

Zombie Lending and Depressed Restructuring in Japan

By RICARDO J. CABALLERO, TAKEO HOSHI, AND ANIL K KASHYAP*

Large Japanese banks often engaged in sham loan restructurings that kept credit flowing to otherwise insolvent borrowers (which we call zombies). We examine the implications of suppressing the normal competitive process whereby the zombies would shed workers and lose market share. The congestion created by the zombies reduces the profits for healthy firms, which discourages their entry and investment. We confirm that zombie-dominated industries exhibit more depressed job creation and destruction, and lower productivity. We present firm-level regressions showing that the increase in zombies depressed the investment and employment growth of non-zombies and widened the productivity gap between zombies and non-zombies. (JEL G21, G32, L25)

This paper explores the role that misdirected bank lending played in prolonging the Japanese macroeconomic stagnation that began in the early 1990s. The investigation focuses on the widespread practice of Japanese banks of continuing to lend to otherwise insolvent firms. We document the prevalence of this forbearance lending and show its distorting effects on healthy firms that were competing with the impaired firms.

The paper by Hoshi (2000) was the first to call attention to this phenomenon, and its ramifications have been partially explored by a number of observers of the Japanese economy. There is agreement that the trigger was the large stock and land price declines that began in the early 1990s: stock prices lost roughly 60 percent of their value from the 1989 peak within three years, while commercial land prices fell by roughly 50 percent after their 1992 peak over the next ten years. These shocks sufficiently impaired collateral values that any banking system would have had tremendous problems adjusting. But in Japan the political and regulatory response was to deny the existence of problems and delay any serious reforms or restructuring of the banks.¹

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¹ For instance, in 1997, at least five years after the problem of nonperforming loans was recognized, the Ministry of Finance was insisting that no public money would be needed to assist the banks. In February 1999, then Vice Minister of International Finance, Eisuke Sakakibara, was quoted as saying that the Japanese banking problems “would be over within a matter of weeks.” As late as 2002, the Financial Services Agency claimed that Japanese banks were well capitalized and no *more* public money would be necessary.

Aside from a couple of crisis periods when regulators were forced to recognize a few insolvencies and temporarily nationalize the offending banks, the banks were surprisingly unconstrained by the regulators.

The one exception is that banks had to comply (or appear to comply) with the international standards governing their minimum level of capital (the so-called Basle capital standards). This meant that when banks wanted to call in a nonperforming loan, they were likely to have to write off existing capital, which in turn pushed them up against the minimum capital levels. The fear of falling below the capital standards led many banks to continue to extend credit to insolvent borrowers, gambling that somehow these firms would recover or that the government would bail them out.² Failing to roll over the loans also would have sparked public criticism that banks were worsening the recession by denying credit to needy corporations. Indeed, the government also encouraged the banks to *increase* their lending to small and medium-sized firms to ease the apparent “credit crunch,” especially after 1998.³ The continued financing, or “evergreening,” can therefore be seen as a rational response by the banks to these various pressures.

A simple measure of the evergreening is shown in Figure 1, which reports the percentage of bank customers that received subsidized bank credit. We defer the details of how the firms are identified until the next section, but for now all that matters is that the universe of firms considered here is all publicly traded manufacturing, construction, real estate, retail, wholesale (excluding nine general trading companies), and service sector firms. The top panel of the figure shows roughly 30 percent of these firms were on life support from the banks in the early 2000s. The lower panel, which shows comparable asset weighted figures, suggests that about 15 percent of assets reside in these firms. As these figures show, these percentages were much lower in the 1980s and early 1990s.

By keeping these unprofitable borrowers (which we call “zombies”) alive, the banks allowed them to distort competition throughout the rest of the economy. The zombies’ distortions came in many ways, including depressing market prices for their products, raising market wages by hanging on to the workers whose productivity at the current firms declined, and, more generally, congesting the markets where they participated. Effectively, the growing government liability that came from guaranteeing the deposits of banks that supported the zombies served as a very inefficient program to sustain employment. Thus, the normal competitive outcome whereby the zombies would shed workers and lose market share was thwarted.⁴ More importantly, the low prices and high wages reduce the profits and collateral that new and more productive firms could generate, thereby discouraging their entry and investment.⁵ Therefore, even solvent banks saw no particularly good lending opportunities in Japan.

² The banks also tried to raise capital by issuing more shares and subordinated debt, as Takatoshi Ito and Yuri Sasaki (2002) document. When the banks raised new capital, however, almost all came from either related firms (most notably life insurance companies) that are dependent on the banks for their financing, or the government, when banks received capital injections. See Hoshi and Kashyap (2004, 2005) for more on this “double-gearing” between banking and life insurance sectors.

³ Subsequently when the Long-Term Credit Bank was returned to private ownership, a condition for the sale was that the new owners would maintain lending to small and medium borrowers. The new owners tightened credit standards and the government pressured them to continue supplying funds. See Gillian Tett (2003) for details.

⁴ See Alan G. Ahearne and Naoki Shinada (2005) for some direct evidence suggesting that inefficient firms in the nonmanufacturing sector gained market share in Japan in the 1990s. Kyoji Fukao and Hyeog Ug Kwon (2006) and Kiyohiko Nishimura, Takanobu Nakajima, and Kozo Kiyota (2005) find that the productivities of the exiting firms were higher than those of the surviving firms in many industries. See also Se-Jik Kim (2004), Diego Restuccia and Richard Rogerson (2007), and Nezih Guner, Gustavo Ventura, and Yi Xu (forthcoming) for attempts to quantify the size of these types of distortions.

⁵ It is important to clarify at the outset that the zombie mechanism complements (rather than substitutes for) standard financial constraint mechanisms. As stated in the main text, an increase in the number of zombies reduces the collateral value of good firms in the industry, and hence tightens any financial constraints.

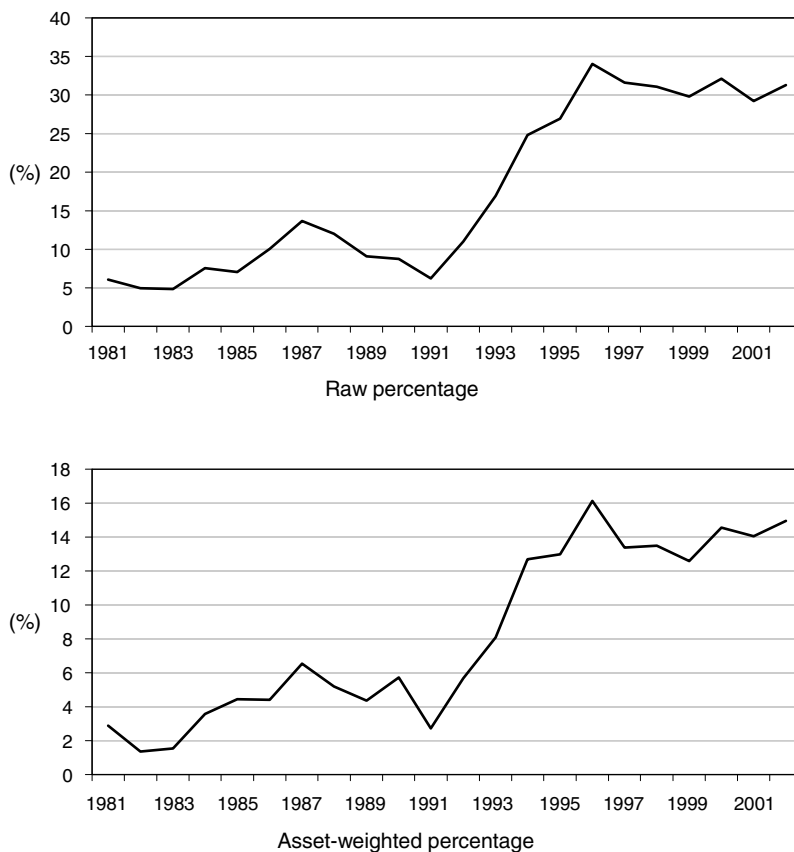


FIGURE 1. PREVALENCE OF FIRMS RECEIVING SUBSIDIZED LOANS IN JAPAN

Note: Percentages calculated as described in the text, with $d_1 = d_2 = 0$ in equation (1).

In the remainder of the paper we document and formalize this story. In the next section, we describe the construction of our zombie measure. There are a number of potential proxies that could be used to identify zombies. As we explain, however, measurement problems confound most of these alternatives.

Having measured the extent of zombies, we then model their effects. The model is a standard variant of the type that is studied in the literature on creative destruction. It is designed to contrast the adjustment of an industry to a negative shock with and without the presence of zombies. We model the presence of zombies as a constraint on the natural surge in destruction that would arise in the wake of an unfavorable technological, demand, or credit shock. The main effect of this constraint is that job creation must slow sufficiently to reequilibrate the economy. This means that during the adjustment the economy is characterized by what Caballero and Mohamad L. Hammour (1998, 2001) have called “sclerosis”—the preservation of production units that would not be saved without the banks’ subsidies—and the associated “scrambling”—the retention of firms and projects that are less productive than some of those that do not enter or are not implemented due to the congestion caused by the zombies.

In Section III, we assess the main empirical implications of the model. We start by studying the interaction between the prevalence of zombies and the amount of restructuring at the industry

level. Although the data are limited to only a few observations, the evidence is suggestive: we find that the rise of the zombies has been associated with falling levels of aggregate restructuring, with job creation being especially depressed in the sectors with the most zombie firms. We also find that the rise of the zombies lowered productivity at the industry level.

We then move on to the core of our empirical analysis which uses firm-level data to directly look for congestion effects of the zombies on non-zombie firms' behavior. We find that investment and employment growth for healthy firms falls as the percentage of zombies in their industry rises. Moreover, the gap in productivity between zombie and non-zombie firms rises as the percentage of zombies rises. These findings are consistent with the predictions that zombies crowd the market and that the congestion has real effects on the healthy firms in the economy. Simple extrapolations using our regression coefficients suggest that cumulative size of the distortions (in terms of investment, or employment) is substantial. For instance, compared with the hypothetical case where the prevalence of zombies in the 1990s remained at the historical average instead of rising, we find the investment was depressed between 4 and 36 percent per year (depending on the industry considered).

In the final section of the paper we summarize our results and describe their implications.

I. Identifying Zombies

Our story can be divided into two parts. First, the banks misallocated credit by supporting zombie firms. Second, the existence of zombie firms interfered with the process of creative destruction and stifled growth. Our measure of zombie should not only capture the misallocation of credit but also be useful in testing the effect of zombies on corporate profitability and growth.

A. Defining Zombies

There is a growing literature examining the potential misallocation of bank credit in Japan (see Toshitaka Sekine, Keiichiro Kobayashi, and Yumi Saita (2003) for a survey). Much of the evidence is indirect. For instance, several papers (including Hoshi (2000), Mitsuhiro Fukao (2000), Kaoru Hosono and Masaya Sakuragawa (2003), Yuri Sasaki (2004)) study the distribution of loans across industries and note that underperforming industries like real estate or construction received more bank credit than other sectors that were performing better (such as manufacturing).⁶

Joe Peek and Eric S. Rosengren (2005) offer the most direct and systematic study to date on the potential misallocation of bank credit. They find that bank credit to poor-performing firms often increased between 1993 and 1999. During poor performance periods, these firms' main banks are more likely to lend to them than other banks. This pattern of perverse credit allocation is more likely when the bank's own balance sheet is weak or when the borrower is a member of the same business group, i.e., is a *keiretsu* affiliate. Importantly, nonaffiliated banks do not show this pattern.

⁶ Other indirect evidence comes from studies such as David C. Smith (2003), Ulrike Schaefer (2005) and Richard Jerram (2004) which document that loan rates in Japan do not appear to be high enough to reflect the riskiness of the loans. Koji Sakai, Ichiro Uesugi, and Tsutomu Watanabe (2005), however, show that poorly performing firms (measured by operating profits or net worth) still pay higher bank loan rates and are more likely to exit compared with better performing firms, at least for small firms. Finally, see also Yasushi Hamao, Jianping Mei and Yexiao Xu (2007), who show that firm-level equity returns became less volatile during the 1990s and argue that this is likely due to a lack of restructuring in the economy.

We depart from past studies by classifying firms as zombies only based on our assessment of whether they are receiving subsidized credit, and not by looking at their productivity or profitability. This strategy permits us to evaluate the effect of zombies on the economy. If instead we were to define zombies based on their operating characteristics, then almost by definition industries dominated by zombie firms would have low profitability, and likely also have low growth. Rather than hard-wiring this correlation, we want to test for it.

The challenge for our approach is to use publicly available information to determine which firms are receiving subsidized credit: banks and their borrowers have little incentive to reveal that a loan is miss-priced. Because of the myriad ways in which banks could transfer resources to their clients, there are many ways that we could attempt to measure subsidies. To get some guidance we used the Nikkei Telecom 21 to search the four newspapers published by the Nihon Keizai Shimbun-sha (*Nihon Keizai Shimbun*, *Nikkei Kin'yū Shimbun*, *Nikkei Sangyō Shimbun*, *Nikkei Ryūtsū Shimbun*) between January 1990 and May 2004 for all news articles containing the words “financial assistance” and either “management reconstruction plan” or (“corporation” and “reconstruction”).⁷ The summary of our findings is given in Table 1.

Our search uncovers 120 separate cases. In most of them there were multiple types of assistance that were included. As the table shows, between interest rate concessions, debt-equity swaps, debt forgiveness, and moratoriums on loan principal or interest, most of these packages involve reductions in interest payments or outright debt forgiveness for the troubled firms.⁸

The decision by a bank to restructure the loans to distressed companies in these ways, rather than just rolling over the loans, helps reduce the required capital needed by the bank. Without such restructuring, banks would be forced to classify the loans to those borrowers as “at risk,” which usually would require the banks to set aside 70 percent of the loan value as loan loss reserves. With restructuring, the banks need only move the loans to the “special attention” category, which requires reserves of at most 15 percent.

In light of the evidence in Table 1, we concentrate on credit assistance that involves a direct interest rate subsidy. We proceed in three steps. First, we calculate a hypothetical lower bound for interest payments (R^*) that we expect only for the highest quality borrowers. We then compare this lower bound to the observed interest payments. Finally, we make several econometric assumptions to use the observed difference between actual interest rate (r) and notional lower bound rate (r^*) to infer cases where we believe subsidies are present.

B. Detecting Zombies

The minimum required interest payment for each firm each year, $R_{i,t}^*$, is defined as:

$$R_{i,t}^* = rs_{t-1}BS_{i,t-1} + \left(\frac{1}{5} \sum_{j=1}^5 rl_{t-j} \right) BL_{i,t-1} + rcb_{\min \text{ over last 5 years, } t} \times Bonds_{i,t-1},$$

where $BS_{i,t}$, $BL_{i,t}$, and $Bonds_{i,t}$ are short-term bank loans (less than one year), long-term bank loans (more than one year), and total bonds outstanding (including convertible bonds (CBs) and warrant-attached bonds), respectively, of firm i at the end of year t ; and rs_t , rl_t , and $rcb_{\min \text{ over the last 5 years, } t}$ are the average short-term prime rate in year t , the average long-term prime

⁷ The Japanese phrases were Kin'yu Shien AND (Keiei Saiken Keikaku OR (Kigyo AND Saiken)).

⁸ These patterns are consistent with the claim by Tett and David Ibbison that almost one-half of the public funds injected into the banking system in 1998 and 1999 were allowed to be passed on to troubled construction companies in the form of debt forgiveness (“Tokyo May Have to Support Banks,” *Financial Times*, September 14, 2001).

TABLE 1—SEARCH RESULTS FOR NEWS ARTICLES REGARDING RESTRUCTURED COMPANIES

Total hits for January 1990 through May 2004	1,196
Of which, related to private sector companies in Japan	1,085
Clear description of the content of “financial assistance” (excludes duplicate articles on the same case)	120
New loans	19
Interest concessions (金利減免)	36
Purchase of new shares (新株引き受け)	29
Debt-equity swaps	26
Debt forgiveness (債権放棄)	44
Moratorium on loan principle (元本支払猶予)	11
Moratorium on interest payments (利子支払猶予)	5

Notes: Search words: “financial assistance” AND (“management reconstruction plan” OR (“corporation” and “reconstruction”)); actual phrases were 金融支援 AND (経営再建計画 OR (企業 AND 再建)).

Source: Nikkei Telecom 21.

rate in year t , and the minimum observed coupon rate on any convertible corporate bond issued in the last five years before t .

This estimate for the lower bound reflects the data constraints we face. In particular, all we know about the firms’ debt structure is the type of debt instrument (short-term bank borrowing, long-term borrowing due in one year and remaining long-term bank borrowing, bonds outstanding due in one year and remaining bonds outstanding, and commercial paper outstanding). In other words, we do not know the exact interest rates on specific loans, bonds, or commercial paper, nor do we know the exact maturities of any of these obligations. Finally, the interest payments we can measure include all interest, fee, and discount expenses, including those related to trade credit.

The general principle guiding the choices we make is to select interest rates that are extremely advantageous for the borrower, so that R^* is in fact less than what most firms would pay in the absence of subsidies. For instance, by assuming that bond financing takes place at rcb_{\min} over the last 5 years, t , we are assuming not only that firms borrow using convertible bonds (which carry lower interest rates due to the conversion option), but also that these bonds are issued when rates are at their lowest. We provide additional discussion of the data choices used in constructing R^* and the alternative approaches that we examined for robustness checks in Appendix A.

To categorize firms, we compare the actual interest payments made by the firms ($R_{i,t}$) with our hypothetical lower bound. We normalize the difference by the amount of total borrowing at the beginning of the period ($B_{i,t-1} = BS_{i,t-1} + BL_{i,t-1} + Bonds_{i,t-1} + CP_{i,t-1}$), where $CP_{i,t-1}$ is the amount of commercial paper outstanding for the firm i at the beginning of the period t , so that the units are comparable to interest rates. Accordingly we refer to the resulting variable, $x_{i,t} \equiv (R_{i,t} - R_{i,t}^*)/B_{i,t-1} = r_{i,t} - r_{i,t}^*$, as the interest rate gap. This measure is “conservative” because we assume the minimum interest rates that are extremely advantageous to the firm and because the interest payment, $R_{i,t}$, includes interest expenses on items beyond our concept of total borrowing (such as interest expenses on trade credit).

Given our procedure to construct r^* we will not be able to detect all types of subsidized lending.⁹ In particular, any type of assistance that lowers the current period’s interest payments

⁹ In addition to the cases studied below, Hoshi (2006) examines the potential problems that might arise from rapid changes in interest rates. For example, if interest rates fell sharply and actual loan terms moved as well, then our gap variable could be misleading about the prevalence of subsidized loans. He constructs an alternative measure (that would be more robust to within-year interest rate changes) and concludes that this sort of problem does not appear to be quantitatively important.

can be detected, including debt forgiveness, interest rate concessions, debt for equity swaps, or moratoriums on interest rate payments, all of which appeared to be prevalent in the cases studied in Table 1. On the other hand, if a bank makes new loans to a firm at normal interest rates that are then used to pay off past loans, then our gap variable will not capture the subsidy. Likewise, if a bank buys other assets from a client at overly generous prices, our proxy will not detect the assistance.

We explore two strategies for identifying the set of zombie firms from the calculated interest rate gaps. Our baseline procedure classifies a firm i as a zombie for year t whenever its interest rate gap is negative ($x_{it} < 0$). The justification for this strategy is the conservative philosophy underlying the construction of r^* . If r^* is a perfectly measured lower bound, then only a firm that receives a subsidy can have a negative gap. However, the problem of labeling a firm with x_{it} just above zero as non-zombie remains even under this perfect scenario.

Thus we resort to a second approach, which is more robust to misclassification of non-zombies. In this second approach we assume that the set of zombies is a “fuzzy” set. In the classical set theory, an element either belongs or does not belong to a particular set so that a 0–1 indicator function can be used to define a subset. In contrast, in fuzzy set theory an element can belong to a particular subset to a certain degree, so that the indicator function can take any value in the interval $[0, 1]$. When the images of the indicator function are confined to $\{0, 1\}$, a set defined by the indicator function is called a “crisp” set. Using this terminology, our first approach assumes the set of zombies is “crisp.” Our second approach, on the other hand, assumes the set is “fuzzy,” allowing some firms to be more or less zombie-like.¹⁰

The indicator function that defines a fuzzy subset is called “membership function,” which we assume to be (for the set of zombie firms):

$$(1) \quad z(x; d_1, d_2) = \begin{cases} 1 & \text{if } x < d_1 \\ \frac{d_2 - x}{d_2 - d_1} & \text{if } d_1 \leq x \leq d_2 \quad \text{where } d_1 \leq 0 \leq d_2. \\ 0 & \text{if } x > d_2. \end{cases}$$

The shape of the membership function is determined by the two parameters, d_1 and d_2 . Figure 2 shows this membership function along with the indicator function implicit in our first approach. It is easy to see the second approach degenerates to our first approach when d_1 and d_2 are both zero.

The second approach is appealing, given the fuzzy nature of the concept of “zombie firms.” These are defined to be those firms that receive sufficient financial help from their creditors to survive in spite of their poor profitability. It is inherently difficult to specify how much financial help is considered to be sufficient, even if we had access to much more information than we do about individual firms. Our fuzzy approach acknowledges this limitation and assigns numbers between 0 and 1 to those firms whose zombie status is ambiguous.

Given the asymmetry (toward conservatism) inherent in the construction of r^* , we assume that d_1 is closer to zero than d_2 . In what follows we show results for $(d_1, d_2) = (0, 50\text{bp})$ and $(d_1, d_2) = (-25\text{bp}, 75\text{bp})$, where bp stands for basis points. Thus, in the first case, we assume a firm with x_{it} below zero is a definite zombie and a firm with x_{it} above 50 basis points is definitely a non-zombie: any firm with x_{it} between zero and 50 basis points has “zombiness” between 0 and 1.

¹⁰ See Hung T. Nguyen and Elbert A. Walker (2006) for an introduction to the fuzzy set theory.

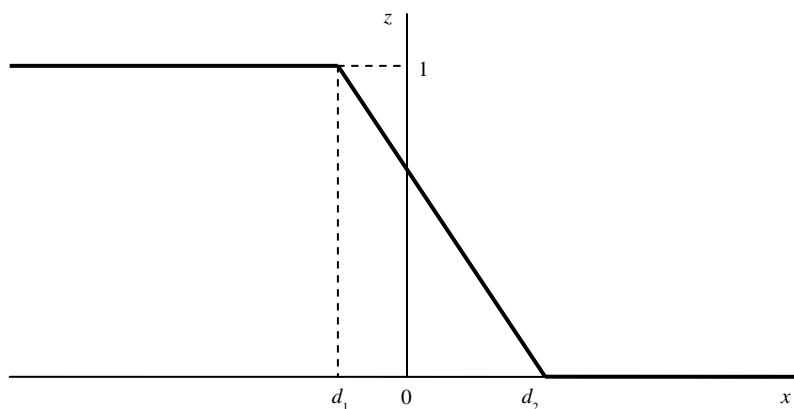


FIGURE 2. MEMBERSHIP FUNCTION FOR A FUZZY ZOMBIE SET

C. Quantifying the Prevalence of Zombies

Figure 1 showed the aggregate estimate of the percentage of zombies using our baseline procedure. As mentioned earlier, treating all firms equally we see that the percentage of zombies hovered between 5 and 15 up until 1993 and then rose sharply over the mid-1990s so that the zombie percentage was above 25 percent for every year after 1994. In terms of congestion spillovers, a size weighted measure of zombies is likely to be more important. Weighting firms by their assets, we see the same general pattern but with the overall percentage being lower, closer to 15 percent in the latter part of the sample.

We view the cross-sectional prevalence of zombies as another way to assess the plausibility of our definition. To conduct this assessment, we aggregated the data used in Figure 1 into five industry groups covering manufacturing, construction, real estate, retail and wholesale (other than the nine largest general trading companies), and services—recall that all the firms included here are publicly traded. The zombie index for an industry is constructed by calculating the share of total assets held by the zombie firms—and for the remainder of the paper we concentrate on asset weighted zombie indices. In addition to showing the industry distribution, we also compute the zombie percentages implied by our second procedure with $(d_1, d_2) = (0, 50\text{bp})$ and $(d_1, d_2) = (-25\text{bp}, 75\text{bp})$.

Figure 3 shows the zombie index for each industry from 1981 to 2002. We draw three main conclusions from these graphs. Starting with the upper-left-hand panel that shows the data for the entire sample, first notice that the crisp zombie measure (our baseline case) and the two fuzzy measures share similar time series movements (with the correlation between the crisp measure and the two fuzzy measures exceeding 0.99). Second, the other five panels show that the proportion of zombie firms increased in the late 1990s in every industry. The third key conclusion is that the zombie problem was more serious for nonmanufacturing firms than for manufacturing firms. In manufacturing, the crisp measure suggests that zombie index rose only from 3.11 percent (1981–1993 average) to 9.58 percent (1996–2002 average). In the construction industry, however, the measure increased from 4.47 percent (1981–1993 average) to 20.35 percent (1996–2002 average). Similar large increases occurred for the wholesale and retail, services, and real estate industries.

There are a variety of potential explanations for these cross-sectional differences. For instance, Japanese manufacturing firms face global competition and thus could not be protected easily

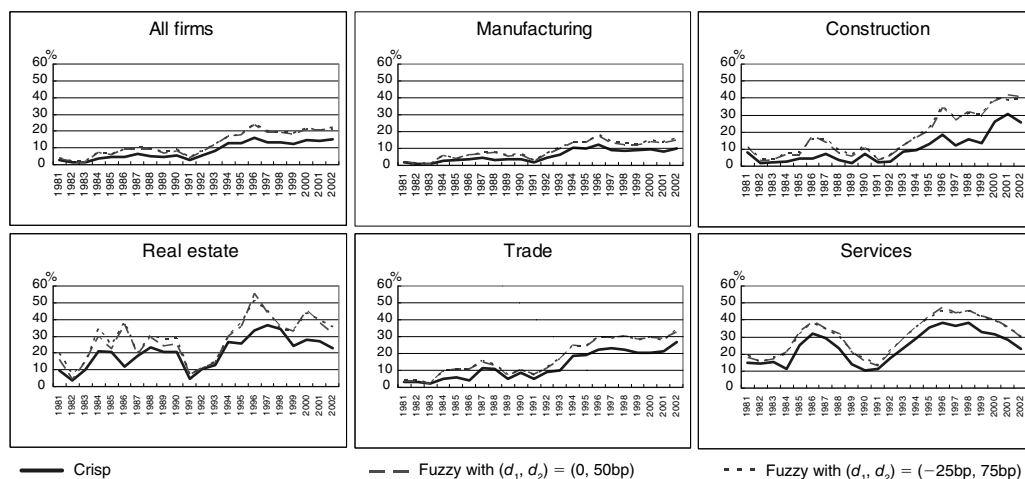


FIGURE 3. CROSS-INDUSTRY INCIDENCE OF ASSET WEIGHTED ZOMBIE PERCENTAGE FOR CRISP AND FUZZY ZOMBIE DEFINITIONS

Note: Fuzzie zombie definitions computed according to equation (1); see text for details.

without prohibitively large subsidies. For example, many of the troubled Japanese automakers were taken over by foreign firms rather than rescued by their banks during the 1990s. In contrast, there is very little foreign competition in the other four industries.

A second important factor was the nature of the shocks hitting the different sectors. For instance, the construction and real estate industries were forced to deal with the huge run-up and subsequent collapse of land prices mentioned earlier. Thus, the adjustment for these industries was likely to be more wrenching than for the other sectors.

But the most important point about the differences shown in Figure 3 is that they confirm the conventional wisdom that bank lending distortions were not equal across sectors and that the problems were less acute in manufacturing—see Sekine, Kobayashi, and Saita (2003) for further discussion. Thus, regardless of which explanation one favors as to why this might be the case, we view it as particularly reassuring that our zombie index confirms this conventional view.

Figure 4, our last plausibility check, shows the asset weighted percentages of zombies for the firms that are above and below the median profit rate for their industry. To keep the graphs readable we show only the crisp measures, but the other measures show similar patterns. In manufacturing the differences are not very noticeable, with slightly fewer high-profit firms being labeled as zombies. In the remaining industries, particularly real estate and construction, it appears that our measure of zombies is identifying firms that are systematically less profitable than the non-zombies, particularly from the mid-1990s onward.

D. Potential Classification Errors

Our classification scheme of zombies is admittedly imperfect, so we also consider a number of alternative schemes. The goal in exploring these alternatives is to assess the effect of misclassifying a zombie firm as a non-zombie (a type I error) or misclassifying a healthy firm as a zombie (a type II error). Most of the alternatives reduce one type of error by increasing the other type of error. Thus, we do not expect the results from these experiments to be identical. Instead, we looked primarily at whether the time series pattern and cross-sectional patterns were similar to

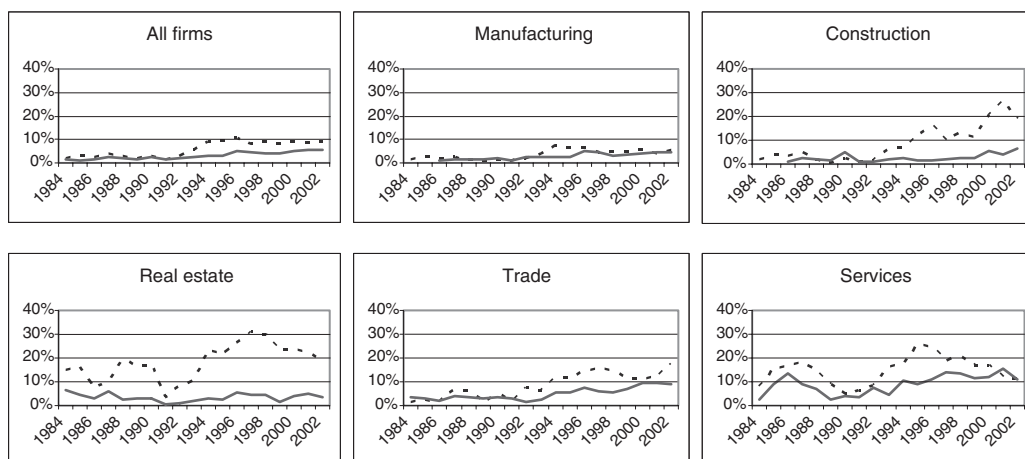


FIGURE 4. ASSET WEIGHTED ZOMBIE PERCENTAGES BY PROFITABILITY

Note: Solid lines show zombie percentage for firms whose profits are above the median for the industry, dashed show below median.

the ones presented in the last section. We also reestimate our basic regressions using these alternative zombie measures instead of our standard measures. The results for the baseline definitions and the alternatives are generally quite similar, and in the remainder of this section we briefly describe the properties of the alternatives.

One possible problem is that some good firms are mistakenly dubbed zombies because they can borrow at interest rates lower than the prime rates. Alternatively, if a good firm pays off its bank loans during an accounting year, we may find its interest payment for the accounting year too small given the amount of bank loans at the beginning of the period, and classify the firm as a zombie.¹¹

To gauge the extent of these problems, we modified our baseline definitions in two ways (both of which will reduce our estimates of the zombie prevalence). In one version, we automatically classified any firm having quality corporate bonds as non-zombies. This makes sense if we believe buyers of bonds will not subsidize firms and hence access to the bond market would dry up for failing firms. We considered two thresholds: bonds rated A or above, or those rated BBB or above, the latter being the cutoff for a bond to be considered investment grade.¹²

We also modified the definition to use data from either two or three years to determine a firm's zombie status; in these alternatives, we average the value of the zombie indicators across either two or three years. By taking only the firms that have persistently low funding costs, we are much more likely to avoid incorrectly labeling a non-zombie as a zombie. However, given the

¹¹ To see how often clearly healthy firms are misclassified as zombies by our crisp definition, Hoshi (2006) examined the firms that had R&I bond rating of AA or above as of November 2004 and are included in our sample. On only one occasion for one out of these 26 firms for five years (1997 to 2001), our zombie index misclassified the firm as a zombie. From this, he concludes that type II error is not a serious problem.

¹² We use the ratings by R&I and its predecessors. We thank Yasuhiro Harada and Akio Ihara of R&I for providing us with the data. When both the firm itself and the bonds that the firm issued are rated, we use the rating for the firm. When the rating for the firm itself is not available and when multiple bond issues are rated, we use the most recent rating announcement (newly rated, changed, or maintained).

nature of the lower bound interest rate used in our calculation, this averaging would be extremely conservative and hence much more likely to characterize zombies as non-zombies.¹³

To explore the potential impact of these type I errors, we reverse the preceding logic and count firms as zombies based on the maximum zombie indicator over either the last two or three years.¹⁴ For example, with the three-year window, we define a new crisp set of zombies that includes all firms for which the crisp indicator identifies a firm as a zombie in the current year or either of the last two years. Naturally, these corrections raise the estimated prevalence of zombies.

Collectively these experiments yield 18 alternative indices (the three baseline definitions, interacted with two different bond rating thresholds, two time averaging schemes, and two maximum time horizons). Table 2 summarizes the characteristics of the various definitions. The second column shows the correlations between the different measures and the crisp index (Z1), while the next column reports the asset weighted percentage of zombies in the last year of the sample (2002). We report the latter data because having inspected versions of Figure 3 for the various definitions, this is a convenient way to summarize the quantitative differences across them.

We read these two columns as suggesting two main conclusions. First, the crisp measure is highly correlated with all other measures. Second, the quantitative significance of the alternatives on the estimated level of zombie prevalence is fairly modest. For instance, the estimates for the conservative alternatives based on the crisp zombie definition (ZA01 to ZA04) in 2002 range from 10.65 percent to 14.14 percent, while Z01 is 14.96 percent. The estimates for the alternatives based on fuzzy zombies (ZA05 to ZA12) range between 17.09 percent and 22.17 percent, while Z02 and Z03 are 21.40 percent and 22.42 percent, respectively.

The remaining columns in the table show correlations between the crisp measure for different industries and the alternative estimates. Given the predominance of manufacturing firms in the sample, it is not surprising that the results for that industry mimic the full sample patterns. The alternatives are also quite similar for construction, trade, and services, and there is no reason why this needs to be the case.

The variation across the zombie definitions for the real state sector is somewhat larger. This partially reflects the fact that there were not many real estate firms in the sample (fewer than 40 in the early 1980s and no more than 60 during the 1990s). Indeed, looking back at Figure 3 it was already apparent that the fuzzy and crisp definitions gave somewhat different pictures of the 1980s. This is because the movement of only a few firms could change the percentages appreciably. Fortunately given the small size of this sector relative to the other four (less than 5 percent of total sample assets reside in this sector), these differences are not responsible for the main findings that follow.

II. A Simple Model of the Effect of Zombie Firms on Restructuring

To analyze the effect of zombies we study a simple environment that involves entry and exit decisions of single-unit incumbent firms and potential new firms. After exploring this case we consider a richer version of the model that describes expansion and contraction decisions of

¹³ If we go all the way to forcing the firms to be obvious zombies in multiple consecutive years the percentages of zombies drops sharply. For instance, using the crisp definition, the percentage of assets in zombie firms is 14.96 percent in 2002. If we consider only firms that are zombies in two (three) consecutive years, the percentage drops to 10.83 percent (8.74 percent).

¹⁴ Hoshi (2006) examines prevalence of type I error by looking at how our zombie measure classifies well-known troubled firms in Japan. He finds that our measure often fails to identify the firms in the list of highly indebted and troubled firms published in *Kin'yu Business* (December 2001) as zombies. Thus, he concludes the type I error is potentially a problem.

TABLE 2—CORRELATION BETWEEN CRISP ASSET-WEIGHTED ZOMBIE PERCENTAGE AND THE ALTERNATIVES

	All firms	2002 Zombie percentage	Manufacturing	Construction	Real estate	Trade	Services
Z01	1.0000	14.96	1.0000	1.0000	1.0000	1.0000	1.0000
Z02	0.9900	21.40	0.9787	0.9580	0.8648	0.9839	0.9784
Z03	0.9910	22.42	0.9768	0.9529	0.8554	0.9860	0.9816
ZA01	0.9985	13.34	0.9953	0.9785	0.9997	0.9977	0.9807
ZA02	0.9867	10.65	0.9807	0.9430	0.9975	0.9892	0.9673
ZA03	0.9810	14.13	0.9734	0.9675	0.9204	0.9774	0.9508
ZA04	0.9607	14.14	0.9456	0.9474	0.8067	0.9548	0.8532
ZA05	0.9851	19.79	0.9645	0.9179	0.8575	0.9756	0.9576
ZA06	0.9748	17.09	0.9445	0.8674	0.8620	0.9658	0.9566
ZA07	0.9743	20.62	0.9583	0.9387	0.8639	0.9726	0.9275
ZA08	0.9467	20.50	0.9225	0.9193	0.7770	0.9575	0.8255
ZA09	0.9875	22.17	0.9636	0.9548	0.8532	0.9823	0.9683
ZA10	0.9855	20.70	0.9595	0.9550	0.8529	0.9793	0.9643
ZA11	0.9725	21.08	0.9516	0.9372	0.8442	0.9746	0.9303
ZA12	0.9434	21.01	0.9150	0.9161	0.7438	0.9592	0.8300
ZA13	0.9796	17.42	0.9764	0.9752	0.8740	0.9742	0.9454
ZA14	0.9692	19.72	0.9602	0.9691	0.7853	0.9613	0.8723
ZA15	0.9707	24.68	0.9522	0.9358	0.7881	0.9659	0.9058
ZA16	0.9485	27.62	0.9142	0.9210	0.7481	0.9584	0.8041
ZA17	0.9676	25.16	0.9463	0.9416	0.7508	0.9706	0.9163
ZA18	0.9429	28.21	0.9097	0.9291	0.6640	0.9625	0.8321

Notes: The first column shows the (alternative) zombie definition. The column “2002 Zombie percentage” reports the 2002 (asset weighted) zombie percentage for all firms calculated using the various definitions. The other columns show the correlation coefficient between the zombie indicator calculated using the various definitions and the baseline crisp zombie indicator (Z01) for the sample of firms indicated in the header row.

(Alternative) Definitions:

Z01	Baseline crisp zombie definition $(d_1, d_2) = (0, 0)$
Z02	Baseline fuzzy zombie with $(d_1, d_2) = (0, 0.005)$
Z03	Baseline fuzzy zombie with $(d_1, d_2) = (-0.0025, 0.0075)$
ZA01	Crisp zombie excluding firms with bonds rated A or above
ZA02	Crisp zombie excluding firms with bonds rated BBB or above
ZA03	Crisp zombie 2-year average of years t and $t-1$
ZA04	Crisp zombie 3-year average of years t , $t-1$ and $t-2$
ZA05	Fuzzy zombie with $(d_1, d_2) = (0, 0.005)$ excluding firms with bonds rated A or above
ZA06	Fuzzy zombie with $(d_1, d_2) = (0, 0.005)$ excluding firms with bonds rated BBB or above
ZA07	Fuzzy zombie 2-year average of years t and $t-1$ with $(d_1, d_2) = (0, 0.005)$
ZA08	Fuzzy zombie 3-year average of years t , $t-1$ and $t-2$ with $(d_1, d_2) = (0, 0.005)$
ZA09	Fuzzy zombie with $(d_1, d_2) = (-0.0025, 0.0075)$ excluding firms with bonds rated A or above
ZA10	Fuzzy zombie with $(d_1, d_2) = (-0.0025, 0.0075)$ excluding firms with bonds rated BBB or above
ZA11	Fuzzy zombie 2-year average of years t and $t-1$ with $(d_1, d_2) = (-0.0025, 0.0075)$
ZA12	Fuzzy zombie 3-year average of years t , $t-1$ and $t-2$ with $(d_1, d_2) = (-0.0025, 0.0075)$
ZA13	Crisp zombie 2-year maximum of years t and $t-1$
ZA14	Crisp zombie 3-year maximum of years t , $t-1$ and $t-2$
ZA15	Fuzzy zombie 2-year maximum of years t and $t-1$ with $(d_1, d_2) = (0, 0.005)$
ZA16	Fuzzy zombie 3-year maximum of years t , $t-1$ and $t-2$ with $(d_1, d_2) = (0, 0.005)$
ZA17	Fuzzy zombie 2-year maximum of years t and $t-1$ with $(d_1, d_2) = (-0.0025, 0.0075)$
ZA18	Fuzzy zombie 3-year maximum of years t , $t-1$ and $t-2$ with $(d_1, d_2) = (-0.0025, 0.0075)$

existing multiunit firms. As a benchmark we first model all decisions being governed purely by the operating profits from running a firm. We then contrast that environment to one where some incumbent firms (for an unspecified reason) receive a subsidy that allows them to remain in business despite negative operating profits.

A. *The Environment*

The essential points of interest can be seen in a model where time is discrete and indexed by t . A representative period t starts with a mass m_t of existing production units. The productivity of the incumbents varies over time and the current level of productivity for firm i in year t , Y_{it}^o , is:

$$Y_{it}^o = A_t + A_t B + A_t \varepsilon_{it}^o = A_t(1 + B + \varepsilon_{it}^o),$$

where A_t represents the state of technology shared by all the incumbent production units at time t , B is a potential shift parameter that can represent an aggregate productivity shock, and ε_{it}^o is an idiosyncratic shock that is distributed uniformly on the unit interval. The state of technology is assumed to improve over time so that $A_{t+1} > A_t$. The main predictions from this model do not depend on the persistence of idiosyncratic productivity shocks, so we assume they are independently and identically distributed.

In addition to the incumbents, there is a set of potential entrants, and we normalize their mass to be $\frac{1}{2}$. Each potential entrant draws a productivity level, Y_{it}^n , before deciding whether to enter or not. We assume that potential entrants have technological advantage over incumbents, so that the productivity for a potential new firm is consistently higher than incumbents by γA_t . Thus,

$$Y_{it}^n = A_t(1 + \gamma) + A_t B + A_t \varepsilon_{it}^n = A_t(1 + \gamma + B + \varepsilon_{it}^n),$$

with ε_{it}^n distributed uniformly on the unit interval. The shock ε_{it}^n is again assumed to have no persistence. The stochastic process for aggregate technology was left unspecified, except for the assumption that it grows by more than the advantage of the new firms, so that $A_{t+1} > (1 + \gamma)A_t$. We also assume that there is an entry cost that is proportional to the state of technology, $\kappa A_t > 0$, that the new entrants must pay to start up.

Finally, both new and old units must incur a cost $A_t p(N_t)$ in order to produce, where N_t represents the number of production units in operation at time t , i.e., the sum of remaining incumbents and new entrants. The function $p(N)$ is increasing with respect to N , and captures any reduction in profits due to congestion or competition.¹⁵ For our purposes, all the predictions we emphasize will hold as long as $p(N)$ is a strictly increasing continuous function of N . For simplicity, we adopt the linear function:

$$p(N_t) = N_t + \mu,$$

where the intercept μ captures cost changes and other profit shocks.

In analyzing this model, it is useful to normalize productivity by the state of technology. For the incumbents, this is given by

$$(2) \quad y_{it}^o \equiv \frac{Y_{it}^o}{A_t} = 1 + B + \varepsilon_{it}^o.$$

¹⁵ For example, we can motivate $p(N)$ as the reduction in profits due to competition in the output market. Suppose the price of output is given by $D^{-1}(N)$, a decreasing function of N , and that the cost of production for each production unit is just proportional to the state of technology, AC . Under our assumption on productivity, an incumbent decides to stay in the market (and a potential entrant decides to enter the market) if $D^{-1}(N)A(1 + B + \varepsilon) - AC > 0$, or equivalently, $1 + B + \varepsilon - C/D^{-1}(N) > 0$. In this specific example, $p(N)$ is $C/D^{-1}(N)$, which is increasing with respect to N .

For the potential entrants:

$$(3) \quad y_{it}^n \equiv \frac{Y_{it}^n}{A_t} = 1 + \gamma + B + \varepsilon_{it}^n.$$

B. Decisions

This basic model will quickly generate complicated dynamics because the existing firms have paid the entry cost and thus face a different decision problem than the new firms for which the entry cost is not sunk. These dynamics are not essential for our main predictions; thus we assume that $\gamma = \kappa$. In this case, the exit decision by incumbents and the entry decision by potential entrants become fully myopic. Since productivity shocks are i.i.d. and there is no advantage from being an insider (the sunk cost of investment is exactly offset by a lower productivity), both types of units look only at current profits to decide whether to operate.

Letting \bar{y}^o and \bar{y}^n denote the reservation productivity (normalized by the state of technology) of incumbents and potential entrants, respectively, we have:

$$\bar{y}^o - p(N) = 0,$$

$$\bar{y}^n - \kappa - p(N) = 0.$$

In this case it is straightforward to find the mass of exit, D_t , and entry, H_t , respectively:

$$(4) \quad D_t = m_t \left[1 - \int_{p(N_t)-1-B}^1 di \right] = m_t(p(N_t) - 1 - B),$$

$$(5) \quad H_t = \frac{1}{2} \int_{p(N_t)-1-B}^1 di = \frac{1}{2} (1 - (p(N_t) - 1 - B)).$$

Adding units created to the surviving incumbents yields the total number of units operating at time t :

$$(6) \quad N_t = H_t + m_t - D_t = \left(\frac{1}{2} + m_t \right) (1 - (p(N_t) - 1 - B)).$$

C. Equilibrium and Steady State

We can now solve for the steady state of the normal version of the economy. The first step is to replace $p(N)$ with $N + \mu$ in (6). The notation is simplified if we define S to be a composite shock that is equal to $1 + B - \mu$. Note that a lower S indicates either higher costs (higher μ) or lower productivity for both incumbents and potential entrants (smaller B). We can now find the equilibrium number of units:

$$(7) \quad N_t = \left(\frac{1/2 + m_t}{3/2 + m_t} \right) (1 + S).$$

Given the total number of operating units, we can solve for equilibrium rates of destruction and creation by substituting (7) into (4) and (5):

$$(8) \quad D_t = m_t \left(\frac{1/2 + m_t - S}{3/2 + m_t} \right),$$

$$(9) \quad H_t = \frac{1}{2} \left(\frac{1 + S}{3/2 + m_t} \right).$$

The dynamics of this system are determined by

$$(10) \quad m_{t+1} = N_t.$$

In steady state, the mass of incumbents remains constant at $m^{ss} = N^{ss}$, which requires that creation and destruction exactly offset each other or, equivalently, that $m_t = N_t$. Using the latter condition and (7) yields a quadratic equation for m^{ss} , which has a unique positive solution of

$$m^{ss} = \frac{S - \frac{1}{2} + \sqrt{\left(\frac{1}{2} - S\right)^2 + 2(1 + S)}}{2}.$$

For small values of S , we can approximate the above by

$$m^{ss} \approx \frac{1}{2} + \frac{2}{3}S.$$

In our subsequent analysis we will assume that the economy begins in a steady state and that the initial (pre-shock) value of S , S_0 , is 0. Given this normalization, the corresponding steady state will be $m_0 = N_0 = 1/2$ and $H_0 = D_0 = 1/4$.

D. A (Permanent) Recession

We can now analyze the adjustment of the economy to a profit shock. By construction the model treats aggregate productivity shifts, changes in A , and cost shocks, changes in μ , as equivalent. Thus, what follows does not depend on which of these occurs. We separate the discussion to distinguish between the short- and long-run impact of a decline in S from $S_0 = 0$ to $S_1 < 0$. By the "short run" we mean for a fixed $m = m_0 = 1/2$. By the "long run," on the other hand, we mean after m has adjusted to its new steady-state value $m_1 = 1/2 + (2/3)S_1$.

It is easy to see from equations (7), (8), and (9) that in the short run,

$$(11) \quad \frac{\partial D}{\partial S} = \frac{-2m_0}{3 + 2m_0} = -\frac{1}{4},$$

$$(12) \quad \frac{\partial H}{\partial S} = \frac{1}{3 + 2m_0} = \frac{1}{4},$$

$$(13) \quad \frac{\partial N}{\partial S} = \frac{1 + 2m_0}{3 + 2m_0} = \frac{1}{2}.$$

That is, when S drops, creation falls and destruction rises, leading to a decline in N . In other words, in a normal economy, a negative profit shock is met with both increased exit by incumbents and reduced entry of new firms.

Over time, the gap between destruction and creation reduces the number of incumbents (recall from (6) and (10) that $\Delta N = H - D$), which lowers the cost ($p(N)$) and eventually puts an end to the gap between creation and destruction caused by the negative shock.

Across steady states, we have that

$$\frac{\partial N}{\partial S} = \frac{\partial m}{\partial S} = \frac{2}{3}.$$

The number of production units falls beyond the initial impact as time goes by, and the positive gap between destruction and creation closes gradually. Note that because N falls less than one for one with S , the long-run reduction in the cost due to reduced congestion is not enough to offset the direct effect of a lower S on creation. That is, creation falls in the long run. And since creation and destruction are equal in the long run, the initial surge in destruction is temporary, and ultimately destruction also ends up falling below its pre-shock level.¹⁶

E. Zombies

Suppose now that “banks” choose to protect incumbents from the initial surge in destruction brought about by the decline in S . There are a variety of ways that this might be accomplished. We assume that the banks do this by providing just enough resources to the additional units that would have been scrapped so that they can remain in operation. With this assumption, a firm that does receive a subsidy is indifferent to exiting and operating, and thus entry and exit decisions remain myopic.

Under the zombie-subsidy assumption, we have that

$$D_{0+}^z = D_0 = \frac{1}{4}.$$

The post-shock destruction remains the same as the pre-shock level. The lack of adjustment on the destruction margin means that now creation must do all the adjustment. Thus, the following two equations, derived from (5) and (6), determine the post-shock creation and the number of production units under the presence of zombies:

$$H_{0+}^z = \frac{1}{2}(1 - N_{0+}^z + S),$$

$$N_{0+}^z = H_{0+}^z + m_0 - D_{0+}^z = H_{0+}^z + 1/4.$$

¹⁶This long-run level effect is undone when creation and destruction are measured as ratios over N , as is often done in empirical work. However, the qualitative aspects of the short-run results are preserved since, empirically, the flows are divided by either initial employment or a weighted average of initial and final employment.

Substituting implies:

$$(14) \quad H_{0+}^z = \frac{1}{3}(1 + S) - \frac{1}{3}(m_0 - D_{0+}^z) = \frac{S}{3} + \frac{1}{4},$$

$$(15) \quad N_{0+}^z = \frac{1}{3}(1 + S) - \frac{2}{3}(m_0 - D_{0+}^z) = \frac{S}{3} + \frac{1}{2}.$$

Differentiating (14) with respect to S , and comparing the result to the short-run change in creation that occurs in the absence of zombies (given by (12)),

$$\frac{\partial H_{0+}^z}{\partial S} = \frac{1}{3} > \frac{1}{4} = \frac{\partial H_{0+}}{\partial S}.$$

Indeed, it is easy to see the expression (12) is less than $1/3$ for any positive m_0 . That is, a decline in S always has a much larger negative effect on creation in the presence of zombies. This result is a robust feature of this type of model. In particular, the same qualitative prediction would hold even if we had not suppressed the dynamics and had allowed persistence in the productivity shocks and a gap between entry costs and the productivity advantage of new firms. Intuitively, this is the case because the adverse shock requires the labor market to clear with fewer people employed. If destruction is suppressed, then the labor market clearing can occur only if job creation drops precipitously.

As Caballero and Hammour (1998, 2001) emphasize, both this “sclerosis”—the preservation of production units that would not be saved without the banks’ subsidies— and the associated “scrambling”—the retention of firms that are less productive than some of those that do not enter due to the congestion caused by the zombies—are robust implications of models of creative destruction when there are frictions against destruction.

Compared with a normally functioning economy, we have shown the existence of zombies softens a negative shock’s impact on destruction and exacerbates its impact on creation. What is the net effect on the number of firms? Differentiating with respect to S :

$$\frac{\partial N_{0+}^z}{\partial S} = \frac{1}{3} < \frac{1}{2} = \frac{\partial N_{0+}}{\partial S}.$$

That is, in response to a negative shock, N falls by less if there are zombies, which means that in the presence of zombies the reduced destruction is not fully matched by the additional drop in creation. It is easy to see that expression (13) is greater than $1/3$ for any positive m_0 . This is another intuitive and robust result. This occurs because as job creation falls, the marginal entrant’s productivity rises. This high productivity allows the marginal entrant to operate despite the higher cost induced by (comparatively) larger N .

A final important prediction of the model is the existence of a gap in profitability (net of entry costs) between the marginal entrant and the marginal incumbent when there are zombies.¹⁷ At impact, the destruction does not change, so that all the firms with idiosyncratic productivity

¹⁷ Note that a wedge like this one also arises when there is a credit constraint on potential entrants but not on incumbents. In our model, depressed entry results from the congestion due to zombies, and the gap is due to the subsidy to

shocks above the old threshold ($\frac{1}{2}$) remain in the industry. On the other hand, new entrants have to clear a higher threshold to compensate for the negative shock in S (which is only partially offset by the lower congestion following the negative shock). As a result, the profitability of the marginal entrant is inefficiently higher than that of the marginal incumbent. The difference (normalized by the existing state of technology) is given by

$$\left[\left(\frac{S}{3} + \frac{1}{2} \right) - S \right] - \frac{1}{2} = -\frac{2}{3} S > 0.$$

In summary, the model makes two robust predictions. The first is that the presence of zombies distorts the normal creation and destruction patterns to force larger creation adjustments following shocks to costs, productivity, or profits. Second, this distortion depresses productivity by preserving inefficient units at the expense of more productive potential entrants. Accordingly, productivity will be lower when there are more zombies, and as the zombies become more prevalent they will generate larger and larger distortions for the non-zombies.

Finally, note that for simplicity we have illustrated the main effects of zombies in the case of a permanent recession. However these effects carry over to temporary recessions as well. The main mechanism through which zombies hurt creation and productivity is through congestion. It is apparent that if the recession were to end, then the presence of congesting zombies would yield a recovery that is less vigorous in terms of creation and productivity growth. This weak recovery aspect is also a fairly general implication of models of creation destruction with frictions in destruction.¹⁸

F. A Firm as a Collection of Projects

By reinterpreting a “production unit” in the model to be a “project” and defining a “firm” as an entity that has many such projects (both existing and potential), we can use the model to discuss expansions and contractions of large firms. This extension brings the theoretical discussion closer to our empirical analysis in later sections.

Let us assume that the industry has a fixed number of firms, which is normalized to be one. Each firm has a mass m_{kt} of incumbent projects, whose productivity (normalized by the existing state of technology) is given by (2). Each firm has a mass $\frac{1}{2}$ of potential new projects, whose productivity (normalized by the state of technology) is given by (3). Each project is hit by an idiosyncratic shock every period, so each firm decides which incumbent projects to terminate and which new projects to start.

A zombie firm is defined to be a firm that does not adjust the project selection rules when a (negative) shock hits the industry, consistent with the discussion above. A non-zombie firm adjusts the project selection rules following the shock. The operating cost (normalized by the state of technology) of the firm is, as before, assumed to be a function of the total amount of projects operated by all the firms in the industry at time t , N_t . Letting λ be the proportion of non-zombie firms in the industry and assuming all zombies (and non-zombies) are homogeneous within the

incumbents. Clearly, however, if the two mechanisms coexist they would reinforce each other, as congestion would reduce the collateral value of potential entrants.

¹⁸ See, e.g., Caballero (2007).

group in terms of the distribution of potential projects they can take, the total number of projects actually taken by all the firms is

$$(16) \quad N_t = \lambda N_t^{nz} + (1 - \lambda)N_t^z,$$

where N_t^z is the total number of projects operated by a (representative) zombie firm and N_t^{nz} is the total number of projects operated by a (representative) non-zombie firm.

Assuming the same linear functional form for $p(N)$ and the same notation for the shock S as in the previous sections, a non-zombie firm starts all the new projects with idiosyncratic productivity shock greater than $N - S$ and terminates all the incumbent projects with idiosyncratic productivity shock less than $N - S$. Thus, destruction (the number of incumbent projects terminated) by non-zombies, denoted by D_t^{nz} , is

$$(17) \quad D_t^{nz} = m_t^{nz}(N_t - S),$$

where m_t^{nz} is the number of incumbent projects for a non-zombie at the beginning of period t . Similarly, creation (the number of new projects implemented) by non-zombies, denoted by H_t^{nz} , is

$$(18) \quad H_t^{nz} = \frac{1}{2}(1 + S - N_t).$$

The total number of projects taken by non-zombie firms in period t is

$$(19) \quad N_t^{nz} = m_t^{nz} + H_t^{nz} - D_t^{nz}.$$

Solving the equations (16) through (19) for a given N_t^z , which by assumption is insensitive to changes in S ,

$$(20) \quad N_t^{nz} = \frac{1/2 + m_t^{nz}}{1 + \lambda(1/2 + m_t^{nz})} [1 + S - (1 - \lambda)N_t^z],$$

$$(21) \quad D_t^{nz} = \frac{m_t^{nz}}{1 + \lambda(1/2 + m_t^{nz})} \left[\lambda \left(\frac{1}{2} + m_t^{nz} \right) - S - \left\{ \lambda \left(\frac{1}{2} + m_t^{nz} \right) - 1 \right\} (1 - \lambda)N_t^z \right],$$

$$(22) \quad H_t^{nz} = \frac{1}{2(1 + \lambda(1/2 + m_t^{nz}))} [1 + S - (1 - \lambda)N_t^z].$$

By differentiating (20), (21), and (22), it is straightforward to see

$$\frac{\partial D_t^{nz}}{\partial S} = -\frac{m_t^{nz}}{1 + \lambda(1/2 + m_t^{nz})} < 0,$$

$$\frac{\partial H_t^{nz}}{\partial S} = \frac{1/2}{1 + \lambda(1/2 + m_t^{nz})} > 0,$$

$$\frac{\partial N_t^{nz}}{\partial S} = \frac{1/2 + m_t^{nz}}{1 + \lambda(1/2 + m_t^{nz})} > 0.$$

Thus, following a negative profitability shock, non-zombie firms increase destruction, reduce creation, and contract. Moreover, the size of these adjustments is increasing in the number of zombies in the industry. This can be shown by differentiating the derivatives above with respect to λ :

$$(23) \quad \begin{aligned} \frac{\partial^2 D_t^{nz}}{\partial S \partial \lambda} &= \frac{m_t^{nz}(1/2 + m_t^{nz})}{[1 + \lambda(1/2 + m_t^{nz})]^2} > 0, \\ \frac{\partial^2 H_t^{nz}}{\partial S \partial \lambda} &= -\frac{(1/2 + m_t^{nz})}{2[1 + \lambda(1/2 + m_t^{nz})]^2} < 0, \\ \frac{\partial^2 N_t^{nz}}{\partial S \partial \lambda} &= -\frac{(1/2 + m_t^{nz})^2}{[1 + \lambda(1/2 + m_t^{nz})]^2} < 0. \end{aligned}$$

Having more zombies in the industry (smaller λ) increases the amount of adjustment induced by a negative shock (negative S).

We can also study the productivity implications for non-zombies. The productivity (normalized by the state of technology) of the marginal incumbent project kept by non-zombie firms is $N_t - S$. Similarly, the productivity of the marginal new project chosen by non-zombies is $\gamma + N_t - S$. Thus, under the assumption of a uniform distribution of idiosyncratic shock for projects, the average productivity of a non-zombie firm, V_t , is

$$(24) \quad V_t = \frac{1 + N_t - S}{2} + \frac{\gamma}{2} \frac{H_t^{nz}}{N_t^{nz}}.$$

Substituting (16), (20), and (22) into (24), yields

$$V_t = \frac{1 + (1 - \lambda)N_t^z + \lambda N_t^{nz} - S}{2} + \frac{\gamma}{2(1 + 2m_t^{nz})}.$$

Thus,

$$(25) \quad \begin{aligned} \frac{\partial V_t}{\partial S} &= \frac{1}{2} \left[\lambda \frac{\partial N_t^{nz}}{\partial S} - 1 \right] - \frac{\gamma}{(1 + 2m_t^{nz})^2} \frac{\partial m_t^{nz}}{\partial S} \\ &= -\frac{1}{2 + \lambda(1 + 2m_t^{nz})} - \frac{\gamma}{(1 + 2m_t^{nz})^2} \frac{\partial m_t^{nz}}{\partial S}. \end{aligned}$$

Immediately after a negative profitability shock hits the industry, the second term of this expression is zero, so that the average productivity of a non-zombie unambiguously goes up.

Over time, a negative shock reduces the number of incumbent projects and gradually increases the proportion of new (and more productive) projects relative to incumbent projects. This further increases average productivity:

$$\frac{\partial m_t^{nz}}{\partial S} = \frac{\partial N_{t-1}^{nz}}{\partial S} = \frac{1/2 + m_{t-1}^{nz}}{1 + \lambda(1/2 + m_{t-1}^{nz})} > 0.$$

Moreover, it is clear that both (negative) terms in (25) are increasing in λ . Thus, when there are more zombies in the industry (smaller λ), the size of the productivity gap increases.

From this analysis we conclude that allowing for multi-project firms does not change the baseline predictions regarding creation, destruction, or productivity. We explored further extensions of the model that allowed for heterogeneity in the productivity levels but found that there were no robust predictions about how heterogeneity might alter these predictions. In particular, if we model heterogeneity as a firm-specific factor that affects the level of productivity (i.e., adding a firm-specific constant to equations (2) and (3)), then there are no changes to our main predictions regarding the effects of increased zombie prevalence.

III. Empirical Evidence for Zombie Distortions

This section provides empirical support for our model and story. We begin by reporting aggregate cross-industry differences. While the aggregate data correspond to only a few data points, they already hint at a negative effect of zombies on the process of creative destruction in Japan. We then move on to the core of our empirical strategy and study firm-level data to characterize how the presence of zombie competitors has hurt the performance of non-zombie firms.

In our industry-level analysis, we start by calculating the average of the crisp zombie index for each industry from 1981 (the start of our sample) until 1993 and compare that to the average for the late 1990s (1996–2002). We use the differences in these two averages to correct for biases introduced by possible correlation between the level of the zombie index and any industry-specific effects. It makes little difference as to how we define the pre-zombie period. In particular, the results we show would be very similar if we took the normal (non-zombie) period to be 1981 to 1990, or 1990 to 1993. Our industry-level evidence consists of relating job creation, job destruction, and productivity data to this change in the zombie index, in order to see if these restructuring and performance measures are more distorted in the industries where zombie prevalence has increased the most.

Figure 5 plots the rate of job creation and destruction against the change in the zombie index. We use the job flow measures constructed by Yuji Genda et al. (2003) as proxies for the concepts of entry and exit in our model. Their measures are based on the Survey of Employment Trends, biannually conducted by the Ministry of Welfare and Labor on a large sample of establishments that employ five or more regular workers. The series used for our analysis includes not only the job creation (destruction) at the establishments that were included in the survey both at the beginning and at the end of the year, but also the estimated job creation (and destruction) by new entrants (and the establishments that exited). To control for the industry-specific effects in job creation/destruction, we look at the difference between the average job creation/destruction rate for the 1996–2000 period and the average for the 1991–1993 period. We are restricted to using the 1991–1993 data as a control because figures of Genda et al. (2003) start only in 1991, and we stop in 2000 because that is the last year they study. Our analysis is also limited by the fact that the job flow measures are calculated only for a broad industrial clarification that groups all manufacturing industries as one sector.

The top of Figure 5 shows that the job destruction rate in the late 1990s increased from that in the early 1990s in every sector, as we would expect to see following an unfavorable shock to the economy. More importantly, the figure shows that the surge in destruction was smaller in the industries where more zombies appeared. Thus, as we expected, the presence of zombies slows down job destruction.

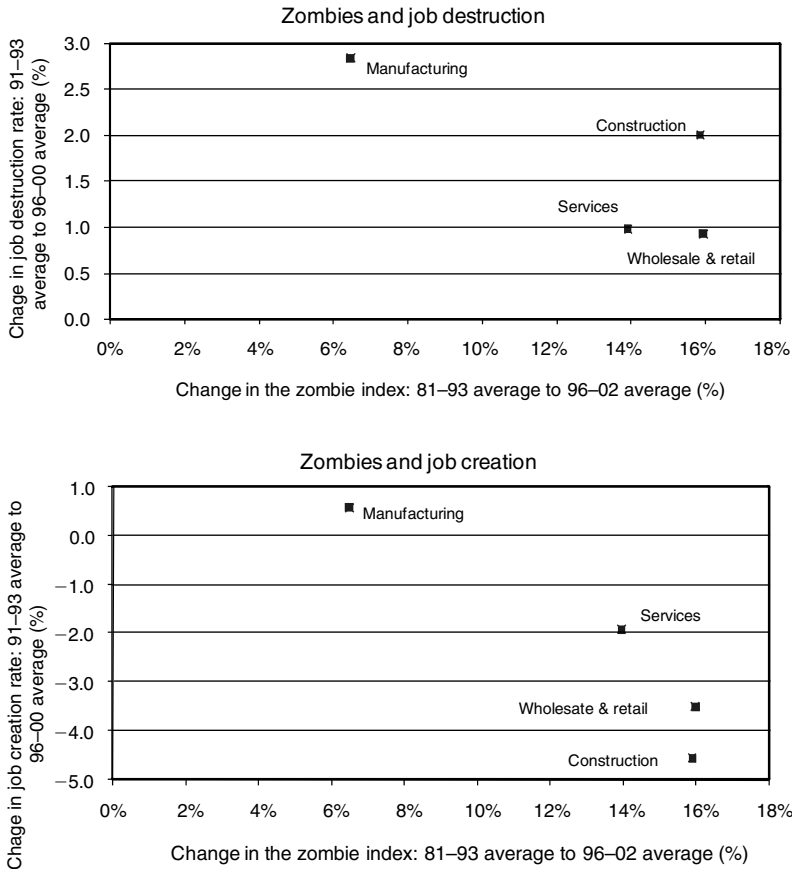


FIGURE 5

The second panel of Figure 5 shows that the presence of zombies depresses job creation. Creation declined more in the sectors that experienced sharper zombie growth. In manufacturing, which suffered the least from the zombie problem, job creation hardly changed from the early 1990s to the late 1990s. In sharp contrast, job creation exhibits extensive declines in non-manufacturing sectors, particularly in the construction sector.

Of course, not all sectors were equally affected by the Japanese crash in asset prices and the slowdown that followed. For example, construction, having benefited disproportionately from the boom years, probably also was hit by the largest recessionary shock during the 1990s. A large shock naturally raises job destruction and depresses job creation further. One way of controlling for the size of the shock is by checking whether in more zombie-affected sectors, the *relative* adjustment through job creation is larger. In this metric, it is clear from Figure 5 that job creation has borne a much larger share of the adjustment in construction than in manufacturing.

Figure 6 contains suggestive industry-level evidence on the productivity distortions caused by zombies. In the model, zombies are the low-productivity units that would exit the market in the absence of help from the banks. Their presence lowers the industry’s average productivity both directly by continuing to operate, and indirectly by deterring entry of more productive firms. The productivity data here are from Tsutomu Miyagawa, Keiko Ito, and Nobuyuki Harada (2004) who study productivity growth in 22 industries. Figure 6, which plots the average growth of the

total factor productivity (TFP) from 1990 to 2000 against the change in the crisp zombie index, shows that the data are consistent with the model's implication: the regression line in the figure confirms the visual impression that industries where zombies became more important were the ones where TFP growth was worst.¹⁹

As mentioned in the introduction to the paper, the role of zombie firms in depressing productivity is a critical channel through which zombies can have longer-lived aggregate affects. One potential concern with the causal interpretation of Figure 6 is that the zombie infestation was most pronounced outside of manufacturing and it is possible that the lagging productivity of these industries is just a normal cyclical phenomenon.²⁰ To examine this concern, Figure 7 shows the (level of) TFP for the manufacturing sector and nonmanufacturing sector from 1980 through 2004.²¹ The data are taken from the EU Klems project (<http://www.euklems.net/>) organized by the European Union and the Organisation for Economic Co-operation and Development (OECD) to permit comparisons of productivity and other economic outcomes across countries. We form the nonmanufacturing series by weighting the reported valued added TFP figures for Construction, Wholesale and Retail Trade, and Real Estate Activities by their value added shares.²² The shaded areas of the graph show business cycle downturns, defined as the period between a peak and the next official business cycle trough (<http://www.esri.cao.go.jp/en/stat/di/041112rdates.html>).

We draw two general conclusions from Figure 7. First, as a rule, productivity growth in the nonmanufacturing sectors is lower than in manufacturing. Second, during the second half of our sample (from 1991 through 2002), productivity growth slowed in both manufacturing and nonmanufacturing. The change is especially clear for recoveries (periods between a trough and the next peak) when the need for vigorous creation is depressed by the congestion caused by zombies: productivity growth during the recoveries in the 1990s is much weaker than in the 1980s.

More important for the zombie hypothesis is that the relative behavior of manufacturing and nonmanufacturing has also shifted during the 1990s. From the end of the deep 1982 recession until the onset of the recession in 1991, manufacturing and nonmanufacturing productivity growth differed by 1.5 percent per year. The relative gap widened substantially through the 1990s; for instance, during the recovery periods of 1993–1997 and 1999–2000, the gap was over 3.8 percentage points per year. This gap pattern is consistent with the prevalence of zombies during the 1990s.

We read the result from our industry level analysis as suggesting that zombies are distorting industry patterns of job creation and destruction, as well as productivity in the ways suggested by the model. To test the model's predictions directly, we next look at firm-level data to see if the rising presence of zombies in the late 1990s had discernible effects on healthy firms (which would suffer from the congestion created by the zombies).

¹⁹ Of course this correlation could arise because industries that had the worst shocks wound up with the most zombies. We can disentangle these explanations by using firm-level data (see below).

²⁰ Dropping the observations for nonmanufacturing industries from Figure 6, however, does not change the slope of the regression line very much. The point estimate of the slope coefficient actually slightly increases from -0.398 to -0.469 . Moreover, removing the two seemingly extreme observations (which correspond to the electronic machinery industry and the textile industry) does not change the qualitative result. The slope coefficient does drop from -0.469 to -0.186 , but it is still negative. Thus, the negative correlation between productivity growth and the zombie prevalence holds even if only manufacturing industries are considered.

²¹ Prior to 1980 manufacturing productivity growth in Japan was exceptionally high (presumably due to the catching up of the Japanese economy). Hence, comparisons of manufacturing and nonmanufacturing productivity in the 1960s and 1970s are not informative about the issues that interest us.

²² In the KLEMS spreadsheet these series are codes F, G, and 70. The manufacturing series is code D.

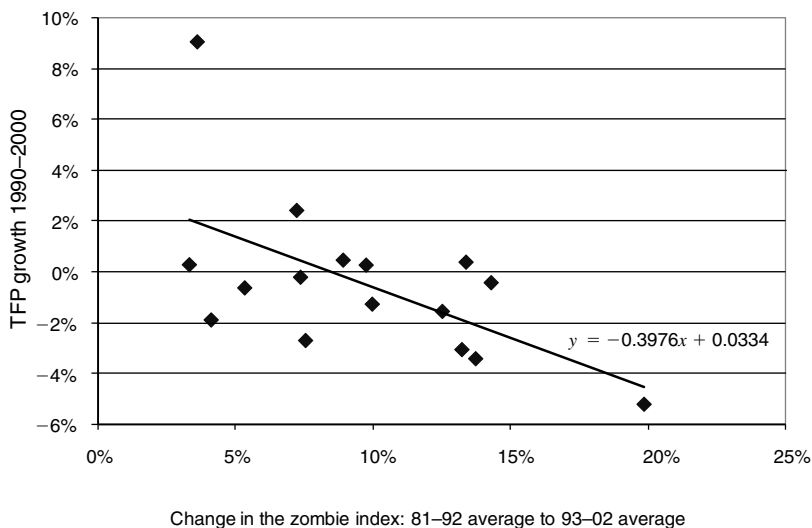


FIGURE 6. ZOMBIES AND TFP GROWTH

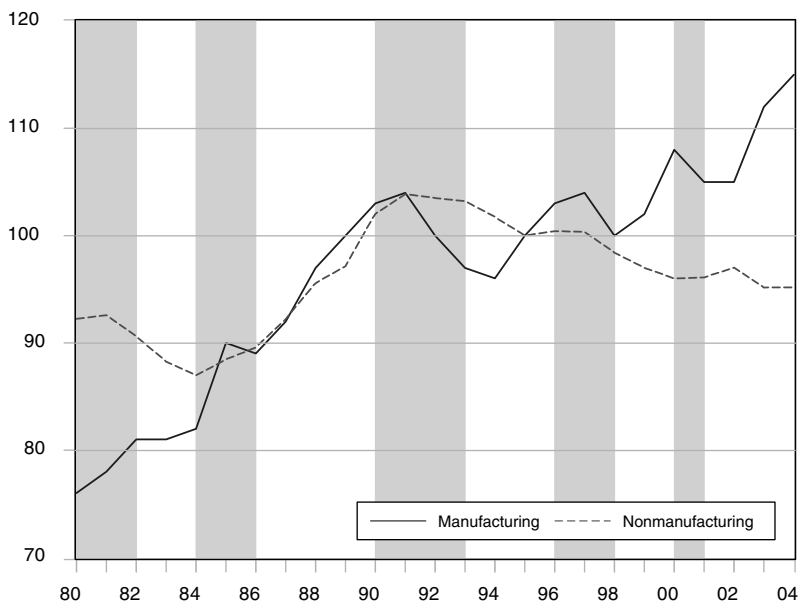


FIGURE 7. TOTAL FACTOR PRODUCTIVITY BY INDUSTRY: 1980-2002 (1995 = 100)

Source: Project on Productivity in the European Union: A Comparative Industry Approach (EU KLEMS2003) (<http://www.euklems.net/>).

The data we analyze are from the Nikkei Needs Financial dataset and are derived from income statements and balance sheets for firms listed on the first and second sections of the Tokyo Stock Exchange. The sample runs from 1981 to 2002, and it contains between 1,844 and 2,506 firms depending on the year. We concentrate on three variables: employment growth (measured by

the number of full-time employees), the investment rate (defined as the ratio of investment in depreciable assets to beginning of year depreciable assets measured at book value), and a crude productivity proxy (computed as the log of sales minus $1/3$ the log of capital minus $2/3$ the log of employment).²³ In all the regressions reported below we dropped observations in the top and bottom 2.5 percent of the distribution of the dependent variable.

The simplest regression that we study is

$$(26) \quad \text{Activity}_{ijt} = \delta_1 D_t + \delta_2 D_j + \beta \text{nonz}_{ijt} + \chi Z_{jt} + \varphi \text{nonz}_{ijt} \times Z_{jt} + \varepsilon_{ijt},$$

where activity can be either the investment rate, the percentage change in employment, or our productivity proxy; D_t is a set of annual dummy variables; D_j is a set of industry dummy variables; nonz_{ijt} is the non-zombie dummy (defined to be one minus the zombie indicator); and Z_{jt} is the percentage of industry assets residing in zombie firms.

Because of the reduced-form nature of both the regression equation and the modeling of the subsidies to the zombies, we do not attempt to interpret most of the coefficients in these regressions. For instance, we include the year dummies to allow for unspecified aggregate shocks. Likewise, we can imagine that the zombies' subsidies are so large that they wind up investing more (or adding more workers) than do healthy firms; so we do not propose to test the theory by looking at the estimates for β , the coefficient on the non-zombie dummy. The one exception to this general principle is that for the productivity specification the model clearly predicts that non-zombies will have higher average productivity than zombies.

We instead focus on what we see as the novel prediction of the theory: that the rising zombie congestion should harm the non-zombies. The prediction is most clearly shown in (23), which shows the effects when we define each firm as a collection of projects. The cross-derivatives in (23) show that when there are more zombies in the industry, a negative shock leads to a larger increase in destruction, reduction in creation, and reduction in the total number of projects carried out by the non-zombies. This prediction suggests that φ should be negative in the investment and employment regressions, and positive in the productivity specification.

The second through fourth columns of Table 3 shows our estimates for equation (26) for the crisp zombie index. We draw two main conclusions from this simple specification. First, as predicted by the theory, increases in percentages of zombie firms operating in an industry significantly reduce both investment and employment growth for the healthy firms in the industry.²⁴ Second, looking at column 4, the productivity gap between zombies and non-zombies rises significantly as the percentage of zombies in an industry rises. These findings are consistent with the main predictions of our model. Note that for the investment (employment) specification one might normally expect that as the percentage of sick firms in the industry rises, the healthy firms would have more (relative to the sick ones) to gain from investing (expanding employment). Thus, under normal (non-zombie) circumstances there would be good reasons to expect φ to be positive rather than negative.

²³ In the model there is no distinction between capital and labor. As noted by an anonymous referee, if subsidized interest rates bias zombies toward capital-intensive technologies, then congestion could be more severe in the capital market than in the labor market. However, it is also possible that subsidized loans are only meant to finance working capital, in which case the bias goes the other way. We have no way to distinguish between these possibilities in our data.

²⁴ We ran a similar regression using investment rates for US firms covered in the Compustat database between 1995 and 2004. In this regression φ was insignificantly different from zero. The limited information on debt structure in Compustat no doubt introduces noise in zombie assignments and we did explore many alternatives to deal with this. But this result suggests to us that there is not a mechanical reason to find that φ is significantly negative in this type of regression.

TABLE 3—IMPACT OF ZOMBIE FIRMS ON THE INVESTMENT, EMPLOYMENT, AND PRODUCTIVITY OF NON-ZOMBIES USING BASELINE ZOMBIE ESTIMATES

Dependent variable	Log sales $-\frac{2}{3} \text{Log } E$ $-\frac{1}{3} \text{Log } K$			Log Sales $-\frac{2}{3} \text{Log } E$ $-\frac{1}{3} \text{Log } K$			Log Sales $-\frac{2}{3} \text{Log } E$ $-\frac{1}{3} \text{Log } K$		
	<i>I/K</i>	$\Delta \text{Log } E$	$-\frac{1}{3} \text{Log } K$	<i>I/K</i>	$\Delta \text{Log } E$	$-\frac{1}{3} \text{Log } K$	<i>I/K</i>	$\Delta \text{Log } E$	$-\frac{1}{3} \text{Log } K$
Non-zombie dummy	0.0256 (0.0056)	0.00109 (0.001751)	0.0139 (0.0135)	0.0248 (0.0057)	0.0002 (0.0018)	0.0119 (0.0137)	0.0238 (0.0056)	0.0001 (0.0017)	0.0150 (0.0136)
Industry zombie percentage	-0.1370 (0.0376)	-0.0454 (0.0116)	-0.3418 (0.0922)						
Non-zombie \times industry zombie percentage	-0.0885 (0.0330)	-0.0232 (0.0102)	0.2183 (0.0756)	-0.0852 (0.0333)	-0.0188 (0.0102)	0.2315 (0.0767)	-0.0716 (0.0321)	-0.0131 (0.0098)	0.1943 (0.0077)
Sales growth							0.3490 (0.0176)	0.1404 (0.0073)	0.3123 (0.0256)
Industry dummies included?	Yes	Yes	Yes	No	No	No	No	No	No
Year dummies included?	Yes	Yes	Yes	No	No	No	No	No	No
Industry \times year dummies included?	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	22,396	22,429	23,090	22,396	22,429	23,090	22,394	22,428	22,847
\bar{R}^2	0.0537	0.0895	0.3599	0.0617	0.1007	0.3590	0.1125	0.1794	0.3705

Notes: The sample consists of between 1,844 and 2,506 publicly traded firms (depending on the year). Each regression is estimated after trimming the top and bottom 2.5 percent of observations (based on the dependent variable). Halbert White (1980) standard errors are reported in parentheses under each coefficient estimate. Point estimates for the various dummy variables are omitted from the table. Any firm with actual interest payments below the hypothetical minimum is considered a zombie and any firm where this is not true is considered a non-zombie ($d_1 = d_2 = 0$ in equation (1)). Two-digit industry classifications are used throughout. The industry percentages for zombies are based on the share of total industry assets residing in zombie firms. *I/K* is the ratio of investment in depreciable assets to beginning of period stock of depreciable assets (measured at book value). *E* is the total number of full-time employees. *K* is the book value of depreciable assets and sales growth is the log difference of each firm's sales.

The main reason, other than ours, for finding a negative φ is if the zombie percentage in the industry (for that year) is somehow standing in for the overall (un)attractiveness of operating in the industry (for that year). To this potential objection to our results we start by noting two things. First, our definition of zombies, by virtue of using only interest rate payments, does not guarantee that growth opportunities are necessarily bad just because the zombie percentage is high. Second, in order to be consistent with our findings, the reaction to industry conditions must be different for zombies and non-zombies. In particular, non-zombies must be more affected by an industry downturn than zombies for φ to come out negative.

Nonetheless, we make several attempts to address this potential problem. Our first alternative is to add industry-year dummies to equation (26), so that we estimate:²⁵

$$(27) \quad \text{Activity}_{ijt} = \delta'_3 D_{jt} + \beta \text{nonz}_{ijt} + \varphi \text{nonz}_{ijt} \times Z_{jt} + w_{ijt}.$$

²⁵ We thank two anonymous referees for suggesting this approach.

This specification controls for all the factors that affect all the firms in an industry in a certain year.²⁶ Note that we cannot identify the coefficient on the industry zombie percentage anymore, but we can still estimate φ , which is the primary coefficient of interest.²⁷

Second, we seek to find other controls for business opportunities for the healthy firms. Our main control to address this problem is to add current sales growth of each firm to the regression specification. Thus, our second alternative specification is

$$(28) \quad \text{Activity}_{ijt} = \delta_3^i D_{jt} + \beta_{\text{nonz}_{ijt}} + \varphi_{\text{nonz}_{ijt}} \times Z_{jt} + \theta s_{ijt} + v_{ijt},$$

where s_{ijt} is the growth rate of sales and the other variables are defined as in the previous two equations.²⁸

The next three columns in Table 3 show that controlling for the full set of interactions between industry and time dummies leads to modest changes in the estimates; the estimate of φ for the employment growth is now different from zero only at the six percent level of significance. These estimates suggest to us that unobserved time-varying industry-specific shocks are not driving the results.

The final three columns in the table show the results when sales growth is included as additional control. For the investment specification, this type of accelerator specification generally performs quite well in goodness-of-fit comparisons among competing specifications (see Ben S. Bernanke, Henning Bohn, and Peter C. Reiss 1988). We recognize that the inclusion of sales growth in the employment and productivity specifications is questionable, but it shows up as highly significant in those specifications as well (and it is hardly obvious which other balance sheet or income statement variables would be better proxies for potential growth opportunities).²⁹ Controlling for sales growth raises the adjusted R^2 for all three equations, and further reduces the estimate of φ for the employment specification, so that it is different from zero only at 20 percent level of significance.

In Appendix B, we report a long list of robustness exercises, including estimating (26), (27), and (28) using alternative definition of zombies, omitting marginal zombies, and using different measures of minimum required interest rates in the construction of zombie indicators. While the level of significance and some of the point estimates vary across these multiple scenarios, the general flavor of the results does not. More specifically, the estimates for φ tend to be negative and consistently significant for the investment regressions, negative and mostly significant for the employment regressions, and positive and consistently significant for the productivity regressions.

In the remainder of our discussion we attempt to quantify the impact of zombie firms on investment and employment growth of non-zombies. We focus on the five nonmanufacturing industries, where our asset weighted measures of zombies were particularly high in the late

²⁶ For instance, if industry-specific policies by the government were time-varying, this specification would control for the changes.

²⁷ We could go further and add firm fixed effects to control for all the factors that are not included in the regression that are specific to each firm. If the zombie status of firms is persistent over time, however, this approach loses much of the useful information. Nonetheless, we estimated regression (27) controlling for firm fixed effects. Surprisingly, the estimate of φ continues to be negative and significant in the investment and employment regressions. The results for the productivity regression change. The point estimate of φ is now negative but it is not significantly different from zero.

²⁸ We also allowed the coefficient on sales growth to differ for non-zombies, but the slope was never different, so to save space we report only the estimates that impose the same coefficient for both types of firms.

²⁹ As an anonymous referee pointed out, it is possible to derive an equation relating employment to past sales as an optimizing choice in which a firm attempts to keep its labor sales ratio close to a desired level in the presence of labor adjustment costs. In this case, employment growth depends on the lagged sales and employment levels. We estimated the regressions of this type with lagged (log of) sales and lagged (log of) the employment as additional variables (with or without sales growth) and found that the estimate of φ is still negative and statistically significant.

1990s. For a typical non-zombie firm in each of these industries, we estimate how much more the non-zombie would have invested or increased employment if there had not been so many zombies in the industry. We consider two alternative low zombies scenarios. In “Case 1,” we assume that the zombie index stayed at its average value from 1981 through 1992 for each industry, and calculate how much more a typical non-zombie firm would have invested (or employed) over the next ten years. In “Case 2,” we assume that the zombie index for the industry was the same as that for manufacturing for each year from 1993 to 2002. We calculate the cumulative investment under these two scenarios and compare it to the typical amount of annual investment (defined as the average of the median rates) during this period. For employment, we compare the cumulative decline attributable to the zombies with the typical annual change over the period (again defined as the average of the median rates). In all of these calculations we take the regression estimates based on the crisp zombie indices in Table 2 using the first specification in the table, and ignore any feedback from industry equilibrium considerations.

More specifically, investment (or employment) is estimated to have been higher than the actual level by $(\hat{\chi} + \hat{\phi})(\text{actual zombie index} - \text{alternative zombie index})$. Noting the possibility that the industry zombie index may be proxying for unobservable industry-year specific profitability shock, one can argue that this calculation overestimates the pure impact of zombies by including the estimate of $\hat{\chi}$. To address this concern, we also report $\hat{\phi}(\text{actual zombie index} - \text{alternative zombie index})$, which would be a lower bound for the pure zombie impact. Of course, all these estimates are subject to substantial uncertainty and do not take into consideration general equilibrium effects, but they are still informative and suggestive of the large negative impact of zombies.

Table 4 shows that both investment and employment growth in non-zombie firms would have been higher in all these industries had there been fewer zombies. In some industries, the difference is quite large. For example, for the typical non-zombie firm in the wholesale industry the cumulative investment loss (compared with the hypothetical case where the zombie index remained at its 1981–1992 average) was about 43.2 percent of capital, which was more than 3.5 years worth of investment during this period. Even the lower bound estimate that includes only the differential effects on non-zombies (calculated from the coefficient estimate on the interaction term) shows the cumulative loss of 17 percent of capital, which is still more than one year worth of investment.

The effects on employment growth are large as well. For example, the employment growth of a typical non-zombie real estate developer would have been higher by 9.5 percentage points at the end of the period if the zombie percentage had not risen (which can be compared to the average hiring in the industry of 0.62 percent per year). Even the lower bound estimate shows that employment growth at a typical non-zombie in the real estate industry would have been higher by more than 3 percentage points.

IV. Final Remarks

Our mechanism has aspects of conventional credit crunch stories, but it is also distinct. In our model, the essence of a credit crunch acts as a reduced-form profit shock. Thus, if a pure contraction in credit availability was all that was going on, the economy would be expected to behave like the normal benchmark case we analyze, with a rise in destruction and a fall in creation. Instead, the data show that destruction *falls* more in the sectors with more zombies, suggesting there is more than a simple credit crunch story at work.³⁰

³⁰ For example, one may argue that a credit crunch could depress creation particularly if it hits small and young firms. However, these firms are not the typical ones in our sample of publicly traded firms. Moreover, we do not observe

TABLE 4—CUMULATIVE IMPACT OF ZOMBIE FIRMS ON NON-ZOMBIES

<i>A. Cumulative investment losses (1993–2002) of the median non-zombie firm in the high zombie industries</i>					
Industry	Wholesale	Retail	Construction	Real estate	Services
Actual average <i>I/K</i> : 1993–2002	0.1184	0.1871	0.1373	0.0920	0.2215
Cumulative Lost <i>I/K</i> Case 1 (lower bound)	0.4323 (0.1697)	0.1883 (0.0739)	0.2988 (0.1173)	0.2842 (0.1115)	0.3020 (0.1185)
Cumulative Lost <i>I/K</i> Case 2 (lower bound)	0.3454 (0.1355)	0.1432 (0.0562)	0.1804 (0.0708)	0.4006 (0.1572)	0.5048 (0.1981)

Notes: “Actual Average *I/K*: 1993–2002” shows the actual average investment rate (*I/K*) of the median non-zombie firm in the industry for 1993–2002. “Cumulative Lost *I/K* Case 1” shows the total amount of investment (*I/K*) of the typical non-zombie that was depressed during the period compared with the hypothetical case where the asset weighted zombie index had stayed at its average level for 1981–1992. “Cumulative Lost *I/K* Case 2” shows the total amount of investment (*I/K*) of the typical non-zombie that was depressed during the period compared with the hypothetical case where the asset weighted zombie index of the industry was the same as that of manufacturing in each year from 1993 to 2002. The coefficient estimates from the regression in column 2 of Table 2 were used for the calculation. The numbers in parentheses show the “lower bounds” of the cumulative losses that include only the differential impacts on the non-zombie (calculated from the coefficient estimate on the interaction term).

<i>B. Cumulative employment change (1993–2002) of the median non-zombie firm in the high zombie industries</i>					
Industry	Wholesale	Retail	Construction	Real estate	Services
Average actual employment growth: 1993–2002	−0.0136	0.0015	−0.0043	0.0062	0.0140
Cumulative lost employment—Case 1 (lower bound)	0.1238 (0.0402)	0.0598 (0.0199)	0.0918 (0.0302)	0.0951 (0.0314)	0.1086 (0.0358)
Cumulative lost employment—Case 2 (lower bound)	0.0977 (0.0320)	0.0452 (0.0151)	0.0548 (0.0183)	0.1363 (0.0445)	0.1864 (0.0602)

Notes: “Average actual employment growth: 1993–2002” shows the actual average annual rate of change in the employment at the median non-zombie in the industry for 1993–2002. “Cumulative lost employment—Case 1” shows the total rate of new hiring at the typical non-zombie that was depressed during this period compared with the hypothetical case where the asset weighted zombie index had stayed at its average level for 1981–1992. “Cumulative lost employment—Case 2” shows the total rate of new hiring at the typical non-zombie that was depressed during the period compared with the hypothetical case where the asset weighted zombie index of the industry was the same as that of manufacturing in each year from 1993 to 2002. The coefficient estimates from the regression in column 3 of Table 2 were used for the calculation. The numbers in parentheses show the “lower bounds” of the cumulative losses that include only the differential impacts on the non-zombie (calculated from the coefficient estimate on the interaction term).

At the same time, we do not dispute the observation that credit availability was likely to have fluctuated in the wake of the asset price collapse. Accordingly, it is not surprising that studies such as Kazuo Ogawa and Shin-ichi Kitasaka (2000) find evidence of a classic credit crunch.

Rather than positing and trying to test between more complicated versions of the zombie and credit-crunch hypotheses, we think it is more important to recognize that these mechanisms are fundamentally complementary. If there were financial frictions then the zombie congestion would exacerbate them by lowering collateral values (even for healthy firms). Thus, we see the spillover effects of the zombies as being the most important to emphasize.

the spike in job destruction that would accompany a credit crunch that afflicts small firms disproportionately. Finally, if we assume that smaller firms’ main credit source is from banks, then the observation that the distortions are bigger when there are more zombies in the same industry would require a very special pattern of lending. The banks would have to be financing more small firms in precisely the industries where the zombies became most important. We are unaware of any evidence suggesting that this was the case.

One key characteristic of our mechanism is that zombies create ongoing distortions which lower job creation and industry productivity. A straightforward extension of the model would make long-run productivity growth endogenous. In this case, the present value of the costs due to the suppression of restructuring generated by continuing forbearance with the zombies would greatly exceed calculation based only on the direct costs of subsidies.

While our model is not structural enough to provide an analysis of optimal government regulation, or to assess whether the costs in terms of productivity loss were outweighed by the benefits of reduced unemployment, we argue that Japanese regulators may have failed to recognize the large costs of allowing zombies to continue operating during the episode. For example, the capital injections given to Japanese banks in the late 1990s did not recapitalize the banks sufficiently so that they no longer had an incentive to evergreen. The forgone benefits that would have accrued had Japan returned at that point to having a normally functioning economy could have been large enough to justify a very generous transition policy package to the displaced workers that would have been released if the zombies were shuttered.³¹

Finally, our description of the Japanese experience is similar to the diagnosis that has been used to describe the early phases of the transition of many former socialist economies to become market-oriented. In these economies the depressing effects on the private sector of the continued operation of state-owned enterprises (typically funded by state-owned banks) is often noted; discussions of the situation in China in the 2000s would be the latest of these examples. Also, note that the key to our mechanism is lack of restructuring, which also may be caused by legal bankruptcy procedures that protect debtors rather than by banks' behavior. For example, in the US airline industry it is routinely asserted that the industry has been plagued because unprofitable carriers go bankrupt, yet they fail to exit the industry.³² These cases suggest that the mechanism that we have sketched is not unique to Japan.³³

APPENDICES

An abbreviated pair of appendices is presented here. Appendix A discusses some issues concerning data construction for this paper. Appendix B describes some robustness checks that we carried out. The complete version of the appendices, which include the tables of regression coefficient that are described below and the table that summarizes some sample characteristics of our database, is available on the *AER* Web site (<http://www.aeaweb.org/articles.php?doi=10.1257/aer.98.5.1943>).

APPENDIX A

The variable R^* plays a critical role in our analysis. In this Appendix we provide some additional details on the construction of this variable and the other data used in the analysis.

In constructing R^* our goal is to produce a plausible lower bound for what firms might pay to borrow. For the portion of the interest payments coming from short-term bank loans, which accounts for about 40 to 45 percent of total lending in our sample, we believe that this is straightforward because almost no loans are made at rates below the prime rate (once we take into

³¹ The same reasoning applies to the question of whether the lack of liquidations in the US airline industry raised or lowered the taxpayers' costs of rationalizing the industry.

³² See David Wessel and Sarah Carey, "For U.S. Airlines, a Shakeout Runs into Heavy Turbulence," *Wall Street Journal*, September 19, 2005.

³³ See Caballero (2007) for a discussion of different models and manifestations of sclerosis in macroeconomics.

account all the origination and other fees). Thus, we view the use of the short-term prime rate as relatively uncontroversial.³⁴

Ideally, we would find an equally conservative assumption for handling long-term loans. It is quite likely that the interest payment on a new long-term loan would be above the prime rate at the time the loan is originated. Unfortunately, the available data on long-term bank debt gives just the stock outstanding without information on the exact maturity of the loans. Thus, we assume that each firm's long-term loans have an average maturity of 2.5 years and with one-fifth of them having been originated in each year for five years. Five years corresponds to the average maturity of bank loans at the time of origination in the dataset of Smith (2003). This assumption implies that the right interest rate is an equally weighted average of the last five years of the long-term prime rates. Thus, we calculate the minimum required interest payment on the long-term loans by multiplying the outstanding long-term loans of all maturities with the five-year average of the long-term prime rates.

Turning to the non-bank financing, we know that during the 1990s, roughly 40 percent of interest-paying debt were bonds and about 3 percent was commercial paper. Our measure of the required payment ignores the interest payments for commercial paper. Given the limited importance of commercial paper financing and the low interest rates on the commercial paper for the 1990s, this is not likely to cause any serious problems for our analysis.

For the remaining debt we assume that it was financed as advantageously as possible. Specifically, we assume that bond financing is done with CBs (which by their nature have lower yields) and that firms were always able to time the issues so that the rate is the lowest within the last five years. Implicitly, this presumes that the firms have perfect foresight and refinance their bonds every time there is a local trough in interest rates. This assumption is almost surely understating the required payments on corporate debt. For instance, from 1996 onward this imputation procedure assumes that all bond financing is done at a zero interest rate. By assuming very low required interest rates on bonds, the approach reduces the risk of our misclassifying credit-worthy companies that enjoy extremely low bond rates in the public market as zombies. On the other hand, the approach increases the risk of failing to identify the zombies that pay interests on the bonds they issued in the past. Thus, we can be confident that any firms we label as zombies must be getting very favorable interest rates from their banks. Put differently, by assuming access to such low bond financing rates, our classification scheme picks out only the most egregious zombies that receive massive help from their banks.

Besides this baseline procedure, we explored several other approaches. One alternative centered on estimating the maturity structure of each firm each year. Here we just describe the calculation for long-term bank borrowing. We estimate the maturity structure of bonds in the same way.

We observe the total long-term bank borrowing for firm i at the end of accounting year t (BL_{it}) and the long-term bank borrowing that comes due within one year ($BL1_{it}$). Let NBL_{it} be the amount of new long-term bank loans that firm i takes in during year t . We use the following equation to estimate NBL_{it} :

$$NBL_{it} = \max \{BL_{it} - BL_{it-1} + BL1_{it-1}, 0\}.$$

³⁴ As an alternative, we computed a required rate that imposed a markup over the London Interbank Borrowing (LIBOR) rate based on the average spreads reported in Smith (2003). This approach produced similar results regarding the numbers of firms with negative interest rate gaps.

Let $BP(n)_{it}$ denote the amount of long-term bank loans to firm i that was given in year $t - n$ and still outstanding at the end of t . We assume the maximum maturity of long-term bank loans to be ten years. If NBL is available for all years in the past ten years, we can estimate $BP(n)$ recursively as follows:

$$BP(0)_{it} = \min \{NBL_{it}, \max \{BL_{it}, 0\}\},$$

$$BP(n)_{it} = \min \left\{ NBL_{it}, \max \left\{ BL_{it} - \sum_{k=0}^{n-1} BP(k)_{it}, 0 \right\} \right\} \quad (n = 1, 2, \dots, 8),$$

$$BP(9)_{it} = \max \left\{ BL_{it} - \sum_{k=0}^8 BP(k)_{it}, 0 \right\}.$$

If NBL_{it} is not available for $n \geq n^*$, we stop the iteration at $n = n^*$ and assume that the remaining borrowings (if any) is uniformly distributed across different maturities. Formally, this implies:

$$BP(0)_{it} = \min \{NBL_{it}, \max \{BL_{it-1}, 0\}\},$$

$$BP(n)_{it} = \min \left\{ NBL_{it}, \max \left\{ BL_{it} - \sum_{k=0}^{n-1} BP(k)_{it}, 0 \right\} \right\} \quad (n < n^*),$$

$$BP(n)_{it} = \max \left\{ \frac{BL_{it} - \sum_{k=0}^{n^*-1} BP(k)_{it}}{10 - n^*}, 0 \right\} \quad (n \geq n^*).$$

For bonds, we also adopted an extremely conservative approach that assumes the minimum required interest rate was zero for the entire sample period. This approach guarantees that any firms with a negative interest rate gap must be receiving unusually low interest rates on their bank borrowing.

The data for prime bank loan rates are taken from the Bank of Japan Web site (<http://www.boj.or.jp/en/stat/statf.htm>). The subscribers' yields for convertible bonds are collected from various issues of *Kin'yu Nenpo* (Annual Report on Finance) published by the Ministry of Finance.

The remaining data we use for the regression analyses are taken from the Nikkei Needs Corporate Financial Database. The data are annual so, for instance, when we refer to 1993 data they are from a firm's balance sheet and income statement for the accounting year that ended between January and December of 1993.

APPENDIX B

We checked the robustness of the significance of the estimated φ 's to several alternative measures of the required minimum interest rate r^* and zombie indices. When we use the fuzzy zombie indices instead of the crisp ones, the estimates of φ get smaller, but part of the difference can be explained by the fact that the industry zombie percentages are larger when we use the fuzzy zombie measures than when we use the crisp measures. Probably related to this, the statistical significance of the estimates of φ is similar; in other words, the declines in the size of the coefficients are accompanied by smaller standard errors, so that the t -statistics are similar.

Adding sales growth to these regressions using fuzzy indices lowers the statistical significance of the estimates of φ . The estimated signs remain negative for employment and investment and positive for productivity but the coefficient for employment growth is no longer significant.

We also estimated the regressions dropping the observations with x_{it} between d_1 and d_2 entirely. The estimates of φ in the investment and employment growth equations are again negative and statistically significant in almost all cases. Indeed, the coefficients are often larger when we drop the observations with x_{it} close to zero. For the productivity proxy, however, the estimated gap between the zombies and non-zombies (β in equation 26) rises substantially, while the estimated value of φ falls and becomes insignificant.

We also reestimated equation (26) and (27) for different zombie definitions shown in Table 2. Because the different zombie definitions change the estimated levels of zombies, we do not expect the point estimates for the interaction term to be the same across specifications; the more conservative definitions would likely yield higher coefficients than the more liberal definitions. This leads us to focus more on the statistical significance of the results, rather than on the magnitudes of the estimates.

The most striking finding is that the significance of the estimates of φ tend to rise substantially when we use more liberal definitions of which firms should be considered as zombies. This suggests to us that the baseline definitions are too restrictive and may miss many zombies.

The other noticeable pattern is that automatically excluding firms with BBB (or higher) rated bonds leads to higher estimated standard errors. With this definition the estimated significance of φ is lower in almost all cases. For these specifications the estimates for employment are typically not significant for either the crisp or fuzzy definitions. The definitions that exclude the firms with A (or higher) rated bonds are somewhat similar, but the differences with the baseline specifications are much less pronounced.

A third observation is that the significance levels using the full set of industry-time dummies (equation (27) estimates) are typically lower than for baseline equation (26) estimates. The difference is most clear for the employment regressions, but the same pattern seems to hold for the productivity and investment specifications.

Beyond these observations, we find no obvious patterns. For some definitions, the significance rises, but in others it drops.

We also estimated the regressions using more detailed estimation of the maturity structure for long-term borrowing and bonds discussed in Appendix A. The coefficient estimates of φ are similar (in size and statistical significance) to those in Table 3 in all the specifications.

Finally, we entertained an alternative assumption that the minimum required interest rate on bonds is zero. The results are again similar to those in Table 3, although for the employment specification with full interactions of time and year dummies, the estimate of φ is insignificant.

All in all, the results of these robustness exercises confirm the same broad patterns as in Table 3. The precision of some of our estimates suffers as we modify the measures of zombies to address different measurement and classification errors. However, the statistical significance of the estimates of φ for the investment and the productivity specifications is especially robust.

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