Macroprudential Policy and Zombie Lending in Korea

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ABSTRACT

During the housing boom in the mid-2000s, Korea used the Loan-to-Value ratio (LTV) regulation and Debt-to-Income ratio (DTI) regulation to limit the expansion of mortgage financing and the rapid rise of housing prices successfully. The limit on mortgage financing, however, made many banks to look for other opportunities to extend credit. The banks ended up competing to lend to small and medium enterprises (SMEs), some of which had questionable quality. This paper shows that increased loans to the non-performing SMEs led to the zombie problem that Caballero et al. (2008) found for Japanese non-performing companies helped by their creditors. Similar to the Japanese zombies, we find the Korean zombies discouraged healthy companies from expanding. We also find the productivity gap between zombies and non-zombies increase as the proportion of zombies in the industry increases.

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1. Introduction

In the 2000s, many countries experienced credit booms and rapidly rising housing prices. As was the case for many other credit booms and asset price bubbles in the past, the booms did not last and housing prices eventually collapsed. Since many systematically important banks turned out to be exposed to housing prices, the collapse led to a serious global financial crisis. The recovery from the global financial and economic crisis has been a very slow process, and many economies are still stagnating.

Policymakers around the world have been discussing the ways to reduce the frequency of financial crises and to minimize the cost if a crisis happens. One strand of such discussion has been on macroprudential policy. Bank for International Settlements (2011) defines macroprudential policy as a "policy that uses primarily prudential tools to limit systemic or system-wide financial risk." Thus, a macroprudential policy uses regulatory tools that were traditionally used to maintain safety and soundness of the individual financial institutions (such as restrictions on the composition of the balance sheet) to contain the risk to the financial system as a whole (such as too much credit expansion).

Some countries already had some macroprudential policies even before the global financial crisis. Korea is one of those countries. In September 2002, Korea introduced an upper limit for the loan to value ratio of mortgage loans to discourage speculative and leveraged investment in housing. The limit was initially set to 60 percent, but it was lowered during the mid-2000s as the credit boom progressed. In August 2005, limits on debt to income ratio for borrowers were also introduced in the areas where housing speculation was considered to be most serious (speculative zones). Igan and Kang (2011) find the loan-to-value (LTV) and debt-to-income (DTI) limits worked to slow down the house price appreciation.

Although the LTV and DTI limits in Korea may have succeeded in containing the housing bubble, they were less effective in reducing the overall credit expansion. To the extent that the policies were successful in reducing the mortgage loans, they rather encouraged the growth of non-mortgage loans. In particular, Korean banks ended up increasing their loans to small and medium firms that did not have easy access to bank loans before the credit boom, including those with poor performance.

This paper studies the economic implications of this unintended effect of the LTV and DTI regulations. We show that the loosening of credit standard for small and medium enterprises created what Caballero, Hoshi, and Kashyap (2008) termed "zombie firms." The increased credit allowed poorly performing firms that would be forced out of the market or pressured to be restructured under the normal condition to survive. Even after the global financial crisis, when the credit boom was over, these zombie firms still continued to survive benefiting now from government policies to help the firms hurt by the crisis. The result was

similar to that of Japan during its lost decade. Protection of zombie firms discouraged expansion by healthy firms and new entries and hurt the productivity growth.

The paper makes at least two contributions. First, it applies the framework of studying zombie firms that was originally developed to analyze Japan by Caballero et al. (2008) to a different country and shows the framework is useful. Second, the paper is also related to the growing literature on macroprudential policy. Some of those papers point out some macroprudential policy tools that are available today may not be as effective as it may seem. For example, Aiyar, Calomiris, and Wieladek (2012) examine macroprudential capital regulation in the UK and find that UK-regulated banks indeed cut their lending when the capital requirement was increased but the decline of lending was substantially offset by increased lending by foreign banks. This paper finds another mechanism that reduced the effectiveness of macroprudential policy in Korea. The LTV and DTI regulations successfully contained mortgage lending, but Korean banks ended up increasing their loans to SMEs including those with poor performance.

The rest of the paper is organized as follows. Section 2 gives a brief overview of the credit boom in Korea after it recovered from the Asian financial crisis of the late 1990s. The section also discusses the LTV and DTI regulations. Section 3 discusses the notion of zombie firms and presents several operational ways to identify zombies using firm level data for Korea. Section 4 provides empirical analysis of the impact of zombie firms at industry level. Section 5 uses firm level data to examine the impact of zombies. Section 6 concludes.

2. Credit boom in Korea: 2000-2003 and 2005-2007

Soon after Korea recovered from the Asian financial crisis, the credit started to grow again, especially in mortgage loans and consumer loans. The experience of 1997-98 crisis convinced the Korean government that they could not continue to rely on the export-led growth model. The policy makers believed that the structure of the Korean economy must be changed so that the growth is also driven by expansion of domestic demand. , To expand the domestic demand, the government pushed through some deregulations in areas that were considered to be instrumental in developing robust domestic markets, such as credit card, construction, and housing industries.

The government also deregulated financial markets and tried to change the financial system from a bank-dominated one to more market oriented one. One lesson they learned from the crisis was that disproportionately relying on one channel of financing (foreign borrowing through the banking system for Korea's case) is too risky. Thus, the government tried to encourage development of alternative financial channels such as equity markets. The government asked large firms to reduce their debt-to-equity ratio below 200% by 1999. The government also encouraged pension funds to increase their stock holdings. With these encouragements from the government, the stock markets in Korea became a reliable source of

funds for large Korean corporations. Thus, many large corporations started to move away from traditional bank financing to more equity financing. The shift was also helped by the IT stock boom in the U.S., where many Korean technology companies competed successfully.

As the banks started to lose their corporate customers to equity markets, they started to focus more on mortgage loans and credit card loans. Rapid growth in credit card loans was a response to the deliberate government policy to expand the use of credit card to stimulate consumption. The low interest rate policy after the crisis also encouraged the credit expansion. Also contributed to the rapid credit expansion was merger waves between big banks after the financial crisis and the fierce competition in lending markets among major banks that followed.

The collapse of the IT bubble in the U.S. in 2000 slowed down the credit expansion temporarily. The distress in credit card lending in 2003 did the same. Neither of those, however, stopped the credit expansion. The loans to households show especially high growth. The share of household loans in total bank loans grew from 27 percent in 1999 to 46 percent in 2004. Table 1 shows the growth of bank loans and bank deposits during the 2000s.

The government saw the rapid expansion of mortgage loans as a problem, because it believed the credit boom was fueling speculative bubbles in the housing markets in urban area. The average price of a condominium in Seoul was growing at over 30 percent per year. This jeopardized President Rho Moohyun's electoral commitment to stabilize housing prices. In September 2002, the government introduced the maximum limit on loan-to-value ratio (LTV) as a part of the first macroprudential policy. Initially the limit was set to 60 percent. The introduction of LTV limit temporarily slowed down the housing price growth, but soon housing prices started to grow again. In August 2005, the government added debt-to-income (DTI) ratio regulation to its list of macroprudential policy for the areas where the government saw the housing bubble was especially prominent (called "speculative zones"). Initially the maximum DTI ratio was set at 40 percent for the mortgage loans in the speculative zones.[1] Between 2005 and 2007, the government tightened the LTV limit twice and the DTI ceiling four times. Table 2, which is taken from Igan and Kang (2011), summarizes the major changes regarding the LTV and DTI regulations from 2002 to 2010. The mortgage loan growth rate finally dropped to 0.07% in 2007 and the housing price increase stopped as Figure 1 shows.

Thus, the LTV and the DTI regulations were eventually successful in stopping the growth of mortgage loans and speculative housing price increases. The regulations, however, did not stop the total credit expansion. This meant bank loans other than mortgages increased even more rapidly. The growth rate of corporate loans jumped from14.02 percent in 2006 to 21.92 percent in 2007. The loan growth was concentrated on small and medium enterprises (SMEs): more than 80 percent of the growth in corporate loans in 2007 was for SMEs.

[1] Ministry of Strategy and Finance designated the speculative zones.

Examining the differences in the growth rates of SME loans among banks, we can confirm that the growth of SME loan is likely to have been motivated by the tighter regulation on mortgage loans. Panel A of Figure 2 shows the relation between the reliance on mortgage loans in 2006, which is just before the final tightening of the LTV and DTI regulations, and the growth rate of SME loans in 2007. The figures shows that the two are positively correlated, suggesting that the banks that relied more on mortgage loans and hence were affected more by the tightened regulations shifted more into SME lending. Panel B of Figure 2 looks at the changes in market shares in the SME loan market. We find the banks that relied more on mortgage loans in 2006 increased their market share in SME loans in 2007. This tendency was especially strong for top five banks (the dashed line is steeper), presumably because their mortgage loans were concentrated in the areas that were designated as speculative.

Table 3 shows the increased SME lending ended up at old incumbent firms rather than new start-ups. For example, the share of the loans to firms that have been around at least 15 years increased from 32 percent in 2005 to 39 percent in 2010. In contrast, the share of loans to the startups which were established within three years dropped from 5.2 percent to 3.4 percent. Thus, the credit expansion for SMEs did not expand the availability of funds for startups with good growth prospects. The credit flowed to old firms, many of which were performing rather poorly as we will see below.

Even after the global financial crisis, the bank credit continued to support poorly performing SMEs. This is because the government convinced banks to extend the due dates of all SME loans to June 2010 as long as the SMEs meet the scheduled interest payments. The policy was certainly successful in mitigating the adverse impacts of credit crunch, but it created other serious problems by putting unprofitable borrowers on extended life support and depressing the process of creative destruction as we show in the rest of this paper.

3. Identifying zombies

Following Caballero, Hoshi, and Kashyap (2008), we define a zombie firm to be a firm with low profitability that would be driven out of the market under the normal competitive condition but is allowed to stay with help from the creditors.

Note that there two parts to this definition. First, zombie firms have low profitability. Second, they are also highly indebted and receive help from the creditors. Caballero et al. (2008) focuses on the latter part of the definition and empirically identify zombies by selecting firms with unusually low interest payments given their debts. In this way, they try to avoid finding a tautology that an industry with many firms with low profitability tends to exhibit low profitability.

A potential problem of Caballero et al. (2008) is that this identification strategy may find many high performance companies that can borrow at unusually interest rates as zombies. As Hoshi (2006) showed, this does not seem to be a serious problem for Japan.

For Korea, our preliminary investigations suggested that the problem is much more serious. Just focusing on the creditors' help and identifying the firms that seem to be receiving help from banks (in the form of low interest rates or rollover of existing loans) lead to classifying many high performing firms into the zombie category, as we report in Appendix 1.

Thus, for this paper, we use both parts of definition to identify zombie firms empirically. To identify poorly performing firms with high debts, we look at the financial expenditure to sales ratio (FES), which divides the total cost of financing (including interest payments on liabilities and any associated fees) by the total sales of the firm. Highly indebted and poorly performing companies have high FES.

As the measure of help from creditors, we look at (1) the amount of increase in bank borrowings from the previous year divided by (2) the sum of short-term bank borrowings and long-term bank borrowings that are due within a year at the end of the previous year. Letting TL_t, SL_t, and CLL_t denote the total bank borrowings, short-term bank borrowings, and long-term borrowings due within a year respectively at the end of year t, the variable we look at is expressed as: $\frac{TL_t - TL_{t-1}}{SL_{t-1} + CLL_{t-1}}$. We call the variable BH for "bank help." If the creditors roll over all the loans that become due during year t and if there are no new loans given to the firm, BH_t is zero. If no loans are rolled over and there are no new loans, BH_t is -100%. If the amount of new loans is larger than the amount of the maturing loans that are not rolled over, BH_t is positive. Thus, given the amount of new loans, a firm that shows high BH has high rollover ratio of maturing loans and hence is more likely to be receiving help from the creditors.

We define zombie firms to be those firms with high FES and high BH. More formally, we identify firm i in industry j as a zombie in a certain year t when the zombie dummy $z_{ijt}(f,h)$ takes one.

$$z_{ijt}(f,h) = \begin{cases} 1 & \text{if } FES_{ijt} > f \text{ and } BH_{ijt} > h \\ 0 & \text{otherwise} \end{cases}, \qquad (1)$$

where FES_{ijt} is the financial expenditure to sales ratio for firm i in industry j at time t. For the thresholds f and h, we use 5% and -10% respectively. If we assume that these firms that are already heavily indebted and not performing well are not likely to have any entirely new loans, h = -10% means that the 90% of the loans that are due are rolled over. The choice of the thresholds is arbitrary, so we will check robustness of our results by experimenting with some other values as well.

The data for our analysis comes from a financial database on Korean corporations built by the Korea Enterprise Data (KED), the largest corporate credit information bureau in Korea which was established by major government financial institutions such as the Korea Credit Guarantee Fund (KODIT), the Korea Technology Finance Corporation (KIBO), the Korea Development Bank (KDB) and the Industrial Bank of Korea (IBK). The data on the KED database are based on the financial statements that were submitted to the founder government financial institutions seeking loans or credit guarantees. Since almost all SMEs apply for credit guarantees from the KODIT and KIBO, the coverage of the database is very wide. The KED supplements the information by adding the financial statements of publicly listed companies. The database also includes the information on the firms that filed for corporate bankruptcies, which are collected from the National Tax Service. The KED database covers about 70 percent of total corporate loans from financial institutions.

Table 4 shows the list of 57 industries included in our analysis. We exclude some industries such as publicly owned utilities from the analysis. For each industry *J*, we define the zombie index to be the weighted average of the zombie dummies:

$$Z_{kt} = \frac{\sum_{j=k} w_{ijt} z_{ijt}}{\sum_{j=k} w_{ijt}} \tag{2}$$

We consider two sets of weights: equal weights and the amount of total assets. We call the zombie index calculated using equal weights "simple average" zombie index and the one calculated using total assets as the weights "asset-weighted" zombie index.

We define the zombie index for all the sample firms in the database in a similar way. Figure 3 shows the time series of the zombie indices for all firms. Panel A shows the simple average index while Panel B shows the asset-weighted index. Each panel shows four indices which are calculated for different threshold values (*f*, *h*). For *f*, we consider 5% and 3%. For *h*, we consider -10% and 10%. Depending on which threshold we use, the graph of zombie index moves up and down, but the time series pattern stays very much the same. Using the simple average or asset-weighted measure does not change the time series pattern, either. We see the number of zombies in the economy sharply increased from 2004 to 2008, when the LTV and DTI regulations were tightened. The asset weighted zombie index, however, does not show such an increase in 2004-2008 period. This suggests the most of the increase in zombies came from small firms. This conjecture is confirmed in Figure 4, where we calculate the zombie index for

only SME firms.[2] In both simple average and asset-weighted average, we see the proportion of zombies among SMEs increased from 2004 to 2008.

Figure 5 shows the zombie index for several different industries. We find the zombie problem in 2004-2008 was especially serious in construction and real estate industries.

4. Impact of zombies: industry level analysis

Using the zombie index that we introduced above, this section examines various impacts of increases in zombies in an industry. This section starts by looking at industry level data. Of 57 industries in Table 4, 11 industries have less than 100 firms. We exclude those industries with small numbers of firms from the analysis in this section. Table 4 reports the number of observations for each industry. Since the database spans 10 years (2001-2010), the average number of firms is obtained by dividing the numbers of observations by 10.

Caballero et al. (2008) built a simple model of entry and exit and showed that existence of zombie firms reduces both entry into and exit out of the industry. By depressing the process of creative destruction, zombie firms end up reducing the productivity growth of the industry. Our data show the patterns mostly consistent with these predictions.

Panel A of Figure 6 plots the average entry rate for the years 2000-2010 for each industry against the average asset-weighted zombie index for the industry for the same period. The entry rate here is defined as the number of new firms that entered the database during the years 2000-2010 divided by the average number of firms for the time period. We can see a negative relation between the entry rate and the zombie percentage of the industries. The slope is estimated to be -0.043 and it is statistically significant at 1% level. This means that when the zombie percentage increases by 9.7% (one standard deviation of our sample) the entry rate is reduced by 0.42%, which is a little more than a half of the sample standard deviation (0.77%).

Panel B of Figure 6 calculates the entry rate slightly differently. Here the entry rate is the average total employment of the new entrant divided by the average total employment of the industry. Again the slope is negative and statistically significant. The industries that have more zombies tend to have less new entries.

One caveat here is that simple scatterplots do not control for the factors that are correlated with both the zombie percentage and the entry rate. One obvious candidate for such factor is the profitability of the industry. An industry where we observe many zombies tends to have low profitability even if there were no effects of zombies further depressing profitability.

[2] Definition of SME firms in Korea differs from industry to industry. Appendix 2 shows how SME firms are defined for each industry in Korea.

Thus, the industry would show low entry rate even without zombies. If this is the case, the slope coefficients in the figures would exaggerate the zombie effect. The problem is more serious here than in Caballero et al. (2008) because our definition of zombies include a measure related with profitability of the firms (FES). In the next section, we try to mitigate this problem by using firm level data and comparing zombies and non-zombies in the same industries.

Figure 7 plots the average exit rate against the average zombie percentage. Panel A calculates the exit rate as the average number of firms that filed for bankruptcy protection divided by the average number of firms in the database. Panel B calculates the exit rate as the average total employment of the exited firms divided by the average total employment in the industry. Again we observe a negative relation between the zombie percentage and the exit rates. When we calculates the exit rate in terms of the number of firms (Panel A), the estimated slope is statistically significant at 5% level, but it is not statistically significant when the exit rate is based on employment. The point estimate in Panel A implies when the zombie percentage increases by one sample standard deviation the exit rate is reduced by 0.63%, which is roughly a quarter of the sample standard deviation (2.46%).

Note that the slopes in Figure 7 may be underestimated because industries with large number of zombies tend to have low profitability and hence higher exit rates. Despite this potential bias, we find the industries with more zombies tend to have lower exit rates.

Figure 8 shows the relation between the zombie percentage and job creation and destruction. Job creation and job destruction are calculated from firm level data in the standard ways. Job creation is the sum of increases in employment at the firms that increased employment from the previous year (including the firms that newly entered), and job destruction is the sum of reductions in employment at the firms that reduced employment from the previous year (including the firms that exited). Job creation rate and job destruction rate is calculated by dividing job creation and job destruction respectively by the total employment at the end of the previous year. Panel A of Figure 8 plots the average job creation rates over the years 2000-2010 for each industry against the average zombie percentage. Panel B plots the average job destruction rate against the average zombie percentage. We find the job creation is lower for industries with more zombies. For the job destruction rate, the relation appears to be positive, but the slope is not statistically significant. It is possible that the impact of low profitability of the industry offsets the effect of zombies here.

To control the impacts of industry specific factors that influence the zombie percentage, job creation, and job destruction at the same time, Figure 9 looks at the correlation between changes in these variables over time. Panel A plots the changes in the average job creation from 2002-2004 period to 2007-2009 against the changes in the zombie percentage over the same time. Similarly Panel B plots the changes in the average job destruction from 2002-2004 period to

2007-2009 against the changes in the zombie percentage. We now see the regression lines in both panels show negative slopes, although the slope in Panel B is not statistically significant.

Figure 10 examines the relation between the total factor productivity (TFP) growth and the zombie percentage using the industry level data. TFP for a firm *i* in an industry *j* at year *t*, TFP_{ijt}, in turn is calculated as follows:

$$TFP_{ijt} = \log VA_{ijt} - \alpha_j \log E_{ijt} - (1-\alpha_j)\log K_{ijt} \ , \qquad (3)$$

where VA_{ijt}, E_{ijt}, and K_{ijt} are the value added, total employment, and the amount of depreciable assets respectively for firm *i* in industry *j* at year *t*. The coefficient α_j is the labor share of income for the industry *j*, and is calculated as the average wage bills over the average value added in the industry *j* in the sample. TFP in industry level is calculated as the asset-weight average of firm level TFP. To control for potential industry specific effect, we look at the change in the TFP growth rate from 2002-2004 to 2007-2009 and plots that against the change in the zombie index from 2002-2004 to 2007-2009. The figure reveals a negative relation between the change in TFP growth and the change in the zombie percentage. Thus, the industries that experienced larger increase of zombie firms from 2002-2004 to 2007-2009 also had smaller increase in TFP growth.

5. Impacts of zombies: firm level analysis

As Caballero et al. (2008) stressed, the model with zombies have important implications for the non-zombie firms that compete in the same market. Zombie firms tend to reduce the profitability of these otherwise healthy firms and discourage their expansions. Another important implication concerns the difference in productivity between zombies and non-zombies. Zombies are allowed to stay in the market even though their productivities are low. Non-zombie firms, however, have to have extra high productivities in order to survive even when zombies depress the profitability for all. This means the productivity difference between the average zombie firm and the average non-zombie firm in the same industry increases as the proportion of zombie firms in the industry increases.

This section estimates a set of regression models to examine these implications on the impacts of zombie firms on otherwise healthy firms in the same industry. Firms in all the 57 industries reported in Table 4 are used for the analysis in this section. We consider three dependent variables: investment rate, employment growth, and total factor productivity. The investment rate is measured by dividing each year's investment in depreciable assets divided by the stock of depreciable assets at the end of the previous year. The employment growth is calculated as the change of natural log of the firm's total employment from the previous year.

The total factor productivity for firm *i* in industry *j* at year *t*, TFP_{ijt} is calculated as equation (3). Following Caballero et al. (2008), we estimate the following three types of regressions.

$$\text{Activity}_{ijt} = \delta_1' D_t + \delta_2' D_j + \beta \text{nonz}_{ijt} + \chi Z_{jt} + \varphi \text{nonz}_{ijt} * Z_{jt} + \varepsilon_{ijt} \quad (4)$$

$$\text{Activity}_{ijt} = \delta_3' D_{jt} + \beta \text{nonz}_{ijt} + \varphi \text{nonz}_{ijt} * Z_{jt} + w_{ijt} \quad (5)$$

$$\text{Activity}_{ijt} = \delta_3' D_{jt} + \beta \text{nonz}_{ijt} + \varphi \text{nonz}_{ijt} * Z_{jt} + \theta s_{ijt} + v_{ijt} \quad (6)$$

Activity is investment rate, log change of employment, or TFP. The equation (4), which is our basic specification, includes the non-zombie dummy (nonz_{ijt}), which is defined to be $1 - z_{ijt}$, the industry zombie index (Z_{jt}), and the interaction term of those two variables as the explanatory variables. Time dummies (D_t) and industry dummies (D_j) are also included in the regression. The equation (5) replaces the time dummies and the industry dummies by the time-industry dummies (D_{jt}), which allows us to control for any factors that vary by industry and time. The cost of including these more general controls is that we cannot include the zombie percentage variable which also vary only by industry and time, but note that we can still estimate the coefficient on the interaction term. Thus, we can still estimate the differential impact of zombies on non-zombies as opposed to zombies, although we cannot estimate the impact of zombies generally on all firms. The last specification (6) adds the sales growth of the firm (s_{ijt}). This is a crude way to control for the profitability that differs among firms.

The regressions are reduced form and the coefficients do not have structural interpretations. Nonetheless, the estimate of φ has an important interpretation for the zombie story. It is a measure of how differently the activity of non-zombies are affected compared to zombies when the proportion of industry assets held by zombies increases. For the investment rate regression and the employment growth regression, we expect the sign of φ to be negative if the zombie story is right. Non-zombies are discouraged from expanding. For the TFP regression, we expect the coefficient to be positive if the zombie story is right. Non-zombies have to be extremely productive in order to stay profitable.

Table 5 reports the estimation results. Each column reports a separate regression. Each cell reports the coefficient estimate and its standard error (in parentheses) for the explanatory variable specified by row. The first three columns show the results for standard specification (4) for the three activity variables. The middle three columns report the results for the specification (5), and the last three columns are for the specification (6).

In all the specifications for the investment and the employment growth regressions, the coefficient estimates on the interaction term is negative and clearly statistically significant (except for the employment growth regression with specification (6) where the coefficient is only

marginally significant). Thus, the regression analysis suggests that investment and employment growth of non-zombie firms are discouraged when the industry has many zombies.

For the TFP regressions, the coefficient estimates on the interaction term is positive and statistically significant in all the specifications.[3] Thus, when the zombie percentage increases, the productivity gap between zombies and non-zombies in the industry tends to widen.

6. Conclusion

During a credit boom in the 2000s, Korean government used LTV and DTI regulations to slow down the housing boom successfully. The policy, however, had an unintended consequence of pushing many banks into expanding loans to SMEs, including those with poor performance. This paper has shown that those SME loans created zombie firms that are very much similar to those unprofitable by protected firms in Japan identified by Caballero et al. (2008). The regression analysis shows that the prevalence of zombie firms discourages the expansion of healthy firms and widens the productivity gap between zombies and non-zombies.

Thus, the paper shows that the zombie problem that Caballero et al. (2008) studied using data from Japan was also observed in Korea. The paper also shows a potential problem of macroprudential policy: limiting one type of credit expansion may encourage credit expansion elsewhere, which may create another problem.

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Appendix 1. Problem of applying the operational definition of zombie firms in Caballero et al. (2008) to Korean firms

Following Caballero et al. (2008), we initially identified the zombies as those firms that are making extremely low interest payments. Specifically, we calculated the minimum required interest payments for firm *i* at year *t*, R_{it}^{*} is defined as:

$$R_{it}^{*} = r_t^{\min} \cdot Loan_{it-1},$$

where $Loan_{it-1}$ is the amount of bank borrowings outstanding at the end of the previous accounting year and $r_t^{\min}$ is the minimum bank loan rate in year *t*. We estimate the minimum bank loan rate for each year using the distribution of SME loans by lending rate published each year by the Bank of Korea. Table A1 shows the data from 2000 to 2010. Table A2 shows the 5% percentile of the distribution for each year, which we use as the minimum interest rate.

When we define the zombies to be the firms that have the actual interest payments below the minimum required interest payments, we end up classifying many healthy firms as zombies. Table A3 shows the zombie percentage (not asset weighted) by quality of firms measured by the rating by the KED. For the firms rated A- or better, the definition based on the minimum interest payment classify roughly 30% of them as zombies. The zombie percentage is much higher than those for firms that are rated between B- and BBB+ or firms that are rated CCC+ or below. Thus, this definition of zombies seems to classify too many good firms as zombies.

Table A4 shows the zombie percentage by quality of firms when we use the main definition given by (1) with f = 5% and h = -10%. Here the zombie percentage becomes higher as the quality of firms declines, as one would expect.

Appendix 2. Definition of Small and Medium Enterprises

The definition of small and medium enterprises (SMEs) in Korea is given by Article 2 of the Framework Act on SMEs and Article 3 of the Enforcement Decree of the Act. This appendix describes the definition as of the end of 2010.

The following table specifies the two types of criteria to be SME for each industry: one criterion on the number of employees and the other on either capital or sales depending on the industry. In general, a firm is classified as SME if at least one of the criteria is satisfied.

Industry (SIC)	Number of employees	Capital or Sales
Manufacturing(10-33)	Less than 300	Capital of 8 billion Korean won or less
Mining(5-8) Construction(41-42) Transportation(49-52)	Less than 300	Capital of 3 billion Korean won or less
Publishing, broadcasting, telecommunication, and information service (58-63) Business Service (74-75) Professional and technical service (70-73) Human health and social work(86-87)	Less than 300	Sales of 30 billion Korean won or less
Agriculture, forestry, fishing (1-3) Electricity, gas and water supply(35-36) Whole sales and retail trade (45-47) Accommodation and food service (55-56) Finance (64-66) Recreation and sports activities (90-91)	Less than 200	Sales of 20 billion Korean won or less
Sewage and waste management service (37-39) Education (85) Maintenance and repair (95-96)	Less than 100	Sales of 10 billion Korean won or less
Real estate (68-69)	Less than 50	Sales of 5 billion Korean won or less

If a firm satisfies any one of the following four conditions, however, the firm is not classified as SME.

1. The number of regular workers is 1,000 or larger.
2. The total assets is worth 500 billion Korean won or more
3. The firm belongs to one of the conglomerate groups specified by the Total Equity Investment Ceiling Rule under the Korean Antitrust Law.
4. More than 30% of the firm is owned by another firm with total assets of 500 billion Korean won or more.

Table 1. The growth rate of major indicators in Korean banking sector (%)

Year	GDP	Total Asset	Total Loan			Deposit
				Household	Corporation	
2000	8.797	12.207	21.630	38.665	14.106	24.138
2001	3.973	4.256	7.778	41.203	-4.686	8.305
2002	7.150	8.747	22.055	36.291	12.920	8.082
2003	2.802	6.095	9.997	10.160	10.660	2.971
2004	4.619	-0.104	2.403	6.536	-1.451	-2.843
2005	3.957	7.919	7.791	9.807	5.367	3.936
2006	5.178	12.989	14.026	13.542	14.116	5.930
2007	5.105	9.513	12.816	3.086	21.929	-1.010
2008	2.298	18.139	11.036	3.797	16.876	13.875
2009	0.319	-7.356	1.067	2.131	0.464	4.712
2010	6.320	-1.965	-0.232	1.800	-1.652	13.155
2011	3.634	4.962	5.884	3.967	6.355	7.529

Source : Financial Supervisory Service
Note : All indicators are based on real growth rate by GDP deflator

Table 2. LTV and DTI regulation in Korea

Year	Month	Description	Direction
LTV			
2002	Sep	Introduced the LTV ceiling as 60 percent	Inception
2003	Jun	Reduced the LTV from 60 to 50 percent for loans of 3 years and less maturity to buy houses in the speculative zones	Tighten
	Oct	Reduced the LTV from 50 to 40 percent for loans of 10 years and less maturity to buy houses in the speculative zones	Tighten
2004	Mar	Raise the LTV from 60 to 70 percent for loans of 10 years or more maturity and less than one year of interest-only payments	Loosen
2005	Jun	Reduced the LTV from 60 to 40 percent for loans of 10 years and less maturity to buy houses worth 600 million won and more in speculative zones	Tighten
2006	Nov	Set the LTV ceiling as 50 percent for loans of 10 years and less maturity to buy houses worth 600 million won and more in the speculative zones and originated by nonbank financial institutions	Tighten
2008	Nov	Removed all areas except the three Gangnam districts off the list of speculative zones	Loosen
2009	Jul	Reduced the LTV from 60 to 50 percent for loans to buy houses worth 600 million won and more in the metropolitan area	Tighten
	Oct	Expanded the LTV regulation to all financial institutions for the metropolitan area	Tighten
DTI			
2005	Aug	Introduced the DTI ceiling as 40 percent for loans used to buy houses in the speculative zones only if the borrower is single and under the age of 30 or if the borrower is married and the spouse has debt	Inception
2006	Mar	Set the DTI ceiling as 40 percent for loans to buy houses worth 600 million won and more in the speculative zones	Tighten
	Nov	Extended the range of application of DTI regulation to the overheated speculation zones in the metropolitan area	Tighten
2007	Feb	Set the DTI ceiling as 40~60 percent for loans to buy houses worth 600 million won and less	Tighten
	Aug	Set the DTI ceiling as 40~70 percent for loans originated by nonbank financial institutions	Tighten
2008	Nov	Removed all areas except the three Gangnam districts off the list of speculative zones	Loosen
2009	Sep	Extended the range of application of DTI regulation to the non - speculative zones in Seoul and the metropolitan area	Tighten
2010	Aug	Exempted the loans to buy houses in the non-speculative zones of the metropolitan area if the debtor owns less than two houses	Loosen

Source : Igan and Kang (2011).

Table 3. Loan breakdown by firm's age(%)

Year	3 years or under	Between 4 and 7 years	Between 8 and 15 years	Over 15 years
2000	6.901	18.452	34.961	39.512
2001	8.878	20.141	36.142	34.686
2002	8.275	23.256	33.340	35.003
2003	7.440	25.551	33.384	33.475
2004	5.647	26.353	35.178	32.638
2005	5.237	26.057	35.960	32.615
2006	5.320	23.287	37.304	33.967
2007	4.821	21.234	40.351	33.476
2008	4.186	19.948	41.317	34.459
2009	3.871	17.760	41.199	37.110
2010	3.400	17.408	40.160	39.032

Source : Korean Enterprise Data

Table 4. Sample breakdown by Industrial classification

SIC	# of sample	% of total
10. Manufacture of Food Products	17,281	2.185
11. Manufacture of Beverages	641	0.081
12. Manufacture of Tobacco Products	22	0.003
13. Manufacture of Textiles, Except Apparel	24,209	3.061
14. Manufacture of wearing apparel, Clothing Accessories and Fur Articles	14,882	1.882
15. Tanning and Dressing of Leather , Manufacture of Luggage and Footwear	5,172	0.654
16. Manufacture of Wood and of Products of Wood and Cork ; Except Furniture	5,584	0.706
17. Manufacture of Pulp, Paper and Paper Products	9,344	1.182
18. Printing and Reproduction of Recorded Media	9,026	1.141
19. Manufacture of Coke, hard-coal and lignite fuel briquettes and Refined Petroleum Products	766	0.097
20. Manufacture of chemicals and chemical products except pharmaceuticals and medicinal chemicals	18,136	2.293
21. Manufacture of Pharmaceuticals, Medicinal Chemicals and Botanical Products	2,571	0.325
22. Manufacture of Rubber and Plastic Products	26,610	3.365
23. Manufacture of Other Non-metallic Mineral Products	15,091	1.908
24. Manufacture of Basic Metal Products	14,554	1.840
25. Manufacture of Fabricated Metal Products, Except Machinery and Furniture	43,773	5.535
26. Manufacture of Electronic Components, Computer, Radio, Television and Communication Equipment and Apparatuses	33,751	4.268
27. Manufacture of Medical, Precision and Optical Instruments, Watches and Clocks	11,130	1.407
28. Manufacture of electrical equipment	24,017	3.037
29. Manufacture of Other Machinery and Equipment	63,158	7.987
30. Manufacture of Motor Vehicles, Trailers and Semitrailers	21,612	2.733
31. Manufacture of Other Transport Equipment	7,736	0.978
32. Manufacture of Furniture	4,857	0.614
33. Other manufacturing	8,034	1.016
37. Sewage, Wastewater and Human Waste Treatment Services	377	0.048
38. Waste Collection, Disposal and Materials Recovery	6,013	0.760
39. Remediation activities and other waste management services	95	0.012
41. General Construction	23,419	2.961
42. Special Trade Construction	85,125	10.764
45. Sale of Motor Vehicles and Parts	8,022	1.014
46. Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	170,747	21.592
47. Retail Trade, Except Motor Vehicles and Motorcycles	26,539	3.356
49. Land Transport ; Transport Via Pipelines	7,863	0.994
50. Water Transport	2,224	0.281
51. Air Transport	66	0.008
52. Storage and support activities for transportation	8,145	1.030
55. Accommodation	1,452	0.184
56. Food and beverage service activities	1,191	0.151

58. Publishing activities	18,967	2.398
59. Motion picture, video and television program production, sound recording and music publishing activities	2,031	0.257
60. Broadcasting	769	0.097
61. Telecommunications	769	0.097
62. Computer programming, consultancy and related activities	2,501	0.316
63. Information service activities	1,785	0.226
68. Real Estate Activities	8,286	1.048
69. Renting and leasing; except real estate	1,326	0.168
70. Research and Development	523	0.066
71. Professional Services	4,487	0.567
72. Architectural, Engineering and Other Scientific Technical Services	7,091	0.897
73. Professional, Scientific and Technical Services, n.e.c.	1,434	0.181
74. Business Facilities Management and Landscape Services	2,512	0.318
75. Business Support Services	4,625	0.585
86. Human Health	4,782	0.605
87. Social Work Activities	68	0.009
90. Creative, Arts and Recreation Related Services	312	0.039
91. Sports activities and amusement activities	1,672	0.211
95. Maintenance and Repair Services	3,628	0.459
Total	790,803	100

Source : Korean Enterprise Data

Note : Some industries which are far from zombie issue are dropped in the sample : agriculture(1), forestry(2), fishing(3), mining(5-8), electricity and gas(35), water supply(36), financial institution(64), insurance and pension funding(65), other financial service(66), public administration and defense(84), education(85), membership organization(94), other personal service and international organization(96-99)

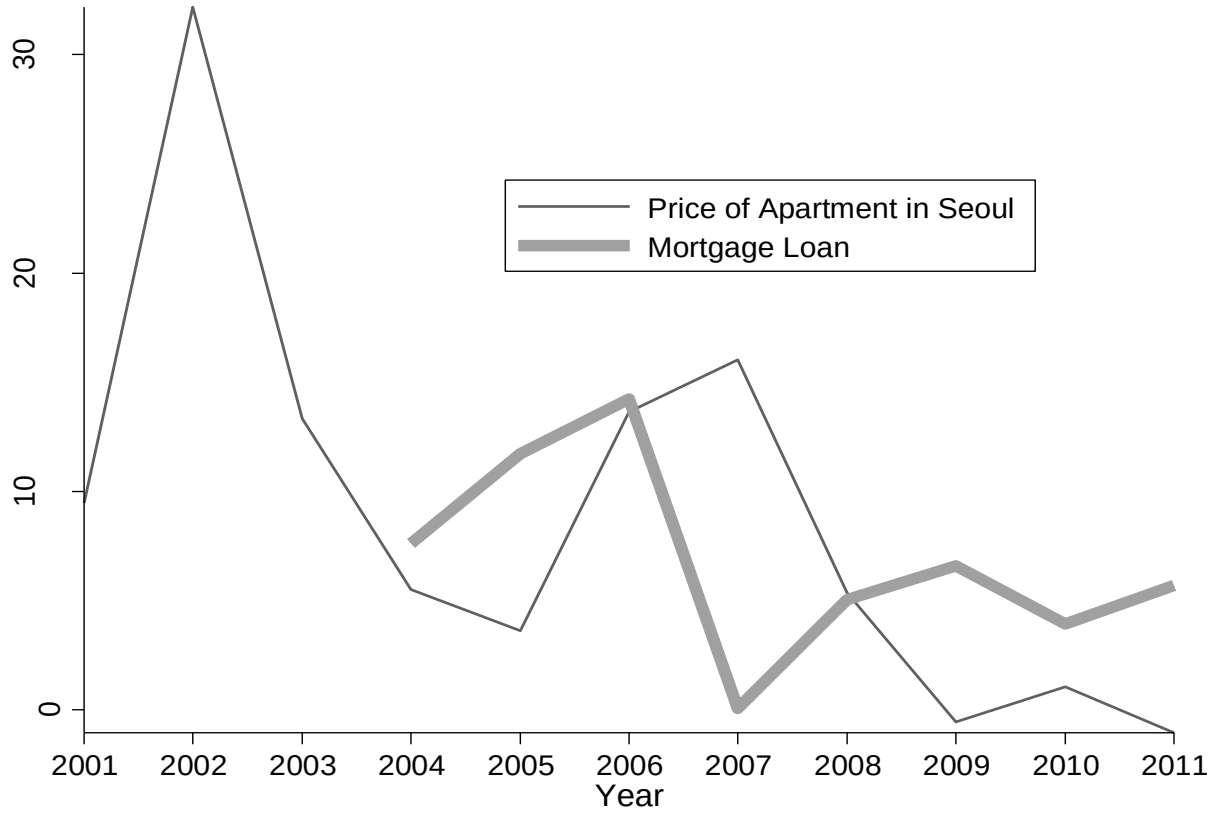
Table 5. Impact of zombie firms on the investment, employment, and productivity of non-zombies

Dependent Variable	I/K	ΔLog E	Log VA - β Log E -(1- β)Log K	I/K	ΔLog E	Log VA - β Log E -(1- β)Log K	I/K	ΔLog E	Log VA - β Log E -(1- β)Log K
Non-zombie dummy	3.8680*** (0.2270)	2.2506*** (0.2104)	0.5663*** (0.0103)	3.8572*** (0.2307)	2.1388*** (0.2113)	0.5819*** (0.0101)	3.6218*** (0.2308)	1.4719*** (0.2119)	0.5303*** (0.0101)
Industry zombie percentage	0.0312** (0.0121)	0.0159 (0.0151)	-0.0050*** (0.0008)						
Non-zombie* Industry zombie percentage	-0.0671*** (0.0087)	-0.0394*** (0.0129)	0.0062*** (0.0007)	-0.0665*** (0.0089)	-0.0342*** (0.0130)	0.0049*** (0.0007)	-0.0653*** (0.0089)	-0.0267** (0.0130)	0.0057*** (0.0007)
Sales growth							0.0172*** (0.0009)	0.0228*** (0.0006)	0.0021*** (0.00002)
Industry dummies included?	Yes	Yes	Yes						
Year dummies included?	Yes	Yes	Yes						
Industry*Year dummies included?				Yes	Yes	Yes	Yes	Yes	Yes
Observation	68,658	751,253	747,590	68,658	751,253	747,590	68,658	751,253	747,590
R^2	0.0865	0.0020	0.5840	0.0993	0.0040	0.5907	0.1056	0.0063	0.5972

Note :

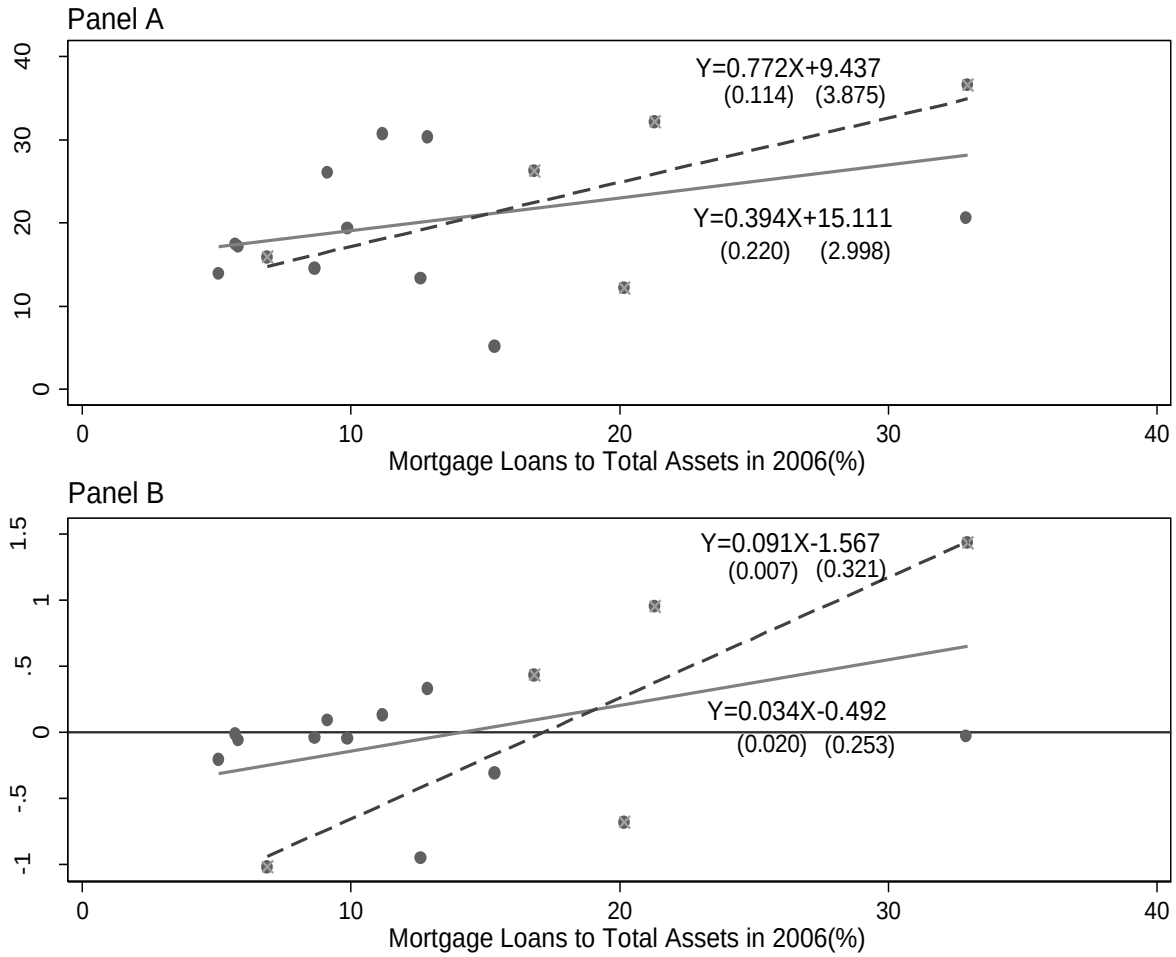
(1) *,**,and *** indicate the 10%, 5% and 1% level of significance, respectively
(2) The sample consists of the firms during 2000 and 2010
(3) The sample is based on SME
(4) Panel Pooled Effect model
(5) Each regression is estimated after trimming the top and bottom 2.5 percent of observations every year (based on the dependent variable).
(6) White(1980) standard errors are reported in parentheses under each coefficient estimate.
(7) Point estimates for the various dummy variables are omitted from the Table.
(8) Two-digit industry classifications are used throughout.
(9) The industry percentages for zombies are based on the share of total industry assets residing in zombie firms.

Figure 1. The growth rate of housing price and mortgage loan



Source : Bank of Korea

Figure 2. The relation between the reliance on mortgage loans and the growth of SME loans by an individual bank



Source : Financial Supervisory Service

Note :

(1) Each unit represents an individual bank and X-marks means Top 5 banks

(2) White(1980) standard errors are reported in parentheses under each coefficient estimate.

Figure 3. Number of zombie firm (Large firms and SME)

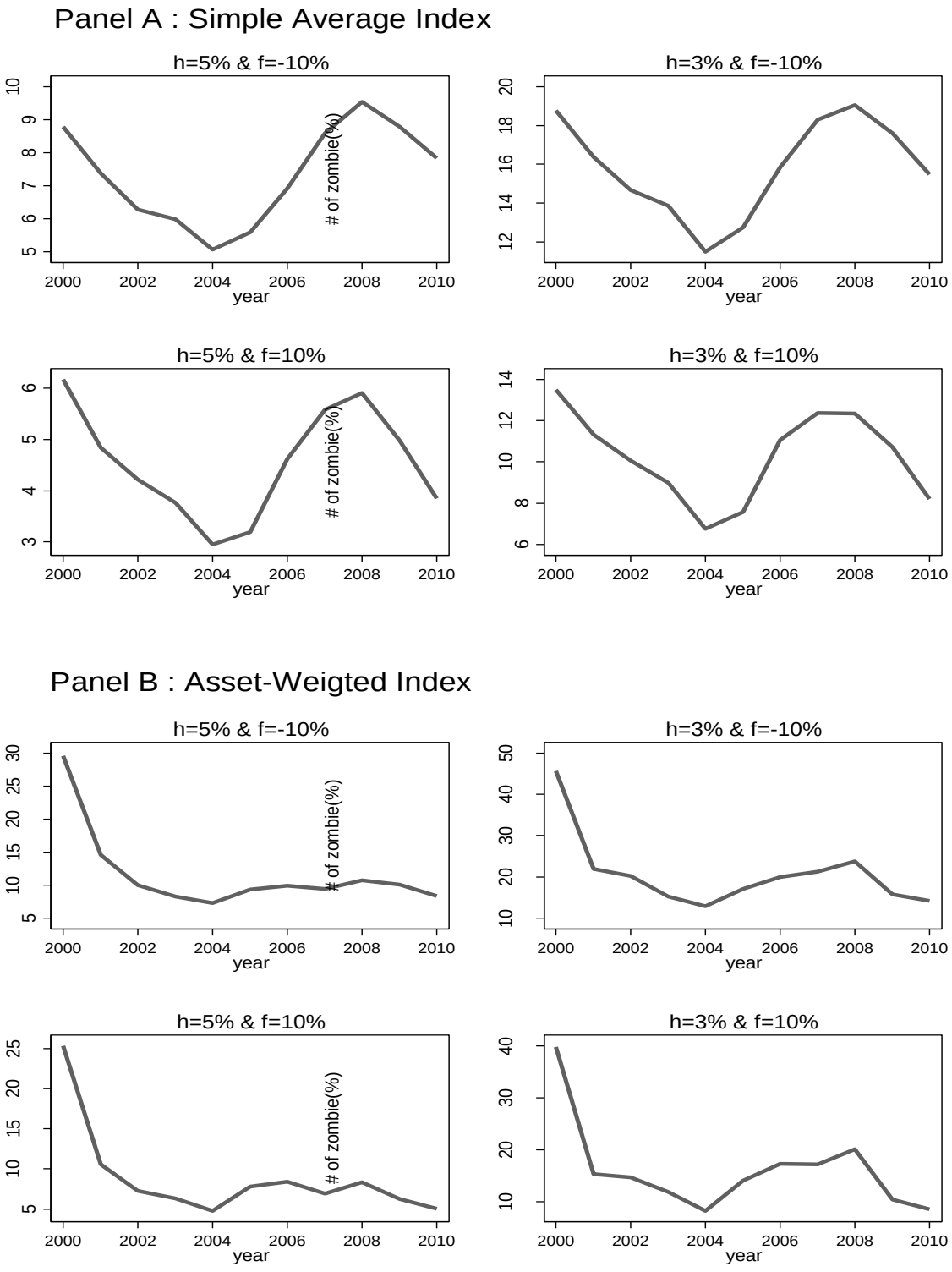


Figure 4. Number of zombie firms (Only SME)

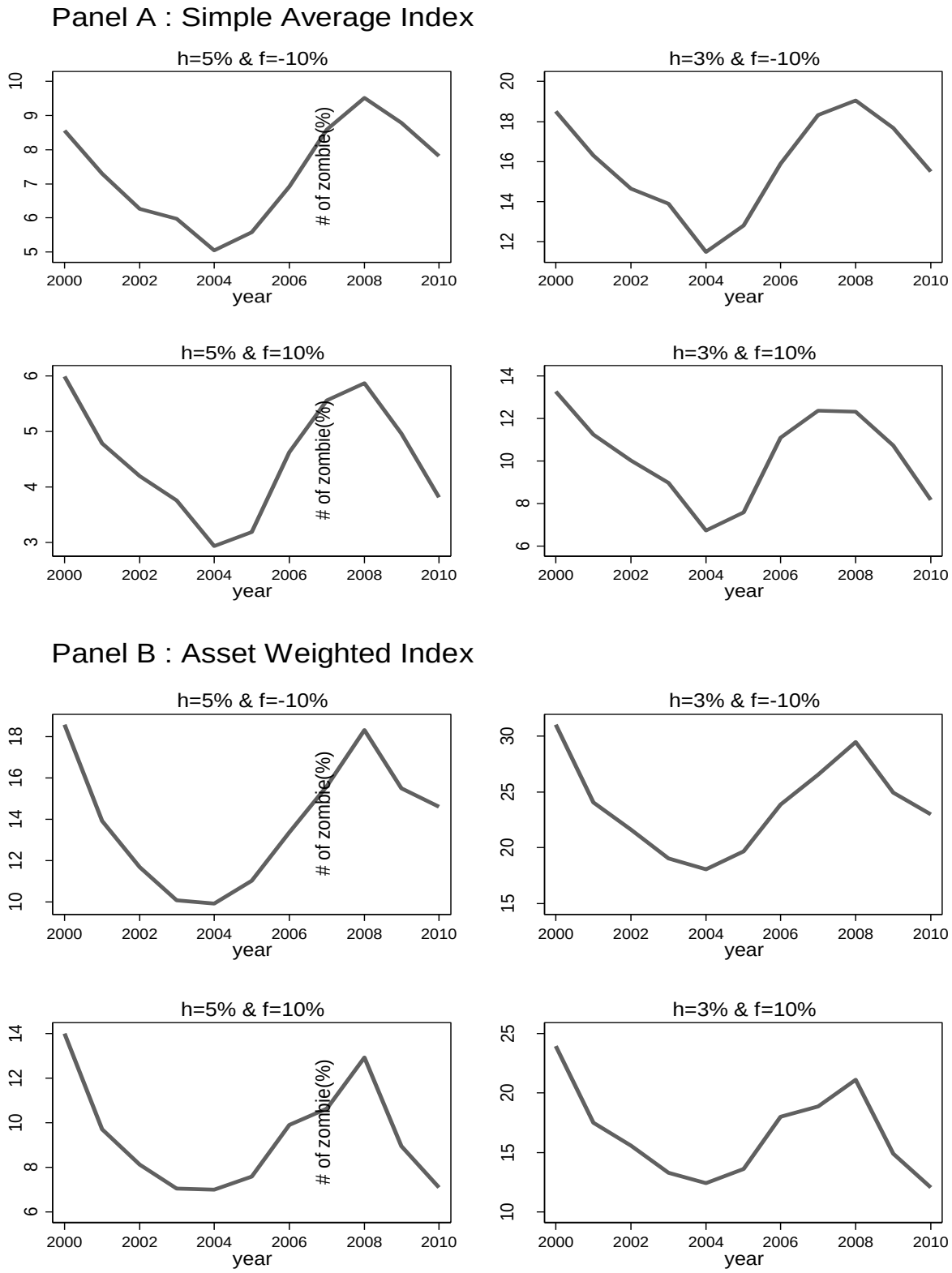
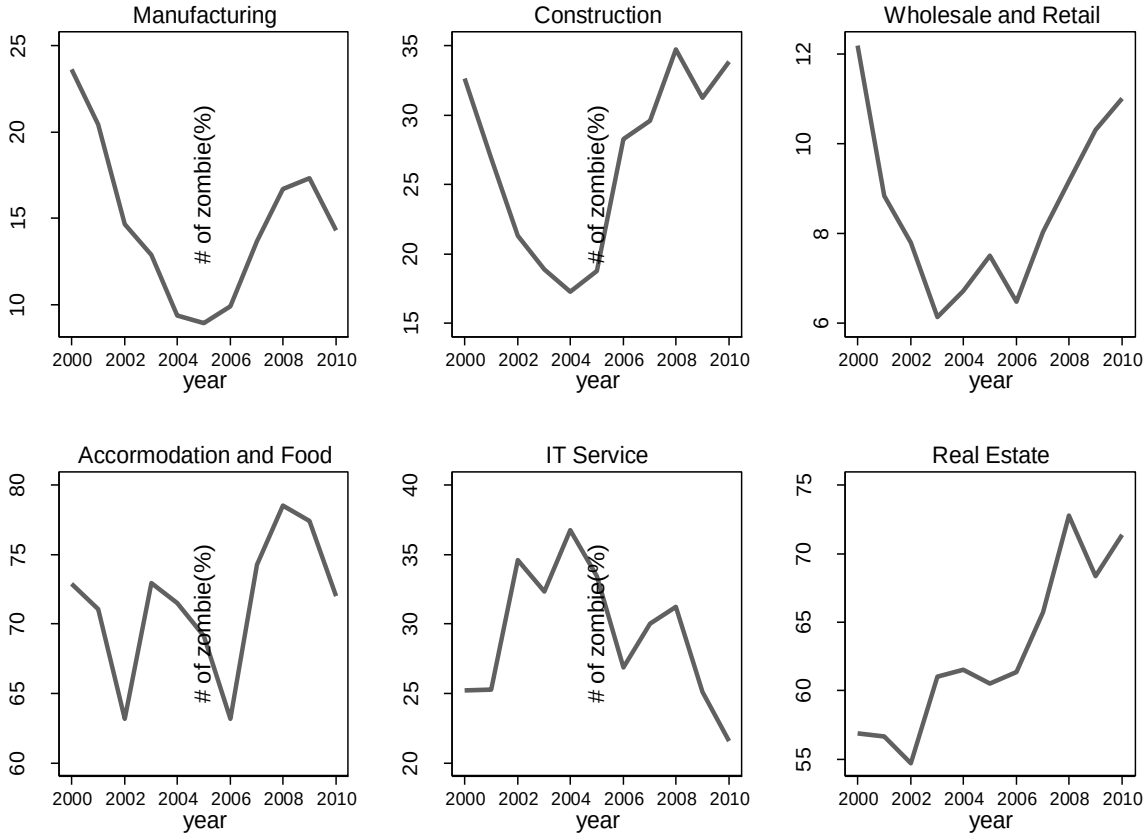
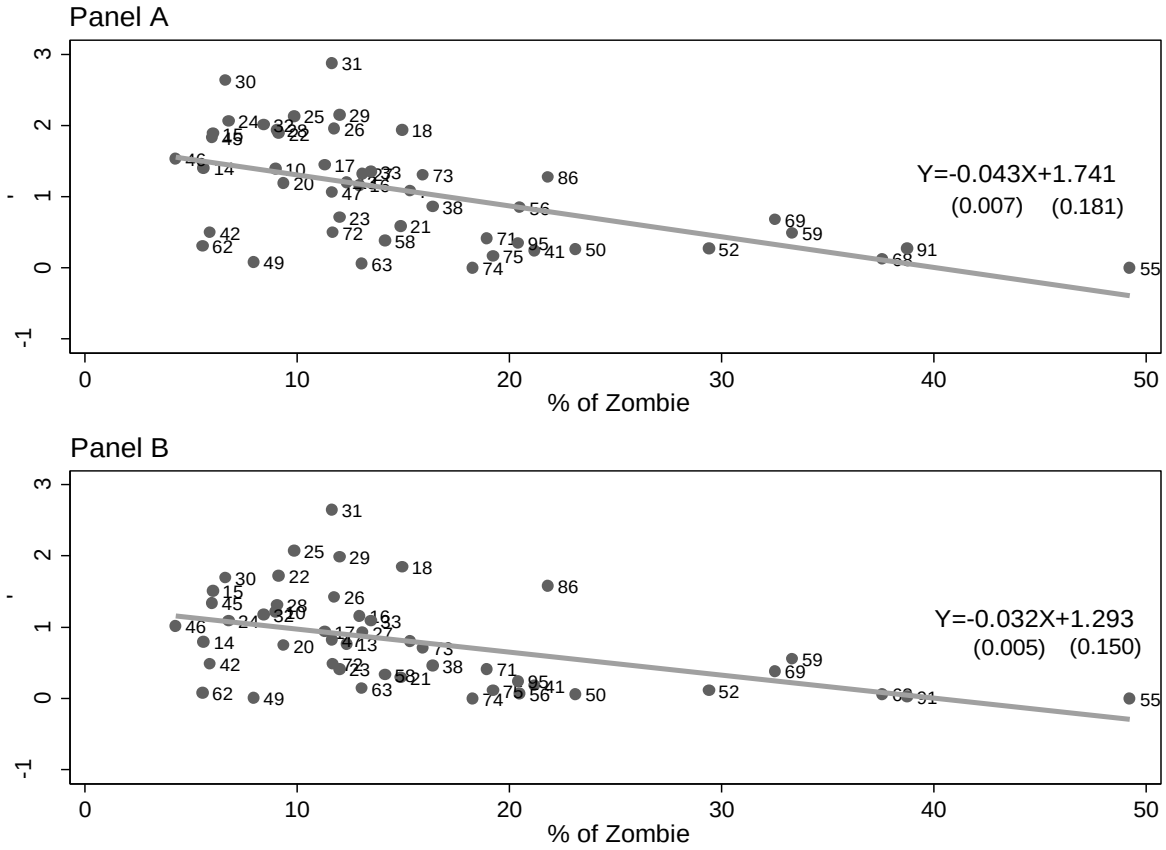


Figure 5. Zombie firms by industry



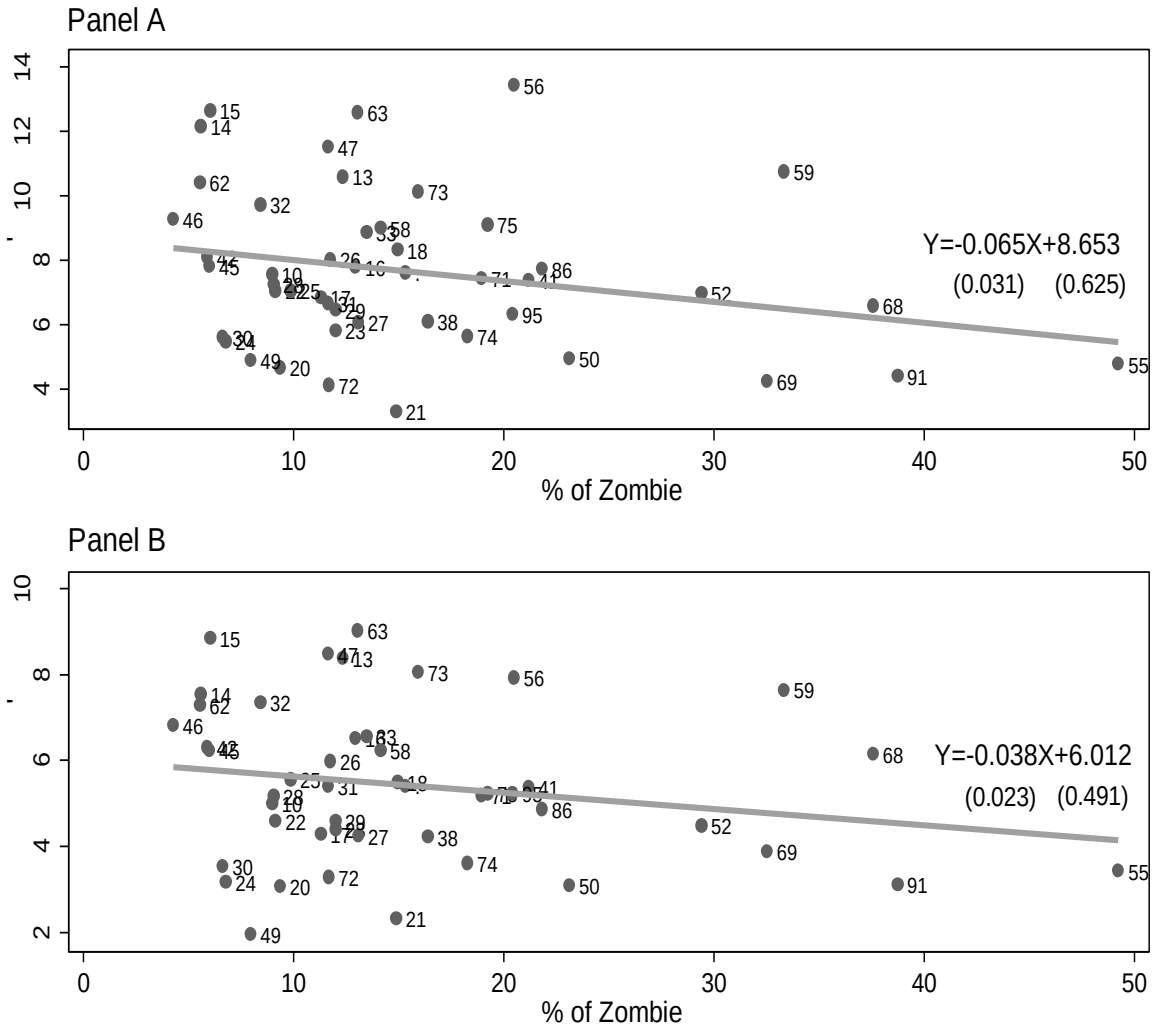
Note :
(1) Definition of zombie is based on asset-based index with h=5% and f=-10%

Figure 6. Entry rate against industrial zombie percentage



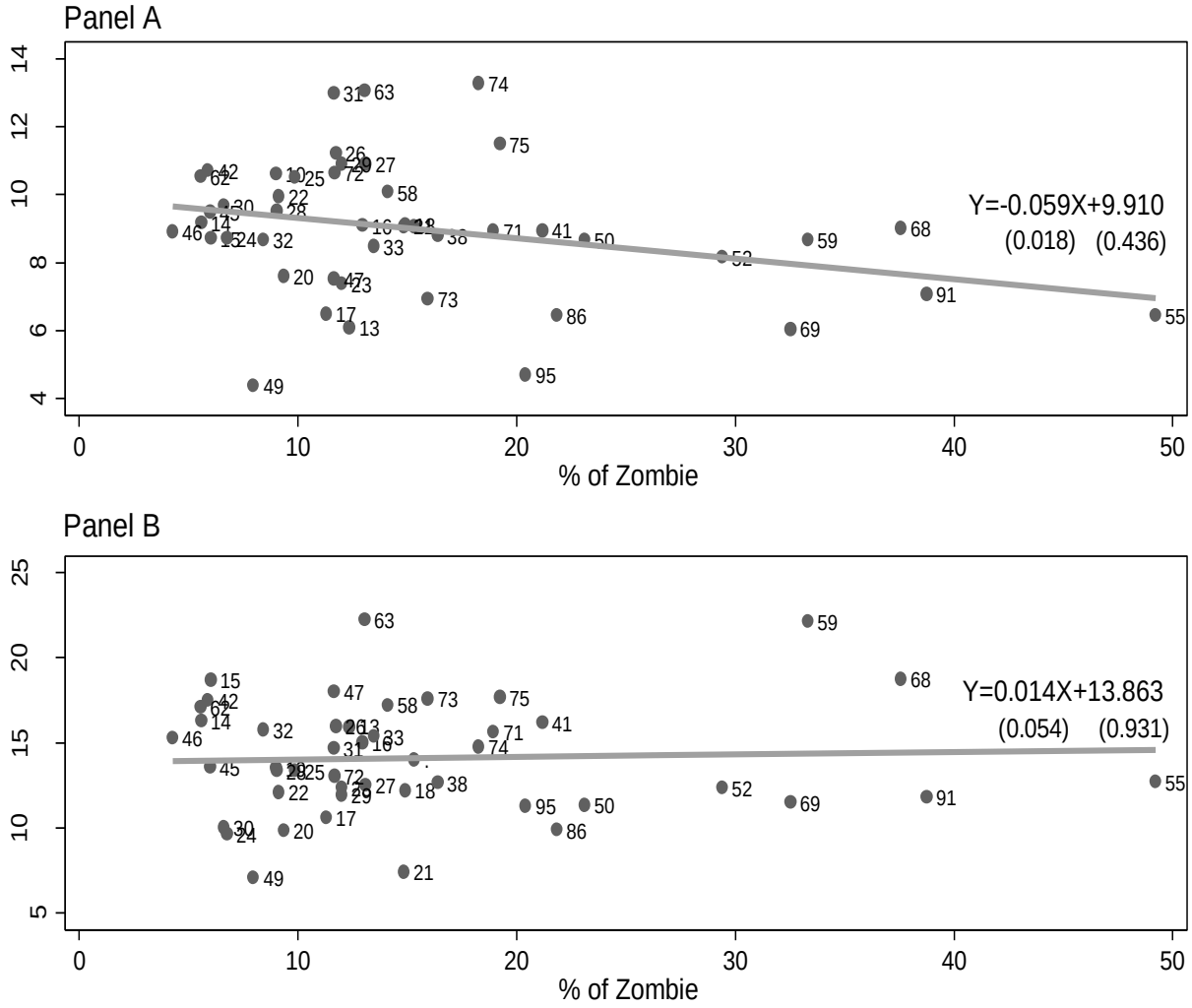
Note :
(2) Each unit represents an individual industry based on two-digit SIC
(3) White(1980) standard errors are reported in parentheses under each coefficient estimate.

Figure 7. Exit rate against industrial zombie percentage



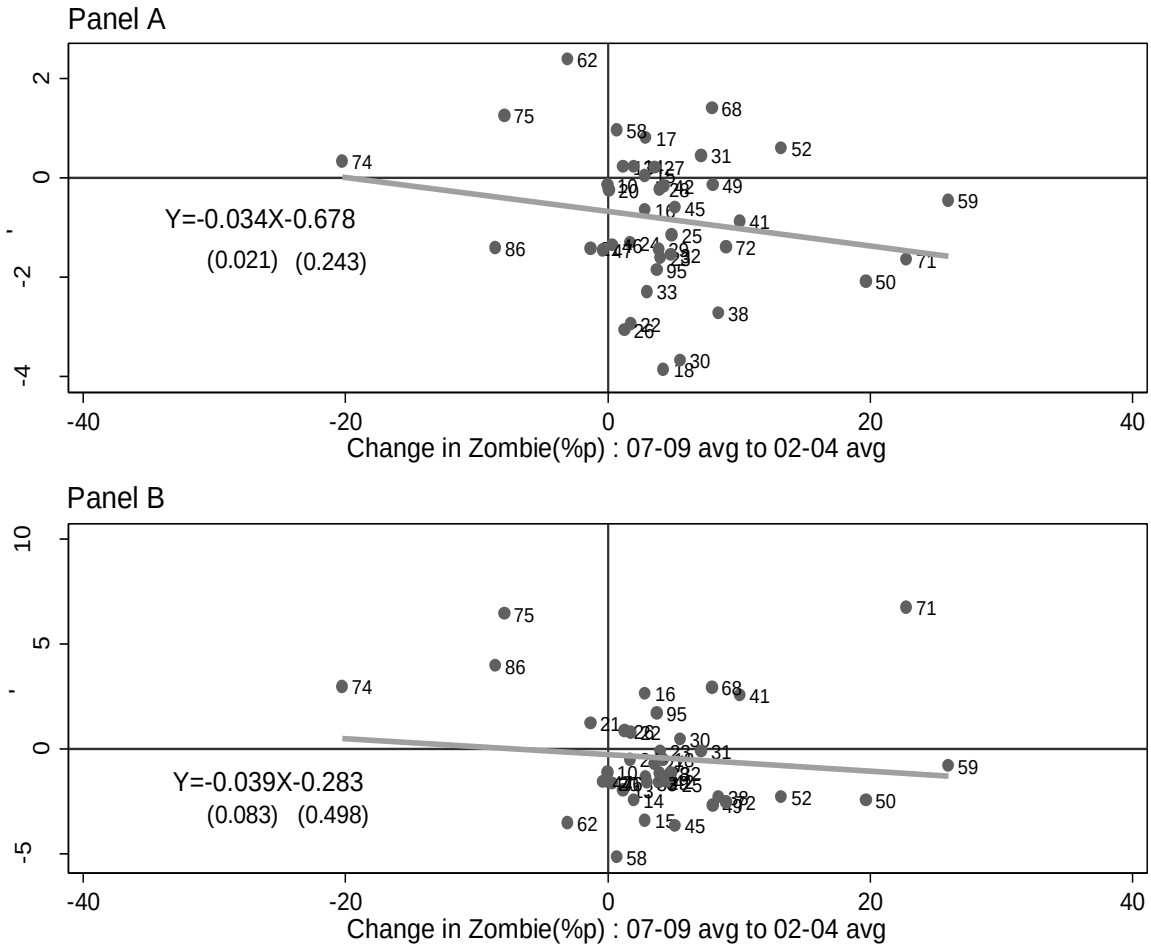
Note :
(1) Each unit represents an individual industry based on two-digit SIC
(2) White(1980) standard errors are reported in parentheses under each coefficient estimate.

Figure 8. Job creation and job destruction rate against industrial zombie percentage



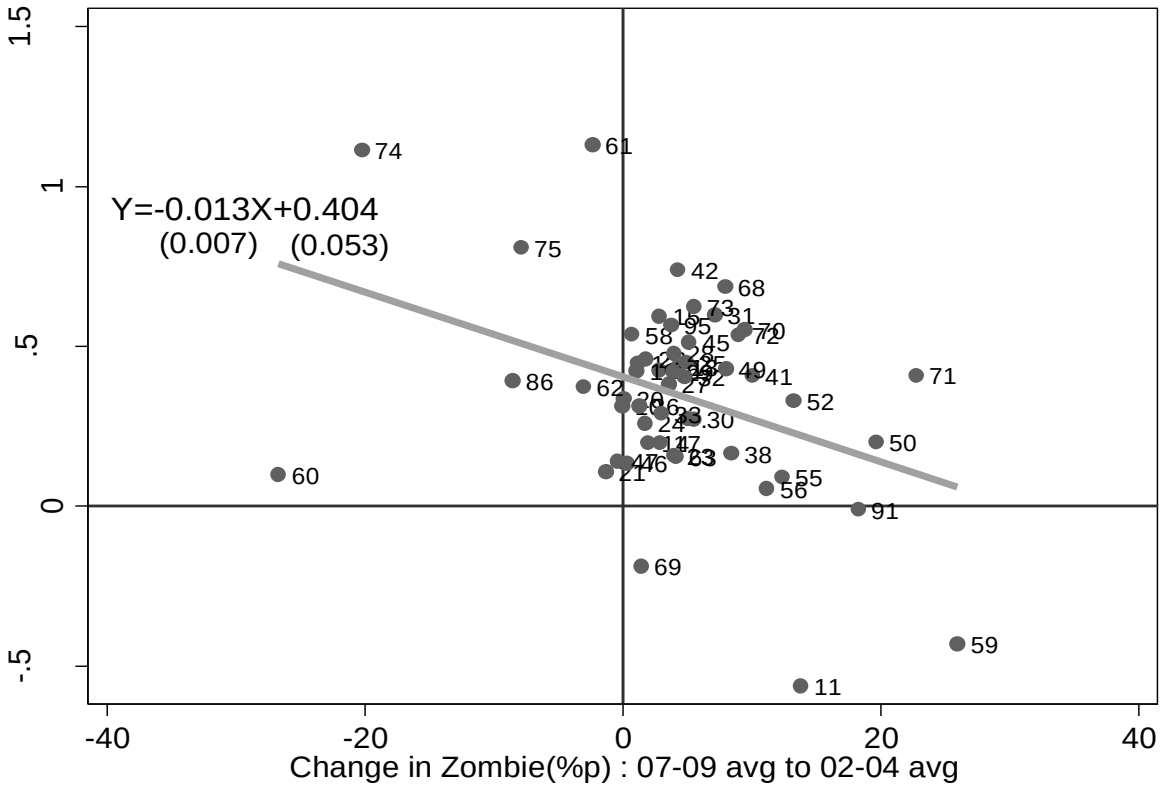
Note :
(1) Each unit represents an individual industry based on two-digit SIC
(2) White(1980) standard errors are reported in parentheses under each coefficient estimate.

Figure 9. Change in zombies and job creation/destruction



Note :
(1) Each unit represents an individual industry based on two-digit SIC
(2) White(1980) standard errors are reported in parentheses under each coefficient estimate.

Figure 10. TFP growth and zombie percentage in industry level



Note :
(1) Each unit represents an individual industry based on two-digit SIC
(2) White(1980) standard errors are reported in parentheses under each coefficient estimate.

Table A1. Distribution of SME Loans by Loan Rate

Loan Rate	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<4%	0.9	0.2	0.5	0.9	1.8	2.9	0.8	0.4	0.3	10.5	6.9
4~5%	0.2	1.8	6.7	13.7	19.8	24.9	10.3	2.4	1.2	23.9	26.7
5~6%	1.9	12.7	26.0	31.4	33.0	34.3	36.7	23.1	9.0	30.1	32.5
6~7%	28.3	30.5	34.1	32.4	28.9	24.7	32.9	41.4	34.5	20.9	20.7
7~8%	24.2	24.1	20.1	14.4	11.2	9.1	13.5	22.4	32.2	8.9	8.1
8~9%	16.8	15.9	8.1	4.7	3.5	2.6	3.6	7.2	15.3	3.3	2.8
9~10%	16.9	9.8	2.9	1.7	1.2	0.9	1.2	1.8	4.9	1.3	1.2
10~11%	6.3	3.1	0.9	0.4	0.3	0.2	0.4	0.6	1.4	0.5	0.5
11~12%	2.6	1.2	0.4	0.2	0.1	0.1	0.2	0.2	0.5	0.2	0.3
>12%	2.0	0.8	0.2	0.2	0.1	0.2	0.4	0.5	0.7	0.4	0.3
TOTAL	100	100	100	100	100	100	100	100	100	100	100

Source : Bank of Korea

Note: Each cell shows the percentage of loans (by amount) that carry the loan rates in the range specified by the row header for the year specified by the column header.

Table A2. Minimum SME Loan Rates

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Upper 5%	6.1	5.3	4.7	4.3	4.2	4.1	4.4	5.1	5.4	2.0	2.8

Note: The rate is estimated as the 5% percentile of the loan rate distribution in Table A1.

Table A3. Zombie Percentage by Quality of Firms (Zombie Definition Based on the Minimum Required Interest Payment)

	Zombie	Non-zombie	Total
(A- or better)	29.518%	70.482%	100%
(B- or better) and (BBB+ or worse)	13.760%	86.240%	100%
CCC+ or worse	13.938%	86.062%	100%

Note: KED ratings are used.

Table A4. Zombie Percentage by Quality of Firms (Zombie Definition Used by this Paper)

	Zombie	Non-zombie	Total
(A- or better)	2.405%	97.595%	100%
(B- or better) and (BBB+ or worse)	6.258%	93.742%	100%
CCC+ or worse	15.529%	84.471%	100%

Note: KED ratings are used.