fixed assets plus depreciation divided by lagged fixed assets. Dependent variables are growth rates of employment, output, short-term debt and long-term debt in Columns (1)-(4). The outcome variable in Column (5) is the level of investment rate. Clustered standard errors (at city level) are reported in parentheses. Significance levels: $*$ (p<0.10), $**$ (p<0.05), $***$ (p<0.01).

Given zombie firms are more responsive to monetary policy shocks controlling for leverage, age, and size differences, we further explore whether or not the sign of responses to positive monetary policy shocks are different across zombie and non-zombie firm groups. We estimate the following equation by restricting firm sample for year t to be zombie firms and non-zombie firms only.

$$y_{icst} = \delta_{cst} + \alpha_i + \beta\epsilon_{M,t-1} + \gamma X_{icst} + \varepsilon_{icst} \tag{6}$$

Table 6 summarizes the estimation results. The results show that conditional on monetary expansion, zombie firms are provided with the right stimulus to expand. However, what is more surprising is that non-zombie firms are shrinking. With respect to capital investment, firms' investment decisions are not statistically affected by monetary policy practices. In sum, we again confirm our findings in Table 4 that on relatively terms, capital, labor, and credits are misallocated to zombie firms given the monetary stimulus. In addition, resources are knocked out of non-zombie firms such that expansionary monetary policy has unintended consequences that contracts these firms. It shows that monetary policy shocks do have distributional effects in the zombie and non-zombie firm dimensions.

Table 6: Responses to Monetary Policy Shocks: Zombie Firms vs. Non-zombie Firms

Subsample: Zombie=1	Δ Employment	Δ Output	Δ ST Debt	Δ LT Debt	I_t/K_{t-1}
$\epsilon_{M,t-1}$	0.006***	0.009***	0.011***	0.021***	-0.002
Subsample: Zombie=0	Δ Employment	Δ Output	Δ ST Debt	Δ LT Debt	I_t/K_{t-1}
$\epsilon_{M,t-1}$	-0.017***	-0.021***	-0.004***	-0.006***	-0.014
City-Industry FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Clustered by	Firm	Firm	Firm	Firm	Firm

Notes: Monetary shocks $\epsilon_{M,t}$ are represented by the M2 growth rate shocks identified from the Markov-Switching framework à la Chen et al. (2017). ST debt and LT debt refer to the short-term and long-term debt on the firm's balance sheet. I_t/K_{t-1} refers to the investment rate, defined as changes in fixed assets plus depreciation divided by lagged fixed assets. Dependent variables are growth rates of employment, output, short-term debt and long-term debt in Columns (1)-(4). The outcome variable in Column (5) is the level of investment rate. Clustered standard errors (at city level) are reported in parentheses. Significance levels: $*$ (p<0.10), $**$ (p<0.05), $***$ (p<0.01).

3.2 Effects on Zombie Status Transitions: Dynamic Reallocation

Over time, we see zombie firms may exit the status of being zombie and have their profits and debt positions improved. In this section, we examine if monetary policy is able to affect the degree of resource misallocation that is associated with zombie firms by shifting the probability of zombies firms transitioning to non-zombie firms.

First, we examine how monetary policy shock may shift the firm's zombie status over time. We focus on how monetary policy shocks would affect the entry or exit of zombie status at the firm-level. Monetary policy shocks could help firms exit their zombie status through improved profit rates or reduced interest rate gap conditional on firm-level control variables.

Table 7 summarizes the tests on the two channels. The results show that monetary expansion is associated with significant improvement in profit rate, however the effect on change in interest rate gap is relatively very limited. Monetary policy shock appears more likely to be an aggregate demand shock that drives some zombie firms out of zombie status. Furthermore, the effect on profit rate is more evident on firms not related to government.

Another interpretation is that monetary expansion could relax the borrowing constraint for firms, then improve the profit margin, especially for firms not related to government which are more constrained in borrowing.

Table 7: Responses to Monetary Policy Shocks: Criterion for Zombie Status Change

$Zombie\,status\,criterion$	$Profit\,rate$	$Interest\,gap$
	(1)	(2)
$M2\,growth\,shock_{t-1}$	0.207***	-0.006
$M2\,growth\,shock_{t-1} \times Gov-related_i$	-0.127***	0.009
$profit\,rate_{it-1}$		0.000
$interest\,gap_{it-1}$	0.140	
$log\,(Capital)_{it-1}$	-0.540***	-0.010
$leverage_{it-1}$	-0.289***	-0.069***
City FE, Industry FE	Yes	Yes
S.E. Clustered by	city	city

Notes: Significance levels: $*$ (p<0.10), $**$ (p<0.05), $***$ (p<0.01).

Then we estimate the effect of monetary policy shock on the zombie status transition probability via the following equation

$$Prob_{t-1,t} = \delta_{cst} + \alpha_i + \beta\epsilon_{M,t-1} + \gamma X_{icst} + \varepsilon_{icst} \tag{7}$$

where the dependent variable is the normalized conditional probabilities for a firm to survive its previous year status of zombie or non-zombie. The interpretations on the probabilities of switching zombie status is straightforward. Control vector X_{icst} includes firm age, size, ownership, leverage, capital-labor ratio, inventory-output ratio for a fuller determination of transition probabilities. The coefficient estimate of β thus suggests to what extent monetary policy can affect the resource reallocation that is associated with presence of zombie firms.

Table 8 summarizes the key estimation results. First, the monetary stimulus in year $t-1$ is able to reduce the probability for a zombie firm to stay as a zombie in year t while enhances the status for a non-zombie firm to stay as a non-zombie. This suggests that expansionary monetary policy shocks well selects good firms to exit the league of zombie firms that are associated with low profits and distortionary borrowing. Besides, most of the other firm-level control variables also have expected signs. Conditional on being larger firms by asset, both persistence of status increase. Interesting, SOE firms are more likely than POE firms to persist over time as zombie firms. In addition, older firms, higher leveraged firms, more capital intensive firms, and those with larger inventory ratio are having larger probability of stay as zombie according to Column (1). Intuitively, these firm features by results in Column (2) suggest that non-zombie firms are more likely to get downgraded to zombie firms. In addition, Table 9 shows how the effect of monetary shock on zombie status transition varies with firm characteristics via interaction terms, in this setup we can control for city-industry-year fixed effect to caputure the differential responses. We find that firms with higher leverage, higher inventory ratio, larger size of employment and in construction sector would be more likely to jump out of zombie status following the monetary policy shock.

Table 8: Monetary Policy: Effects on Zombie Status Transitions

Dependent Variable	$P(Z_t = 1 \mid Z_{t-1} = 1)$	$P(Z_t = 0 \mid Z_{t-1} = 0)$
	(1)	(2)
$\epsilon_{M,t-1}$	-0.008***	0.006***
$log(Asset)_{it-1}$	0.006***	0.0043***
$log(age)_{it-1}$	0.044***	-0.0076***
SOE_t	0.129***	-0.074***
$Leverage_t$	0.020***	-0.018***
$Capital_t/Labor_t$	0.011***	-0.002***
$Inventory_t/Output_t$	0.0002*	-0.0009***
City-Industry FE	Yes	Yes
S.E. Clustered by	City	City

Notes: Significance levels: $*$ (p<0.10), $**$ (p<0.05), $***$ (p<0.01).

Table 9: Monetary Policy: Heterogeneous Effects on Zombie Status Transitions

Transition Prob.	$P(Z_t = 1 \mid Z_{t-1} = 1)$	$P(Z_t = 0 \mid Z_{t-1} = 0)$
	(1)	(2)
$M2\,growth\,shock_{t-1} \times Gov-related$	-0.004	0.007***
$M2\,growth\,shock_{t-1} \times Leverage$	-0.003***	0.000
$M2\,growth\,shock_{t-1} \times Inventory/Output$	-0.003***	-0.002
$M2\,growth\,shock_{t-1} \times log(Employment)$	-0.008***	0.004
$M2\,growth\,shock_{t-1} \times Construction\,Sector$	-0.0043**	-0.0002
City-Industry-Year FE	Yes	Yes
S.E. Clustered by	city	city

Notes: Significance levels: $*$ (p<0.10), $**$ (p<0.05), $***$ (p<0.01).

Another important fact on the extension margin of zombie dynamics is that, there is an asymmetric response of zombie status change to monetary policy shocks. Table 10 shows that positive monetary policy shocks contribute more in the zombie to non-zombie transition, while the effect on non-zombie to non-zombie transition is also statistically asymmetric.

Table 10: Monetary Policy: Asymmetric Effects on Zombie Status Transitions

Transition Prob.	$P(Z_t = 1 \mid Z_{t-1} = 1)$	$P(Z_t = 0 \mid Z_{t-1} = 0)$
Asymmetric response	(1)	(2)
$M2\,growth\,shock_{t-1}$	0.137***	-0.011***
$M2\,growth\,shock_{t-1} \times Postive\,MP\,shock$	-0.157***	0.018***
$log(Asset)_{it-1}$	0.004***	0.005***
$log(age)_{it-1}$	0.048***	-0.009***
SOE	0.127***	-0.090***
$Leverage$	0.014***	-0.018***
$Capital/Labor$	0.016***	-0.004***
$Inventory/Output$	0.000	-0.001
City-Industry FE	Yes	Yes
S.E. Clustered by	city	city

Notes: Significance levels: $*$ (p<0.10), $**$ (p<0.05), $***$ (p<0.01).

Finally, we present the positive link between the degree of capital and labor misallocation and the share of zombie firms. Following Hsieh and Klenow (2009), we use the cross-sectional dispersion at the city-industry-year level of nominal value added of firm i per unit of capital (standard deviation of marginal revenue product of capital Std-MRPK) and that per number of employees (standard deviation of marginal revenue product of labor Std-MRPL) to proxy for the extent of factor misallocation. Table 12 presents the results of a regression of standard deviation of MPRK and MPRL. on asset-weighted zombie shares. The coefficient estimates on Std(MPRL) and Std(MPRK) suggest that the presence of zombie firms itself is associated with non-trivial resource misallocations.

Table 11: Relationship between Zombie Shares and Dynamic Resource Misallocation

Dependent Variable	Std(MRPL)	Std(MRPK)
	(1)	(2)
Weighted $Z - Shares_{cst}$	0.161***	0.183***
	(0.011)	(0.086)
City-Industry-Year FE	Yes	Yes
S.E. Clustered by	City	City
Observations	68,302	83,105
Adj. R-squared	0.192	0.115

Notes: Significance levels: $*$ (p<0.10), $**$ (p<0.05), $***$ (p<0.01).

In sum, expansionary monetary policy, though at the cost of reinforcing the resource misallocation to zombie firms at the intensive margin, alleviates the degree of misallocation associated with the size of zombie share by reducing the probability of having persistent zombie firms.

4 Model

We proceed to quantitatively evaluate the firm dynamics of Chinese economy and the heterogeneous responses to monetary policy changes across firms. Our model environment features the heterogeneous firms who are subject to three market frictions: size-dependent borrowing constraint, non-convex capital adjustment cost, and the distorted cost of borrowing. While the former two helps align the model-implied firm distribution of investment and leverage ratio to Chinese data, the latter is a reduced-form way of identifying the degree of "zombieness" in a model, i.e. how much a low-profit firm's continuation depends on interest rate subsidy.

4.1 Firms

Firms produce differentiated varieties of goods. Each firm i's output $y_{i,t}$ is produced via a Cobb-Douglas production function $y_{i,t} = A_{i,t}k_{i,t}^{\alpha}l_{i,t}^{1-\alpha}$ with productivity factor $A_{i,t}$, the predetermined capital $k_{i,t}$ and labor input $l_{i,t}$ in period t. Demand function of this variety is given by $y_{i,t} = p_{i,t}^{-\xi}$ with $p_{i,t}$ the good price and elasticity of demand $\xi > 0$.[8]

Productivity factor $A_{i,t}$ can be further decomposed in the following log-additive form such that

$$\log(A_{i,t}) = \log(A_t) + \log(A_i^P) + \log(A_{i,t}^T) \tag{8}$$

where A_t captures the level of aggregate total factor productivity and A_i^P and $A_{i,t}^T$ denote the permanent and transitory component of firm-level productivity respectively. This setup entertains the possibility of modeling State-owned-Enterprise (SOE) and non-SOE firms differently by the permanent productivity A_i^P. The transitory firm productivity is assumed to follow an AR(1) stationary process such that

$$\log(A_{i,t}^T) = \rho \log(A_{i,t-1}^T) - \frac{\sigma_T^2}{2(1+\rho)} + \upsilon_{i,t}^T \tag{9}$$

where ρ measures the persistence of idiosyncratic transitory productivity shocks $\upsilon_{i,t}^T \sim \mathbb{N}(0, \sigma_T^2)$ with σ_T the unconditional S.D. of shocks. The constant normalizes the unconditional mean of $A_{i,t}^T$ to be unit one.

Firms maximizes the infinite sum of discounted stream of profits $E_0 \sum_{t=0}^{\infty} \beta^t f(\pi_t)$. $f(.)$

[8]It follows that the firm i's revenue is $\pi_{i,t} = A_{i,t}^{\frac{\xi-1}{\xi}} k_{i,t}^{\alpha\frac{\xi-1}{\xi}} l_{i,t}^{(1-\alpha)\frac{\xi-1}{\xi}}$, which shows that revenue has decreasing returns to scales with respect to capital and labor.

function gives the flexibility to build in risk-aversion and flow profit for each period $\pi_{i,t}$ is given by

$$\pi_t = p_{i,t}y_{i,t} - w_t l_{i,t} + b_{i,t+1} - (1 + \epsilon_{i,t} \cdot r_t)b_{i,t} - x_{i,t} - \frac{\psi}{2}\frac{(k_{i,t+1} - k_{i,t})^2}{k_{i,t}} - \iota_{x_{i,t} \neq 1}\chi k_{i,t}. \quad (10)$$

Firm's profit is captured by sales revenue in addition to newly incurred debt $b_{i,t+1}$ after the wage payment $w_t l_{i,t}$, investment $x_{i,t} = k_{i,t+1} - (1-\delta)k_t$ along with capital adjustment cost, and outstanding debt obligations including interest payment are paid. Note that the adjustment cost has both convex (quadratic cost) and a non-convex component (fixed cost, fraction χ of exiting capital is wasted if non-zero investment/disinvestment is taken).

A key model ingredient here is that each firm i at each period faces differentiated interest rate adjustment $\epsilon_{i,t} > 0$ relative to the benchmark baseline interest rate r_t. We assume that this scale factor has unconditional mean of one across firms and over time in line of an AR(1) process

$$\log(\epsilon_{i,t}) = \rho_\epsilon \log(\epsilon_{i,t-1}) - \frac{\sigma_\epsilon^2}{2(1+\rho_\epsilon)} + e_{i,t} \quad (11)$$

$e_i t \sim \mathbb{N}(0, \sigma_\epsilon^2)$ denotes the idiosyncratic interest rate adjustment shocks that affect the ex-post effective borrowing cost faced by firm i. Note that $\epsilon_{i,t} > 1$ captures the case when firms are borrowing with an above-baseline interest cost whereas $\epsilon_{i,t} < 1$ means this firm's borrowing is subsidized. Ultimately, we use the intersection of endogenous distribution of profits and the exogenously determined interest rate distortions to identify the margins of zombie firms: low profits along with interest rate subsidies. Monetary policy changes will be modeled as changes to the baseline interest rate r_t. The model is then able to quantitatively examine firms exiting and entering the zombie club along with staying zombies' investment, debt, and labor decisions with and without monetary policy changes.

In addition, we assume firms' borrowing is subject to a size-dependent constraint à la

Gopinath et al. (2017)

$$b_{i,t} \leq \phi_0 \cdot k_{i,t} + \phi_1[\exp(k_{i,t}) - 1] \tag{12}$$

Equation (12) differs from the conventional borrowing constraint in the way that some convexity of debt borrowing with respect to existing capital is built in. It implies that larger borrowing-constrained firms as measured by capital size has larger debt position. Parameters of ϕ_0 and ϕ_1 will be disciplined by the fact suggested by data that larger Chinese firms is associated with larger leverage ratio.

4.2 Model Solution

We solve a partial equilibrium version of this model at this stage. For ease of computation, we define firm's net worth $q_{i,t} = k_{i,t} - b_{i,t}$. We impose that firms are risk-averse in form of holding a CRRA utility function $f(\pi_{i,t}) = \frac{\pi_{i,t}^{1-\gamma}}{1-\gamma}$.[9] Then we re-express the profit maximization problem into a recursive form regarding firms value function.

$$V(q, k; Z^P, Z, r, Z^T, \epsilon) = \max_{q',k',l}\{V^{adj}, V^{non-adj}\} \tag{13}$$

where V^{adj} and $V^{non-adj}$ respectively denotes the firm value of taking non-zero or zero investment.

$$\begin{aligned} V^{adj} &= \max_{q',k',l} f[p(y)y - wl - (r\epsilon + \delta)k + (1 + r\epsilon)q - q' - \frac{\psi}{2}\frac{(k' - k)^2}{k} - \chi k] \\ &+ \beta \mathbb{E} V(q', k'; Z^{P'}, Z', r', Z^{T'}, \epsilon') \end{aligned} \tag{14}$$

$$\begin{aligned} V^{non-adj} &= \max_{q',l} f[p(y)y - wl - (r\epsilon + \delta)k + (1 + r\epsilon)q - q'] \\ &+ \beta \mathbb{E} V(q', k; Z^{P'}, Z', r', Z^{T'}, \epsilon') \end{aligned} \tag{15}$$

[9]This approximates a general equilibrium format of the model setup such that profits will be returned to households who have some coefficient of risk-aversion $\gamma > 0$.

Further, we can reduce the choice variable of this dynamic programming problem into k' and q' after substituting out the optimal l given the first order condition of labor input. Again the borrowing constraint expressed in q and k can be written as

$$k \leq \frac{1}{1-\phi_0}[q + \phi_1(\exp(k) - 1)] \tag{16}$$

We solve the model by fixing the wage rate w at unit one and iterating over the value function with occasionally binding constraint and investment discontinuity considered.

4.3 Calibration

In this section, we discuss the calibration exercise of our key parameter set and show the model-implied distribution moments. For an overview, we show in the following the key metrics regarding capital investment, labor hiring, and debt growth, which are our main focus of data moments that helps discipline the model.

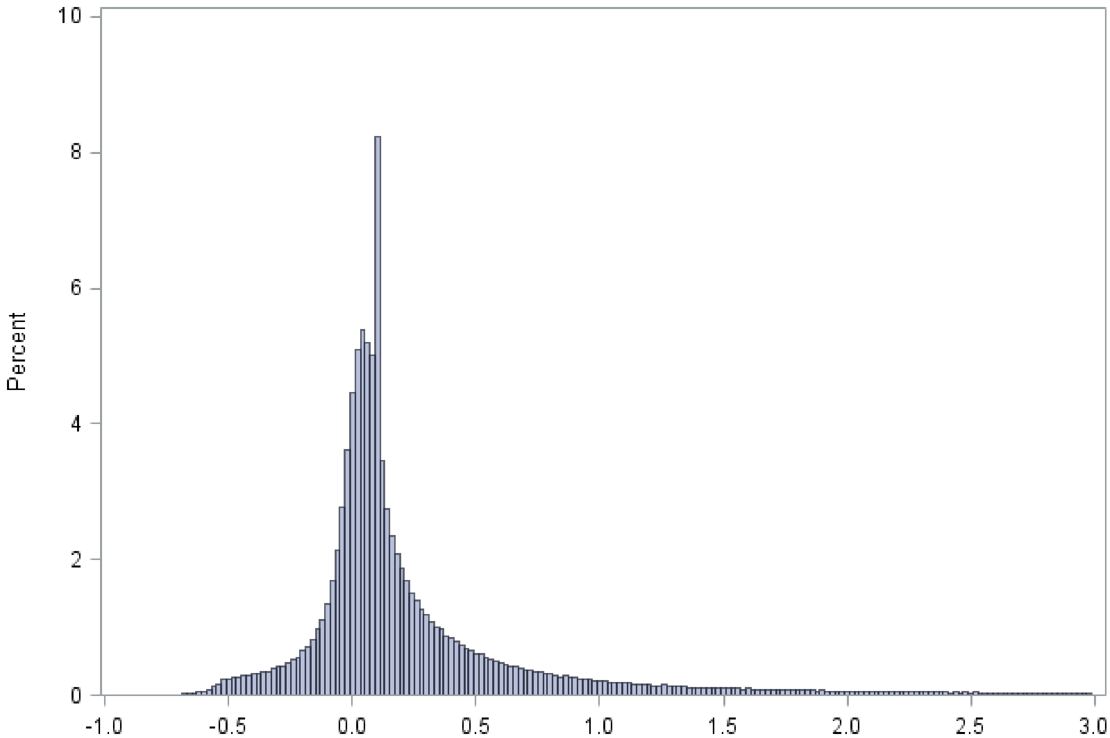
Table 12: Moments Summary

Variable	Obs	Mean	S.D.	Median
Investment rate	1,400,435	0.314	0.720	0.100
Hiring rate	1,372,497	0.070	0.397	0.000
Short debt: growth	1,372,432	0.338	1.110	0.066
Short debt: flow	1,372,431	0.056	0.232	0.027
Short debt: leverage	1,372,431	0.553	0.292	0.544
Long debt: growth	1,372,431	0.295	0.937	0.061
Long debt: flow	1,372,431	0.061	0.237	0.029
Long debt: leverage	1,372,431	0.607	0.294	0.608

Notes: Significance levels: $*$ (p<0.10), $**$ (p<0.05), $* * *$ (p<0.01). The data is from China Industry Business Performance Data builded by National Bureau of Statistics of China with rang from 2002 to 2009. Investment rate is winsorized at the top and bottom 2.5 percent, then other variables are winsorized at the top and bottom 1 percent on this basis.

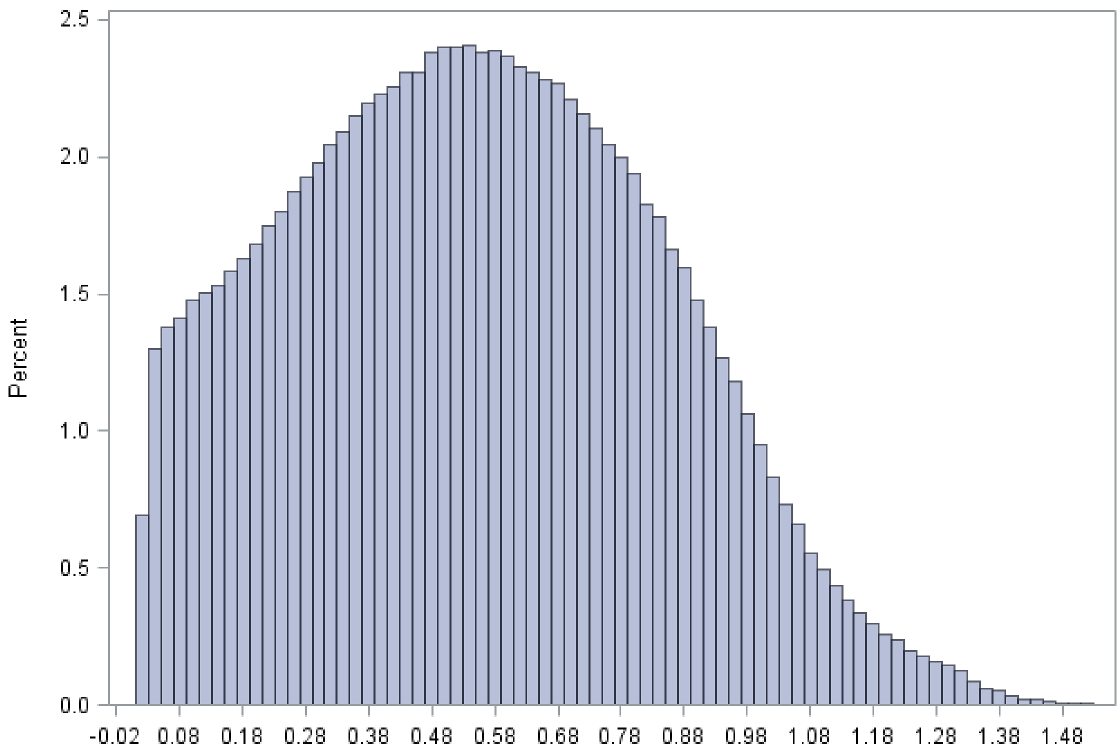
We set an ad-hoc capital depreciation rate of 10% per year, which constructs the mean investment-capital ratio, i.e. the investment rate. In the following, we also plot the distribution of investment rate and leverage ratio of Chinese manufacturing firms as suggested by the data.

Figure 4: Distribution of Investment Rates of Chinese Firms



Note: Sample from years 2002-2009. hinese Industrial Firm-level Data

Figure 5: Distribution of Leverage Ratio (Short-debt) of Chinese Firms



Note: Sample from years 2002-2009. hinese Industrial Firm-level Data

For parameters ϕ_0 and ϕ_1, we discipline these two coefficients by disciplining our model by the correlation between leverage and capital size and few other moments of Chinese firm leverage ratios. The following regression suggests that larger Chinese firms as measured by capital size tend of borrow more in terms of leverage, which echos our specification of a size-dependent constraint. A correlation of 0.2 is used to as target for calibrating ϕ_1.

Table 13: Leverage Ratios and Firms' Borrowing

Dep. Var	*log(b/q)*	*log(b/q)*
k	0.218***	0.190***
	(48.62)	(47.19)
k^2	-0.009***	-0.007***
	(-42.93)	(-37.28)
	(-51.21)	(-67.55)
Cons.	-2.130***	-1.926***
	(-89.06)	(-89.61)
Obs.	1189520	1189524
$Adj.R^2$	0.024	0.026

Notes: ***Significant at 1%, **significant at 5%, *significant at 10%. Robust standard errors are shown in parentheses.

In addition, we also consider the fraction of leverage ratios that are below 1 %, which helps gauge to what extent, on average, firms are constrained by ϕ_0. Further, we take the fraction of investment spikes ($x/k > 20\%$) and that of close-to-zero investments $x/k \in (-10\%, 10\%)$ to pin down ψ, which scales the convex adjustment cost and χ, which measures the scale of fixed cost when non-zero investment is taken. We summarize our key parameter list in the following table.

Table 14: Calibrated Parameters and Data Targets

Symbol	Value	Parameter	Target	Model Moments
ϕ_0	2.1	Frac. SM leverage	5.6%	3.6 %
ϕ_1	0.08	correlation of $\ln(b/k)$ and k	0.2	0.18
ψ	1.1	Quadratic Cost	Frac. ik spikes 34%	24 %
χ	0.04	Fixed Cost	Frac. of non-zero ik 4%	2.2 %
δ	0.025	Quarterly Depreciation Rate	Annual Investment Rate	10 %
β	0.97	Discount factor	risk-free rate	
ξ	3	demand elasticity	set	
α	0.35	capital share in production	set	

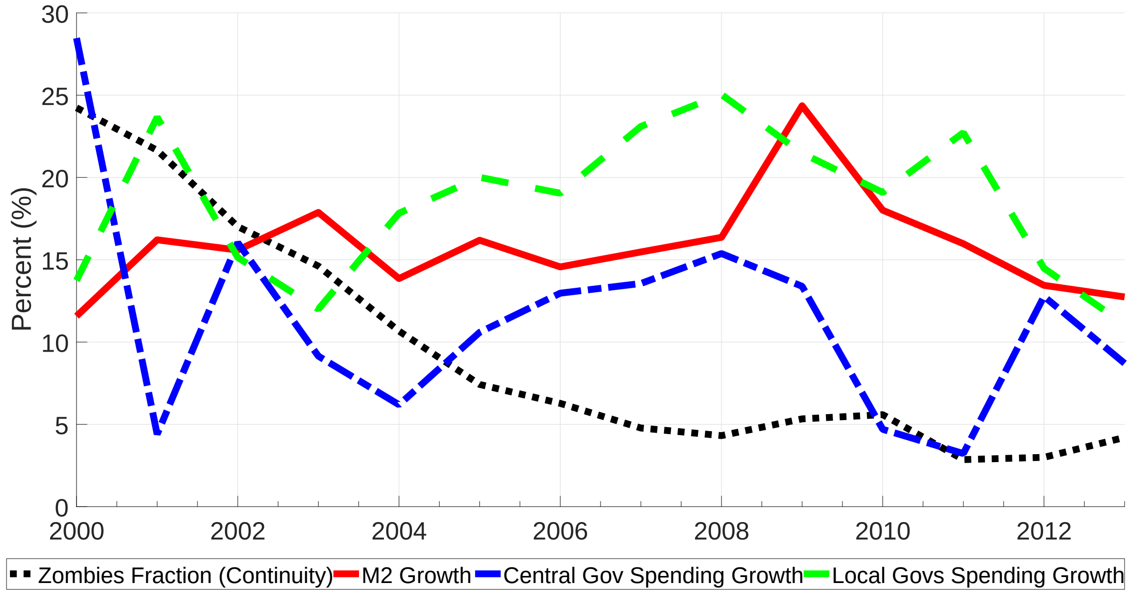
5 Conclusion

In this paper, we study the distributional effects of monetary policy on firm performance and reallocation dynamics. Based on China Manufacturing Census data ranging from 1998 to 2013, this paper documents the evidence of two competing forces arising from China's monetary policy practices. First, monetary expansion leads to an improvement upon the extensive margin of Chinese firm dynamics by selecting good firms out of the bad league of zombie" firms that are marked by negative profits and subsidized borrowing. Simultaneously, conditional on staying as zombies, these firms are associated with greater resource misallocations, thus an deterioration of reallocation at the intensive margin. We then build a heterogeneous-firm model with financial frictions that features the productivity heterogeneity along with size-dependent debt constraints and borrowing subsidies to rationalize the heterogeneous effects of monetary policy, the endogenous entries and exits of zombie firms, and the reallocation dynamics of Chinese firms.

By looking into the differential responses of zombie firms and non-zombie firms to identified monetary shocks in China, we are able to examine the effectiveness of China's monetary policy per the presence of zombie firms. An important policy implications of this paper arises: given the capital formation and employment growth in response to positive monetary policy shocks are largely driven by zombie expansions, mechanically forcing the zombie firms to exit may attenuate the overall effectiveness of China's monetary policy.

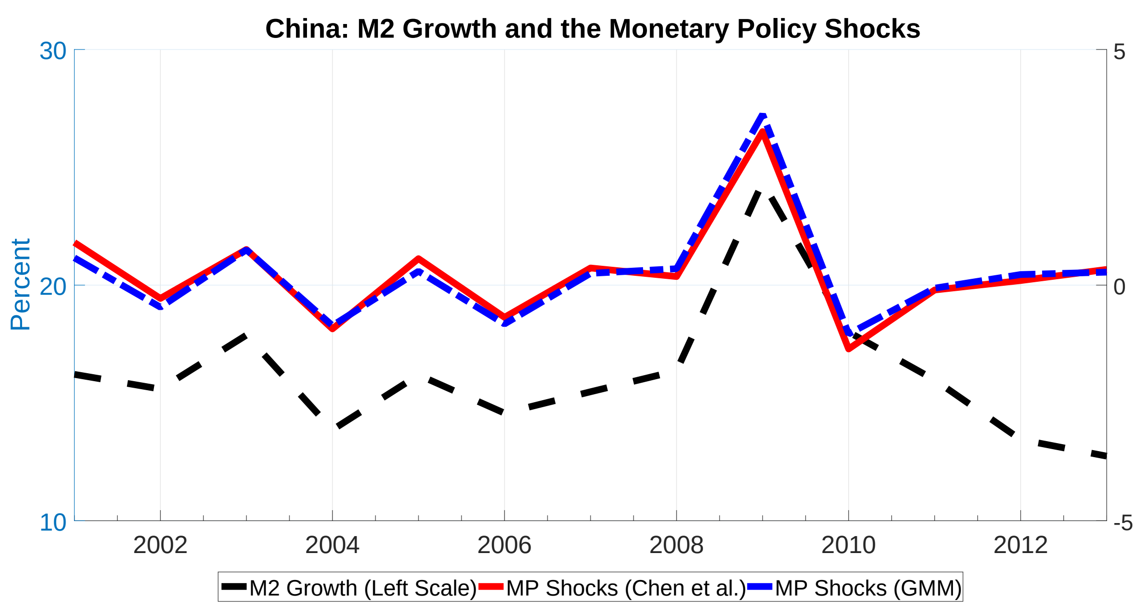
6 Additional Tables and Figures

Figure 6: China: Proportion of Zombie Firms (1999-2013)



Notes: Zombie firms are the manufacturing firms with negative interest rate gap and negative profits.

Figure 7: China: Proportion of Zombie Firms (1999-2013)



Notes: Zombie firms are the manufacturing firms with negative interest rate gap and negative profits.

Appendix

A Zombie Status Duration Break-downs

We use two measures to proxy for the zombie duration: first, the actual number of years for a firm identified as zombies; second, the fraction of zombie years relative to a firm's observed length of operations in our sample. Table 15 and Table 16 summarize the estimates broken down by industry and by province respectively. We descendingly sort the numbers by the actual years of a firm's being zombie firm. In Table 15, apart from the obvious heterogeneity in zombie status duration across sectors, it shows that a firm's zombie status may appear to be temporary as the mean duration of zombie years is less than one. However, conditional on the observed life of firms operations, 10 % up to 20 % of the life time for a firm would be troubled in the "zombie" status. Table 16 suggests a sizable heterogeneity of zombie firm duration across provinces. For example, the mean duration of zombies as measured by the zombie-status share of the life time operating years is about four times of that for firms in Guangdong. In addition, at least for 10 % of firms registered in Beijing, they are persistently identified as zombie firms throughout the sample whereas only one third of the life time a firm in Guangdong is considered zombie periods.

Table 15: Duration of Zombie Status by Province

Province	N Firms	Mean No. ZYears	Std. No. ZYears	Mean % ZYears	Std. % ZYears
Beijing	12479	2.58	2.77	0.61	0.41
Hainan	1036	2.50	2.49	0.62	0.39
Guizhou	4341	2.43	2.69	0.65	0.39
Yunnan	4529	2.38	2.68	0.59	0.40
Shanxi	6502	2.27	2.58	0.61	0.40
Shanghai	27314	2.22	2.56	0.49	0.40
Shaanxi	6468	2.11	2.63	0.55	0.42
Guangdong	76062	2.09	2.48	0.47	0.40
Tianjin	13870	2.09	2.63	0.48	0.42
Gansu	4719	2.02	2.34	0.58	0.42
Qinghai	915	1.94	2.11	0.69	0.38
Xinjiang	3429	1.92	2.25	0.62	0.40
Ningxia	1472	1.87	2.27	0.58	0.41
Guangxi	9251	1.85	2.31	0.54	0.42
Heilongjiang	7380	1.76	2.31	0.57	0.42
Liaoning	29135	1.51	2.21	0.38	0.41
Chongqing	7568	1.50	2.23	0.41	0.41
Jilin	8676	1.47	2.08	0.48	0.43
Jiangsu	89154	1.45	2.12	0.37	0.41
Inner Mongolia	5143	1.43	2.01	0.46	0.42
Zhejiang	81816	1.41	2	0.34	0.38
Sichuan	18132	1.37	2.09	0.38	0.40
Hebei	22504	1.27	2.19	0.34	0.42
Fujian	24788	1.26	2.08	0.30	0.37
Anhui	20749	1.21	1.97	0.33	0.41
Tibet	378	1.18	1.71	0.53	0.41
Hubei	21969	1.17	1.93	0.38	0.42
Jiangxi	12124	1.06	1.81	0.36	0.42
Hunan	17926	1.02	1.70	0.37	0.42
Henan	32499	0.86	1.83	0.26	0.39
Shandong	63632	0.79	1.71	0.23	0.37

Table 16: Duration of Zombie Status by Industry

Industry	N Firms	Mean No. ZYears	Std. No. ZYears	Mean % ZYears	Std. % ZYears
Tobacco	500	0.94	1.42	0.27	0.38
Printing, Reproduction of Recording Media	11712	0.94	1.65	0.24	0.36
Beverages	9793	0.92	1.66	0.25	0.38
Medicines	10909	0.91	1.59	0.21	0.33
Foods	15394	0.82	1.47	0.24	0.37
Processing of Petroleum, Coking, Processing of Nuclear Fuel	4370	0.79	1.37	0.22	0.34
Chemical Fibers	3910	0.76	1.36	0.22	0.35
Paper and Paper Products	16437	0.75	1.42	0.19	0.33
Non-metallic Mineral Products	52763	0.72	1.43	0.19	0.33
Transport Equipment	28004	0.71	1.40	0.19	0.33
Textile	50323	0.70	1.38	0.18	0.32
Smelting and Pressing of Ferrous Metals	16333	0.69	1.24	0.22	0.36
Raw Chemical Materials and Chemical Products	44288	0.69	1.32	0.18	0.32
Processing of Food from Agricultural Products	38503	0.67	1.29	0.20	0.34
Communication Equipment, Computers and Other Electronic Equipment	31619	0.66	1.15	0.22	0.36
Textile Wearing Apparel, Footwear, and Caps	30860	0.65	1.28	0.18	0.32
Articles For Culture, Education and Sport Activity	9881	0.60	1.26	0.17	0.31
Measuring Instruments and Machinery for Cultural Activity and Office Work	14408	0.58	1.06	0.22	0.36
Furniture	8316	0.57	1.19	0.16	0.31
Leather, Fur, Feather and Related Products	14679	0.56	1.18	0.16	0.30
Special Purpose Machinery	34603	0.54	1.22	0.18	0.34
Artwork and other Manufacturing	12413	0.51	1.03	0.17	0.32
General Purpose Machinery	57033	0.47	1.13	0.14	0.30
Plastics	42130	0.46	1.11	0.15	0.31
Electrical Machinery and Equipment	40875	0.45	1	0.16	0.32
Processing of Timber, Wood, Bamboo, Rattan, Palm, and Straw Products	14556	0.44	1.07	0.13	0.28
Metal Products	49250	0.42	1.01	0.15	0.31
Rubber	14672	0.37	1	0.14	0.32
Smelting and Pressing of Non-ferrous Metals	22500	0.37	0.89	0.15	0.32

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