Zombie Lending and Depressed Restructuring in Japan

Ricardo J. Caballero

Massachusetts Institute of Technology and NBER

Takeo Hoshi

University of California at San Diego, Graduate School of International Relations and Pacific Studies and NBER

Anil K Kashyap

University of Chicago, Graduate School of Business, Federal Reserve Bank of Chicago and NBER

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Abstract:

In this paper, we propose a bank-based explanation for the decade-long Japanese slowdown. The starting point for our story is the well-known observation that most large Japanese banks were only able to comply with capital standards because regulators were lax in their inspections. To facilitate this forbearance the banks often engaged in sham loan restructurings that kept credit flowing to otherwise insolvent borrowers (that we call zombies). Thus, the normal competitive outcome whereby the zombies would shed workers and lose market share was thwarted. Our model highlights the restructuring implications of the zombie problem. The counterpart of the congestion created by the zombies is a reduction of the profits for potential new and more productive entrants, which discourages their entry. In this context, even solvent banks will not find good lending opportunities. We confirm our story's key predictions that zombie-dominated industries exhibit more depressed job creation and destruction, lower productivity, and greater excess capacity. Most importantly, we present firm-level regressions showing that the increase in zombies has depressed the investment and employment growth of non-zombies and been associated with a widening of the productivity gap between zombies and non-zombies. Our evidence suggests that the healthiest non-zombies were harmed the most by the zombies.

1. Introduction

After growing faster than all the other major developed economies during the 1980s, Japan's economic growth slowed sharply in the early 1990s. The performance was particularly anemic between 1998 and 2003, when growth averaged less than 0.8% per year. While there are many proposed explanations for the poor performance there is still no consensus about it.

In all likelihood, there were many inter-related factors dragging down the Japanese economy. Lack of aggregate demand is one of them. However, since 1995 short term interest rates have been less than 0.5 percent and since 1997 the central government budget deficit has exceeded 6% of GDP each year. Thus the problem has deeper roots than just an aggregate demand insufficiency. What are, then, the structural mechanisms behind household and corporate pessimism that stifled consumption and investment?

This paper explores a story first proposed by Hoshi (2000) that has been partially elaborated upon by a number of observers of the Japanese economy. It focuses on the role of the banking system in misallocating credit following the large stock and land price declines that began in early 1990s: stock prices lost roughly 80% of their value from the 1989 peak through mid 2003, while commercial land prices fell by roughly 60% since their 1992 peak. These shocks impaired collateral values sufficiently that any banking system would have had tremendous problems adjusting. But in Japan the political and regulatory response was to deny the existence of any problems and delay any reforms or restructuring of the banks.[1] Aside from a couple of crisis periods when regulators were forced to recognize a few insolvencies and temporarily nationalize the offending banks, the banks have been surprisingly unconstrained by the regulators.

The one exception to this rule is that banks do have to comply (or appear to comply) with the international standards governing their minimum level of capital (the so-called Basle capital standards). This has meant that when banks want to call in a non-

[1] For instance, in 1997, at least 5 years after the problem of non-performing loans was recognized, the Ministry of Finance was insisting that no public money would be needed to assist the banks and in February 1999 then Vice Minister of 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.

performing loan, they are likely to have to write off existing capital, which in turn pushes them up against the minimum capital levels. The fear of falling below the capital standards has led many banks to continue to extend credit to insolvent borrowers, gambling that somehow these firms will recover or that the government will bail them out.[2] Failing to rollover 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 "ever-greening," can therefore be seen as a rational response by the banks to these various pressures.

A simple measure of the ever-greening is shown in Figure 1, which reports the percentage of bank customers that are receiving 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, retail, wholesale (excluding nine general trading companies) and service sector firms. The top panel of the figure shows roughly 30% 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% 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 (that we call "zombies") alive, the banks allow them to distort competition throughout the rest of the economy. The zombies' distortions come 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 participate. Effectively the growing government liability that comes from guaranteeing the deposits

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[2] The banks also tried to raise capital by issuing more shares and subordinated debt, as Ito and Sasaki (2002) document. When the banks have raised new capital, however, it has almost all come 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) 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 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 Tett (2003) for details.

of banks that support the zombies is serving 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 that new and more productive entrants can earn, thereby discouraging their entry. In addition, even solvent banks see no particularly good lending opportunities in Japan.

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 a technological, demand, or credit shock. The main effect of that constraint is that job creation must slow sufficiently to re-equilibrate the economy. This means that during the adjustment the economy is characterized by what Caballero and Hammour (1998, 2000) 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 that are less productive than some of those that do not enter due to the congestion caused by the zombies

In the fourth section of the paper, we assess the main aggregate implications of the model. In particular, we study the interaction between the percentage of zombies in the economy and the amount of restructuring, both over time and across different sectors. 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 parts of the economy with the most zombies firms. We then explore the impact of zombies on sectoral performance measures. We find that the prevalence of zombies lowers productivity.

[4] See Ahearne and Shinada (2004) for some direct evidence suggesting that inefficient firms in the non-manufacturing sector gained market share in Japan in the 1990s. See also Kim (2004) and Restuccia and Rogerson (2003) for attempts to quantify the size of these types of distortions.

In section 5 we analyze 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 has risen as the percentage of zombies has risen. Most strikingly, the presence of the zombies depresses activity the most for the fastest growing healthy firms. All of 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.

In the final section of the paper we discuss how our explanation for the Japanese stagnation interacts with other leading explanations, including conventional credit crunch hypotheses and standard productivity slowdown stories. We argue that none of these stories can explain the full magnitude and length of the Japanese stagnation without a mechanism to amplify the impacts of the negative shocks. We also describe the policy implications of our explanation for the Japanese sclerosis.

2. 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.

2.1 Defining Zombies

There is a growing literature examining the potential misallocation of bank credit in Japan (see Sekine, Kobayashi, and Saita (2003) for a survey). Much of the evidence is indirect. For instance, several papers (including Hoshi (2000), Fukao (2000), Hosono and Sakuragawa (2003), 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).[5]

Peek and 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. These firms' main banks are more likely to lend to the firms than other banks dealing with these firms when the firm's profitability is declining. This pattern of perverse credit allocation is more likely when the bank's own balance sheet is weak or when the borrower is a keiretsu affiliate. Importantly, non-affiliated banks do not show this pattern.

We depart from past studies by trying to identify zombies by classifying firms only based on our assessment of whether they are receiving subsidized credit, and not by looking at their productivity or profitability. This strategy naturally permits us to evaluate the effect of zombies on the economy. If 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 of 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").[6] The summary of our findings are given in Table 1.

[5] Other indirect evidence comes from studies such as Smith (2003), Schaede (2004) and Jerram (2004) that document that loan rates in Japan do not appear to be high enough to reflect the riskiness of the loans. Finally, see also Hamao, Mei and Xu (forthcoming) who show that firm-level equity returns became less volatile during the 1990s and argue that is this is likely due to a lack of restructuring in the economy.

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

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 principle or interest, most of these packages involve reductions in interest payments or outright debt forgiveness by the troubled firms.[7]

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% 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%.

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.

2.2 Econometric procedure for detecting Zombies

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

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

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

[7] These patterns are consistent with the claim by Tett and Ibison (2001) 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.

rs_t, rl_t, and $rcb_{\text{min over the last 5 years}, t}$ are the average short-term prime rate in year t, the average long-term prime rate in year t, and the minimum observed 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 and long term bank loans, bonds outstanding that are 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 and fee expenses. We provide additional discussion of the data choices used in constructing R* in the data appendix.

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, $x_{i,t} \equiv \frac{R_{i,t} - R^*_{i,t}}{B_{i,t-1}} = r_{i,t} - r^*_{i,t}$, as the interest rate gap.

Figure 2 shows the distribution of the interest rate gap (measured in percentage points) for all of the firms in our sample between 1981 and 1992 in the top panel, along with the same information for 1993 through the end of our sample in 2002 in the bottom.

Concentrating first on the pre-1993 data, we note two key features of the data. First, only 9.3 percent of the observations are to the right of zero, suggesting that r* is on the whole doing a good job of capturing a lower bound rate. We assume that the remaining cases where the gap is below zero reflect a combination of measurement error in r* and the possibility that some banks were granting some subsidies as part of their normal business practices to help temporarily impaired customers.[8] Thus, the fact that some of the gaps are negative does not strike us as *per se* troubling.

[8] See chapter 5 of Hoshi and Kashyap (2001) for more detailed discussion how the assistance worked until the 1980s and how it appears to have changed since then.

Second, the median gap for the firms is 280 basis points, a plausible spread between the borrowing costs of a typical firm and an exceptionally high quality borrower. For instance, the interest rate gap between seasoned AAA U.S. bonds (the highest rating given by Moodys) and Baa seasoned bonds (the lowest investment grade rating) fluctuated between 70 and 270 basis points over this period. Given that many of our Japanese firms are far below investment grade quality this average gap seems reasonable.

The graph also suggests that a small percentage of the firms have huge gaps between the interest payments they are making and R^*. This is not surprising since a firm with little or no bank debt will have a very low value for R^*. If these firms have issued bonds or commercial paper, then the combination of their issuing fees and interest payments could be sizable; these observations do not drive our results.

The lower panel shows two notable changes since the early 1990s. First, the distribution of the gap shifted noticeably to the left in the latter sample. After 1993 roughly 31.6% of the firms have a negative gap. Second, the distribution also became much more compressed. In the latter sample, the median gap is roughly 55 basis points. Appendix gives some details on the alternatives we used in constructing r* and explains why we do not believe this shift is merely a reflection of problems in the way our lower bound is built. Instead we believe that the gap is giving a strong indication that amount of subsidized lending exploded starting in the mid-1990s.

Importantly, 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 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.

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[9] In addition to the cases studied below, Hoshi (2005) 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 several alternative measures (that would be more robust to within year interest rate changes) and determines that this sort problem does not appear to be quantitatively important.

We explore two strategies for converting the information in Figure 2 into estimates that a particular firm is a zombie. Our baseline procedure classifies a firm as a zombie whenever the interest rate gap is negative ($x_{it} < 0$). In doing so, we are treating firms with x_{it} just above and below zero as being very different. This can be loosely justified by the asymmetric philosophy underlying the construction of r*. Intuitively, if r* is a perfectly measured lower bound, then the only way that a firm could have a negative gap would be if a borrower definitely got a subsidy.

Our maintained assumption is that these subsidized firms are cause of the problems for the economy, so we are most concerned about being sure to find the subsidized firms. Conversely we are less confident about the firms where the interest rate gap is slightly positive, since some of these firms might be ones who are exceptionally credit-worthy. Our baseline procedure also does not attempt to distinguish between zombies, for instance by treating the firms with $x_{it} < 0$ differently depending on value of x_{it}.

Our second approach tries to use the magnitude of x_{it} to assess the probability that a firm could be a zombie. In doing so, we acknowledge that r* is a noisy lower bound. We are most worried about cases where r* is too high, in this case a negative gap would result just because the firm is more credit-worthy than we had assumed. Accordingly the second approach presumes that for firms with large negative values of the gap the firm is most likely to be a zombie, while those with large positive values are least likely to receiving subsidies. To facilitate comparison with our baseline measure we assign probabilities using a functional form that collapses to the baseline approach as a limiting case.

The details for this procedure are in given the second appendix. Essentially, it consists of smoothing the 0-1 indicator of the first procedure, to consider the possibility of misclassification. With this purpose we define the zombie-indicator function as:

$$z(x) = \max\left\{1 - p(0)\left(\frac{p(x)}{p(0)}\right)^{\gamma}, 0\right\} \qquad (1)$$

where the function p(x) corresponds to the probability a firm with gap x is not a zombie, when evaluated using a measurement error function estimated directly from the data using a diffuse prior. Thus, when γ=1, z(x) represents the probability a firm with gap x is zombie, when using the weakest prior to assess that probability. At the other extreme, as γ goes to infinity, we recover our benchmark case described in the first procedure.

In order to estimate the function p(x) we use a two step procedure. In the first one we identify a subset of firms which are highly unlikely to be zombies, and compare the distribution of observed x's for these firms and the entire population. We show that before the zombie era, these distributions resemble each other. In the second step we use this symmetry to argue that the distribution of measurement error for both groups should also be equal during the zombie era, so we can use the observed distribution of x's for the subset of firms identified as non-zombies as the function p(x).

Of course critical in this two-steps procedure is that we identify the non-zombies with a criterion based on information other than their observed x. For this, we argue that a firm issuing a bond in a period cannot be a zombie in that period. Anecdotal evidence suggests firms with doubtful credit rarely are able to issue bonds in Japan; they seem to be rationed out of the market rather than being able to issue bonds carrying much higher interest rates. Presumably investors would worry about the possibility that a zombie firm would divert funds raised in a bond issue to pay back banks, and refuse to buy the bonds at any price.

In what follows we show results for γ=2 and γ=10. These values imply that the cutoffs where the probability that a given firm is a zombie with at least 99% probability are an interest rate gap of -100 and -16 basis points respectively.

2.3 Quantifying the prevalence of zombies

Figure 1 shows 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 five and 15 percent 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 the congestion spillovers, a size weighted measure of zombies is 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 show the zombie percentages implied by our second procedure with $\gamma=2$ and $\gamma=10$.

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 $\gamma=\infty$ estimates (our baseline case) and $\gamma=10$ lines are indistinguishable (after 1993). The $\gamma=2$ estimates give a larger role to potential measurement error and consequently imply that at each point in time there are more zombies (since the distribution of x is asymmetric around the 0 threshold). But note that the time series movements are similar (with the correlation between the two series being 0.975). This is the first of several indications that allowing for moderate amounts of measurement error does not make much of a difference.

Our second conclusion is that 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 non-manufacturing firms than for manufacturing firms. In manufacturing, the $\gamma=\infty$ estimates suggest that zombie index only rose from 3.11% (1981-1993 average) to 9.58% (1996-2002 average). In the construction industry, however, the $\gamma=\infty$ index increased from 4.47% (1981-1993 average) to 20.35% (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 world competition and thus are not easily protected without huge subsidies. One example of this is that many of the

Japanese automakers were taken over by foreign firms 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 et al (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 $\gamma=\infty$ estimates, but the other estimates are similar. In manufacturing the differences are not very noticeable, with slightly fewer high profit firms being labeled as zombies. In the remaining industries, particularly in 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. Importantly, there is nothing about the procedure we used in identifying the zombies that would make this a tautology.

3. A model of the effect of zombie firms on restructuring

To analyze the effect of zombies we study a very simple environment that involves entry and exit decisions of both incumbent firms and potential new firms. As benchmark we start with a normal environment where all decisions are based purely on the operating profits from running a firm. We then contrast that environment to one where incumbent firms (for an unspecified reason) receive a subsidy that allows them to remain in business despite negative operating profits.

3.1 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:

$$y_{it}^{o} = A + \in_{it}^{o}$$

where $\in_{it}^{o}$ is an idiosyncratic shock that is distributed uniformly on the unit interval. The major predictions from this model do not depend on the persistence of the productivity shocks, so we make the (simplest possible) assumption that they have no persistence.

In addition to the incumbents, there are also a set of potential entrants and we normalize their mass to be ½. The potential entrants each draw a productivity level, y_{it}^{n}, before deciding whether to enter or not. The productivity for i[th] potential new firm in year t is:

$$y_{it}^{n} = A + B + \in_{it}^{n}$$

with $B > 0$ and $\in_{it}^{n}$ distributed uniformly on the unit interval. The shock $\in_{it}^{n}$ is again assumed to have no persistence. These assumptions imply that on average the potential new firms will be more productive (and more profitable) than the incumbents (for one period only, then they become incumbents as well). However, we also assume that there is an entry cost, $\kappa > 0$, that they must pay to start up.

Finally, both new and old units must incur a cost $p(N_t)$ in order to produce, where N_t represents the number of production units in operation at time t, i.e., the sum of the existing units that do not exit and new entrants. The cost $p(N)$ is increasing with respect to N and captures any scarce input such as land, labor or capital, or any common output. In reduced form, $p(N)$ describes the reduction in profits due to congestion or competition. 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 simplest linear function:

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

where the intercept μ is potential shift variable that captures cost changes and other profit shocks.

3.2 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, so we assume that $B = \kappa$. 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 $\overline{y}^o$ and $\overline{y}^n$ denote the reservation productivity of incumbents and potential entrants, respectively, we have:

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

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

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

$$D_t = m_t \left[1 - \int_{p(N_t)-A}^{1} di \right] = m_t(p(N_t) - A), \qquad (2)$$

$$H_t = \frac{1}{2}\int_{p(N_t)-A}^{1} di = \frac{1}{2}(1-(p(N_t)-A)). \quad (3)$$

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

$$N_t = H_t + m_t - D_t = \left(\frac{1}{2}+m_t\right)\left(1-\left(p(N_t)-A\right)\right). \quad (4)$$

3.3 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 (4). The notation is simplified if we define S to be composite shock that is equal to A-μ. Note that a lower S indicates either higher costs (higher μ) or lower average productivity (smaller A). This yields the equilibrium number of units:

$$N_t = \left(\frac{1/2+m_t}{3/2+m_t}\right)(1+S). \quad (5)$$

Given the total number of operating units, we can solve for equilibrium rates of destruction and creation by substituting (5) into (2) and (3):

$$D_t = m_t\left(\frac{1/2+m_t-S}{3/2+m_t}\right) \quad (6)$$

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

The dynamics of this system are determined by:

$$m_{t+1} = N_t. \tag{8}$$

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 (5), yields a quadratic equation for m^{ss}, which has a unique positive solution of:

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

One can easily show that the other root is negative. 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 $H_0 = D_0 = 1/4$.

3.4 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. So 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 $S_1 < 0$ (lower productivity or higher costs). 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 (6) and (7) that in the short-run:

$$\frac{\partial D}{\partial S} = -\frac{1}{4} = -\frac{\partial H}{\partial S}. \qquad (9)$$

That is, when S drops, creation falls and destruction rises, leading to a decline in *N* (see (4)). In other words, in a normal economy, negative profits shocks are 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 (4) and (8) that $\Delta N=H-D$), which lowers the cost of inputs (*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:

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

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 since *N* falls less than one for one with S, the long run reduction in the input cost due to reduced competition 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.[10]

3.5 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

[10] This 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 in the data the flows are divided by initial employment, or a weighted average of initial and final employment.

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.

The maximum short run effect would be on impact, when the normal economy would show a spike in destruction (see 5). 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:

$$N_{0+}^{z} = H_{0+}^{z} + m_{0} - 1/4 = H_{0+}^{z} + 1/4. \qquad (10)$$

Replacing this expression into (3), we can solve out for *H*:

$$H_{0+}^{z} = \frac{1}{4} + \frac{S}{3},$$

This can be compared to the impact change in creation that occurs in the absence of zombies. Doing so, we see:

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

That is, a decline in S 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 causes the labor market to clear with fewer people employed. If destruction is suppressed, then the labor market clearing can only occur if job creation drops precipitously.

As Caballero and Hammour (1998, 2000) 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 contracting frictions.

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? It is straightforward to show:

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

That is, in response to a negative shock, *N* falls by less if there are zombies. In other words, in the presence of zombies the reduced destruction is not fully matched by a drop in creation. This is another intuitive and robust result. Loosely speaking, this occurs because the reduction in job creation means that the marginal firm that is entering despite the zombies has high productivity. 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.[11] At impact, the destruction does not change, so that all the firms with idiosyncratic productivity shocks above the old threshold (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 is given by:

[11] Note that a wedge like this one also arises when there is a credit constraint on potential entrants but not on incumbents. Instead, in our model depressed entry results from the congestion due to zombies, and the gap is due to the subsidy to incumbents. Clearly, however, if the two mechanisms coexist they would reinforce each other, as congestion would reduce the collateral value of potential entrants.

$$\left[\left(\frac{1}{2}+\frac{S_1}{3}\right)-S_1\right]-\frac{1}{2}=-\frac{2}{3}S_1>0.$$

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.

By slightly re-interpreting what a "firm" means in our model, we can also see how the congestion effects caused by zombies will affect firms with different levels of profitability. Instead of assuming that a firm has only one project, suppose a firm consists of a set of projects, some of which are in place (incumbents) but the others have not been started (potential entrants). Then, the above model can be re-interpreted as a model in which projects that are hit by productivity shocks every period and firms are deciding which projects to terminate (exits) and which new projects to start (entries).

Suppose further that firms differ in the quality of their projects. In particular, some (high profitability) firms have many projects that are unusually profitable, but some other (low profitability) firms have only a few profitable projects. Low profitability firms will not start many new projects, and the presence of zombies may not influence this very much. Higher profitability firms, however, are more likely to have some new projects that become profitable each period that might be crowded out by the zombies. This effect, however, could be non-monotonic because if a firm has a sufficiently good mix of projects, then its projects might still be worth initiating. We will also test for whether higher quality firms are disproportionately harmed by the zombies, but (because of the potential non-monotonicity) we see this prediction as less robust than the previous two.

4. The effect of zombies on job creation, destruction and productivity

We use the two robust predictions of the model to guide our search for evidence that the zombie problem has affected Japan's economic performance significantly. We begin by looking at aggregate cross-industry differences. In the next section, we study firm-level data to characterize how the behavior of the non-zombie firms has been altered by the presence of zombie competitors.

Because our $\gamma=\infty$ zombie indices exist from 1981 onwards, we start by calculating the average zombie index for each industry from then 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 possible biases in the level of zombie index and any industry-specific effects. In what follows, 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 evidence consists of relating creation, destruction, and productivity data to this change in the zombie index, in order to see if these measures are more distorted in the industries where zombie prevalence has increased the most.

Our most direct evidence on this point is in Figure 5, which plots the rate of job creation and destruction against the change in the zombie index. We use the job flow measures constructed by Genda et al. (2002) as proxies for the concepts of entry and exit in our model. The series used for our analysis include not only the job creation (destruction) at the establishments that were included in the survey in both at the beginning and at the end of the year, but also the estimated job creation (destruction) by new entrants (and the firms 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 1996-2000 period and the average for 1991-1993 period. We are restricted to using the 1991—93 data as a control because figures of Genda et al. start only in 1991 and we stop in 2000 because that is the last year they cover.

The top of Figure 5 shows that the job destruction rate in the late 1990s increased from that in the early 1990s in every industry, as we would expect to see following an unfavorable shock to the economy.[12] More importantly, the graph 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.

The second panel of Figure 5 shows that the presence of zombies depresses job creation. Creation declined more in the industries 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 markets and the slowdown that followed it. 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. Despite this source of (for us, unobserved) heterogeneity, the general patterns we expected from job flows hold. 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 quite clear from Figure 5 that job creation has borne a much larger share of the adjustment in construction than in manufacturing.

Our evidence on productivity distortions caused by the interest rate subsidies is given in Figure 6. In the model, zombies are the low productivity units that would exit the market in the absence of help from the banks. Directly by continuing to operate, and indirectly by deterring entry of more productive firms, they bring down the average productivity of the industry. The productivity data here are from Miyagawa, Ito and 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 $\gamma=\infty$ zombie index, shows that the data are consistent with the model's

[12] Our simple model assumes that the job destruction rate stays the same even after a negative shock in a zombie industry. It is straightforward to relax this by assuming, for example, 90% of zombies are rescued by banks. None of the major results would change. The job destruction would go up after a negative shock but not as much as it would under the normal environment.

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.[13]

5. Firm-level zombie distortions

We read the evidence in Figures 5 and 6 as showing that zombies are distorting industry patterns of job creation and destruction, as well as productivity in the ways suggested by the model. To test directly the model's predictions we next look at individual firm-level data to see if the rising presence of zombies in the late 1990s had discernible effects on the healthy firms (which would suffer from the congestion created by the zombies.)

The data we analyze are from the Nikkei Needs dataset and are derived from income statements and balance sheets for firms listed on the first section of the Tokyo Stock Exchange. The sample begins in 1981 and continues through 2002, and the sample size fluctuates between 1,844 and 2,506 firms depending 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.) In all the regressions reported below we dropped observations in the top and bottom 2.5% of the distribution of the dependent variable.

The simplest regression that we study is:

$$\text{Activity}_{ijt} = \delta' D_{jt} + \beta \text{nonz}_{ijt} + \chi Z_{jt} + \varphi \text{nonz}_{ijt} {*} Z_{jt} + \varepsilon_{ijt} \qquad (11)$$

where activity can be either the investment rate, the percentage change in employment, or our productivity proxy, D_{jt} includes set of annual indicator variables and a set of industry dummy variables, nonz_{ijt} is the probability that the firm is non-zombie, and Z_{jt} is the percentage of industry assets residing in zombie firms.

[13] Of course this correlation could arise because industries that had the worst shocks wound up with the most zombies. This interpretation would not easily explain why job destruction did not rise in these industries.

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. 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 the healthy firms; so we do not propose to test the theory by looking at the estimates for β, the coefficient for the non-zombies. 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. This prediction suggests that φ would be negative in the investment and employment regressions, and be positive in the productivity specification. Note that for the investment (employment) specification one might normally suspect that as the percentage of sick firms in the industry rises, the healthy firms would have more and more to gain from investing (expanding employment). Thus, under normal circumstance there would be good reasons to expect φ to be positive rather than negative.

The main reason, other than ours, for finding that φ would be negative is if the zombie percentage in the industry is somehow standing in for the overall attractiveness of operating an industry. In this case, perhaps even the healthy firms in an industry might contract activity when the percentage of zombies is rising. We note that our definition of zombies, by virtue of only using interest rate payments, does not guarantee that growth opportunities are necessarily bad just because the zombie percentage is high. Nonetheless, we seek to find other controls for business opportunities for the healthy firms to minimize this potential omitted variable bias. Our main control to address this problem is to add current sales growth of each firm to the regression specification. Thus, our baseline regression is:

$$\begin{aligned}\text{Activity}_{ijt} = {} & \delta' \text{D}_{jt} + \beta \text{nonz}_{ijt} + \chi Z_{jt} + \varphi \text{nonz}_{ijt} * \text{Z}_{jt} + \theta s_{ijt} + \\ & \psi \text{nonz}_{ijt} * \text{s}_{ijt} + \zeta s_{ijt} * \text{Z}_{jt} + \pi \text{nonz}_{ijt} * \text{Z}_{jt} * \text{s}_{ijt} + \text{v}_{it} \qquad (12)\end{aligned}$$

where s_{ijt} is the growth rate of sales and the other variables are defined as in equation (11).

The coefficient π in (12) reveals an additional potential effect for the zombies. If π is different from zero, then it implies that faster growing healthy firms and slower growing healthy firms are differentially affected by the presence of the zombies. As mentioned earlier, a natural interpretation of the model suggests that the zombie distortions should be larger for the healthiest firms. This would be the case if $\pi < 0$.

The second through fourth columns of Table 2 shows our estimates for equations (11) for the $\gamma=\infty$ zombie index. We draw three main conclusions from this simple specification. First, as predicted by the theory, increases in percentages of zombie firms operating in an industry significantly reduces both investment and employment growth for the healthy firms in the industry. Below we provide several calculations aimed at showing the quantitative significance of these effects. Our second main finding, shown in column 4, is that the non-zombies have significantly higher productivity than the zombies. Finally, the productivity gap between the zombies and non-zombies rises as the percentages of the zombies in an industry rises.

From the perspective of the model this last finding could be interpreted as showing that the congestion by the zombies is raising the necessary level of productivity of healthy new entrants, thereby widening the disparity between zombies and non-zombies. Alternatively, one could argue that the same bad shocks that help keep the percentages of zombies high would be expected to create a productivity difference between zombies and non-zombies. We do not believe that these two alternatives can be easily distinguished, although we take comfort in the fact that model predictions regarding employment growth and investment appear to also hold.

As mentioned above, the competing explanation for the sign of the estimated φ in equation (11) is that the industry zombie percentage is an indirect measure of the growth opportunities in the industry, even for the healthy firms. We believe the best way to address this concern is to find controls that directly capture growth opportunities. The columns 5 and 6 we estimate (12) which include contemporaneous firm-specific sales growth as the potential growth proxy; for the investment specification, this type of accelerator specification generally performs quite well in a-theoretic horse-races among competing specifications (see Bernanke, Bohn and Reiss (1988)).

In both columns 5 and 6, the estimated coefficient on sales growth is highly significant, and in each equation the $\overline{R}^2$ is nearly twice as high as the simpler specifications in columns 2 and 3. In the specifications with sales growth, the estimated magnitude of the φ's drops compared to the simpler specifications, but the estimates of the φ's, remain negative and significant. This suggests that perhaps some of interaction term's significance may have been due to omitting proxies for growth opportunities, but that does not seem to be the sole reason.

In both of these specifications, the estimated values for π are significantly negative. This suggests that the non-zombie firms that are most impaired by zombie firms are the fastest growing healthy firms. Below we also give some rough estimates that quantify the size of this distortion.

We have checked the robustness of the significance of the estimated φ's and π's to many changes in the regression specifications. Table 3 repeats the regressions from Table 2, using the γ=2 and γ=10 zombie indices. We draw two conclusions from this table. First, the estimates of φ and π are same as in Table 2. The significance of the estimates are much lower with γ=2 than with γ=10, so that estimates for φ and π are often only significant at the 20% percent level of confidence when we use γ=2 zombie indices.[14]

We considered several other alternatives that are not reported since the results are so similar to those shown in tables 2 and 3. In particular, the regressions in Tables 2 and 3 consider only the post 1993 period, when the zombie percentages began to rise noticeably (and for which the γ=2 and γ=10 estimates imply that zombies begin to appear). When we re-estimated the table 2 specifications to include the 1980s, the estimates for investment and employment growth the main results are no different. For the productivity proxy, the estimated gap between the zombies and non-zombies (β in equation 12) rises substantially, while the estimated value of φ falls dramatically and becomes insignificant. We are not sure what to make of this.

We also tried defining the non-zombies differently. Specifically, we counted a firm as a non-zombie only if it has not been classified as a zombie in two consecutive

[14] We could in principle assign the individual firm probabilities and the industry probabilities using separate estimates for γ. We performed a few experiments of this type for employment growth and did not find any clear patterns as to which was more important.

years. This change shows no important differences from the baseline specification. We also found that defining the non-zombies to only firms that had not been zombies in 3 consecutive years made no difference.

Having concluded that the interaction effects are statistically significant across a variety of specifications, we now turn to examine their economic significance. Table 4 offers a first-pass attempt to quantify the impacts of zombie firms on investment and employment growth of non-zombies. We focus on the five non-manufacturing industries, where our asset weighted measures of zombies were particularly high in the late 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.[15] 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 $\gamma=\infty$ zombie indices.

Table 4 shows both investment and employment growth would have been higher in all these industries if there were less zombies. In some industries, the difference is quite large. For example, for the typical non-zombie firm in the wholesale industry the cumulative lost amount of investment was about 12.1% of capital, which was slightly more than one year worth of investment during this period. The employment growth of a typical non-zombie real estate developer would have been about 3.0% higher at the end of the period if the zombie percentage had not risen (which can be compared to the

[15] More specifically, the investment (or employment) is estimated to have been higher than the actual level by $(\hat{\chi} + \hat{\varphi})(actual \quad zombie \quad index - alternative \quad zombie \quad index)$.

average hiring in the industry of 0.62% per year). Overall, we read these effects as being substantial.

Figure 7 uses estimates from Table 2 for equation (12) to infer the differential effect of varying degrees of zombie infestation for non-zombies with different levels of sales growth; formally, this amounts to studying $\frac{\partial^2 Activity}{\partial nonz \partial Z} = \phi + \pi s$. The left panel shows the zombie distortion on investment is significantly worse for fast growing firms; the dotted lines in the graph show the 95 percent (asymptotic) confidence intervals. Not only are these marginal effects significant, the overall quantitative impact is large. For instance, for a firm with ten percent sales growth, if the industry zombie percentage were to increase from 0.1 to 0.2, investment would fall by 1.3 percentage points per year; if the firm instead had 15 percent annual sales growth, the investment drop would be 1.55 percentage points per year. Given the median investment rate of 14,7% per year (1993-2002) we view these effects as large.

The right panel in the figure presents an analogous calculation for employment. The marginal effects again are significant (for all cases where sales growth is above two percent per year). For a firm with sales growth of ten percent per year, an increase in the zombie percentage from 0.1 to 0.2 would depress annual employment growth by 0.25 percentage points per year. Since employment growth for this sample of firms was approximately zero, the implied cumulative effect of the high level of zombies during the late 1990s is big.

Given the depressed condition of the economy between 1993 and 2002 it is not clear which benchmark to use in gauging the size of the effects. Normally, we would have expected to find some firms with sales growth of 10 to 15 percent per year, but these firms are quite rare in Japan over this period. Nonetheless, it appears that there were substantial distortions for the healthiest firms.

5. Final Remarks

Let us now take stock and discuss the implications of our empirical findings. First, the mechanism we have highlighted compounds the problems caused by a traditional credit crunch. Recall that the reduced form profit shock that we analyze in the model subsumes a simple credit crunch. 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. It follows that the evidence we presented to support the zombie model, also shows that a pure credit crunch explanation (a la Kitasaka and Ogawa (2000)) for the recent experience is insufficient.[16]

This in turn implies that some of the policy advice that might be given for a standard credit constrained economy may not be as relevant for Japan. One key distinction is that the zombies are creating an on-going distortion that lowers job creation and industry productivity. A straightforward extension of the model makes long-run productivity growth endogenous and in this case the present value of the costs due to the suppression of restructuring generated by continuing forbearance that permits the zombies to exist, is probably much higher than just the present value of the subsidies that keep zombies alive.

Properly recognizing the large costs of allowing zombies to continue operating is important, since this is the benchmark that should be used in considering alternative policies. In particular, 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 extra money that would have been required to do so should be compared to losses from forgoing all the benefits that would have accrued had Japan returned at that point to having a normally functioning economy. These forgone benefits 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.[17]

Drawing any further conclusions requires us to enrich the model to explicitly consider the banks and their incentives. Our preliminary work on this extension adds banks with potentially binding capital-adequacy constraints to the model developed in

[16] There are also other implications that we have not tested so far that could be further used to distinguish these two models. For instance, the zombie model explains why the firms that do enter or expand need not have high values of Tobin's Q – essentially because the zombie congestion costs lower their profitability. In contrast, a standard credit crunch model would predict that these firms should be earning rents by virtue of being able to operate against reduced competition. See Caballero and Hammour (2005) for a discussion of the channels through which financial factors may depress restructuring during recessions.

[17] The same reasoning applies to the question of whether the lack of liquidations in the U.S. airline industry raised or lowered the taxpayers' costs of rationalizing the industry.

section 3. When the capital constraints are not binding, the model behaves as in the standard (normal) case, while when the constraint is binding the banks have an incentive to evergreen.[18] More importantly, when the capital-adequacy constraints are binding the enriched model exhibits hysteresis: if the shock S that caused the initial contraction disappears, the economy recovers only slowly, as the congestion effect is only gradually undone. This is in sharp contrast with the zombie-less economy, where the recovery begins immediately when the recessionary shock vanishes.

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 becoming 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 current situation in China would be the latest of these examples. Also, in the U.S. airline industry it is routinely asserted that the industry has been plagued because unprofitable carriers go bankrupt, yet they fail to exit the industry (see Wessel and Carey (2005).) These cases suggest that the mechanism that we have sketched is not unique to Japan.[19]

[18] Hosono and Sakuragawa (2003) and Sakuragawa (2002, Chapter 5) also develop models that suggests the capital ratio regulation increases the incentive for banks to evergreen. However, they do not model the link between ever-greening and economic growth.

[19] See Caballero (2005) for a discussion of different models and manifestations of sclerosis in macroeconomics.

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Appendix 1

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% 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 account all the origination and other fees). Thus, we view the use of the short term prime rate as relatively uncontroversial.[20]

Ideally, we would find an equally conservative assumption for handling long-term loans. It is quite likely that 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. So we assume that each firm's long term loans have an average maturity of 2.5 years and with one-fifth having been originated in each year for five years. We make this assumption because the vast majority of long-term bank loans are for five years. 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% of interest paying debt was bonds and about 3% 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.

[20] As alternative we instead computed a required rate that imposed a mark up 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.

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 going to understate the required payments on corporate debt. For instance, from 1996 onwards this imputation procedure will assume that all bond financing is done at a zero interest rate. We make this extreme assumption intentionally since it guarantees that any firms that 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 will pick out only the most egregious zombies.

One reason we are confident that our procedure is so conservative is that starting in 1998 we can obtain the interest expenses broken down by type of debt (e.g., bank loans or corporate bonds). Over the post-1998 period we can subtract out the bond interest payments (and commercial paper interest payments) from the total and compare $R^*_{i,t}$ for the remaining interest payments. This approach tends to shift the entire distribution of estimated interest rate gaps shown in the various panels of Figure 3 further to the left. For the years after 1998 this pushes the raw percentage and asset weighted percentages of firms with negative interest rate gaps to around 45% and 40% respectively (as compared to roughly 30% and 15% under the baseline procedure). However, the shifts in the distributions are very similar across industries.

The data for prime bank loan rates are taken from the Bank of Japan web site (http://www.boj.or.jp/en/stat/stat_f.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 balance sheet and income statement as of the accounting year ended between January and December of 1993.

Appendix 2

Our baseline procedure for determining whether a firm is a zombie is a step function that sets the probability be one if the interest rate gap is negative and zero otherwise. Our alternative procedure is designed to smooth the step function.

As mentioned in the text this is rationalized by arguing that the interest rate gap x_{it} is measured with error. We assume that bond-issuing firms cannot be zombies and that data for them on x_{it} provides an estimate of potential measurement error. Unfortunately, data on x_{it} shown in Figure 2 suggests that this distribution has likely changed over time. One way to deal with this would be to simply assume that the distribution for the issuing firms is identical to the measurement error distribution for non-issuers at all points in time. Alternatively, we could try to transform of the issuer distribution of y and compare that to a transformation of the non-issuer distribution to identify zombies. Of course, this would require us to come up with an appropriate transformation. We opt for a data-based, middle ground of comparing the issuer and non-issuer distributions in the pre-1993 to assess what type of transformation to consider.

These distributions are shown in the top panel of Figure A-1. To our eyes they appear close enough that it we are prepared to use the issuer distribution without any transformation to infer whether a given firm is a zombie; more formally, the means, variances, and higher moments of the distributions are similar. If we assume that any measurement error is the same for the issuers and non-issuers, and that issuers are never zombies, then it follows that there were no zombie firms prior to 1993.

We have several reasons that we are comfortable with this implication. One is that although the stock market had peaked in December of 1989, the rest of the macroeconomic environment through 1992 was still not unusual. For instance, real GDP reached its peak in 1992, and land prices reached theirs in 1991. Looking back, one might argue that by 1992 things were badly amiss in Japan, but most observers at the time were not arguing that the downturn at that time was in any way unusual. Second, detailed studies of the condition of the Japanese banking industry (e.g. Fukao (2003)) suggest that the banks were still solvent and perhaps even profitable as of 1992. So there is little reason to suspect that banks had perverse incentives at that point. Third, as far as we know, there is no direct evidence suggesting the credit misallocation problems prior to 1993. Peek and Rosengren start their analysis in 1993 on the grounds that initial Basel capital accords were implemented then. So we view 1993 as a relatively conservative starting point.

Our second assumption is that the measurement error for issuers and non-issuers also comes from the same distribution after 1993. Looking at the bottom panel of Figure A-1, it is apparent that the distribution of y for non-issuers shifted much more to the left than did the distribution for the issuers. Our procedure will rationalize this shift by supposing that many of the issuers were receiving subsidies.

To assign a probability that a firm is a zombie we approximate the measurement error distribution using histograms of data on x_{it} for issuers after 1993. Our raw zombie probability is computed as Prob(x_{it}'<x) if x_{it}' was taken from this distribution.[21] Given the high degree of overlap in the issuer and non-issuer distributions, these raw probabilities (that correspond to γ=1 in equation 1) indicate that even firms where the interest rate gap is 150 basis points have a 40 percent chance of being a zombie and 70 percent of the firms have at least a 30 percent chance of being a zombie. In other words, the raw probabilities are not very informative.

To see the basis of this problem Figure A-2 shows how the implied zombie probability varies as the interest rate gap varies from -2 percentage points to 2 percentage points. The dashed line in the graph shows the cumulative distribution function for interest rate gap and indicates that this interval covers 70 percent of the data (for the 1993 to 2002 bond-issuers sample).

When gamma is equal to 1, a firm with an interest rate gap of -2 percentage points there has a 99% chance that the firm is a zombie. That percentage still exceeds 95% when the gap is -1 percentage points, but the probability begins dropping steadily and reaches 80% when the gap is zero. Even when the interest rate gap is 2 percentage points the raw zombie probability is thirty percent.

[21] The test is conducted for all the issuers and non-issuers so that we can compare the findings to the ones obtained with our baseline procedure. If we instead set the zombie probability equal to zero for all the issuers the results described below are hardly affected.

When $\gamma=2$, a firm is estimated to 99% chance of being a zombie when the interest rate gap is -1 percentage point. With gamma equal to 2 the firm is equally likely to be a zombie or non-zombie when the interest rate gap is about 47 basis points.

The $\gamma=10$ case is very close to the step function. A firm is dubbed a zombie with 99% probability or above until the interest rate gap is -16 basis points and the probability falls below one percent as soon as the gap is 15 basis points.

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.

Table 2
Impact of Zombie Firms on the Investment, Employment and Productivity of Non-Zombies Using Baseline Zombie Estimates

Dependent Variable	I/K	ΔLog E	Log Sales – ⅔ Log E – ⅓ Log K	I/K	ΔLog E
Sample	1993-2002	1993-2002	1993-2002	1993-2002	1993-2002
Constant	0.2390 (0.0084)	0.0137 (0.0024)	3.3842 (0.0196)	0.2465 (0.0084)	0.0162 (0.0025)
Non-Zombie Dummy	0.0256 (0.0056)	0.00109 (0.001751)	0.0139 (0.0135)	0.0241 (0.0058)	0.0009 (0.0017)
Industry Zombie %	-0.1370 (0.0376)	-0.0454 (0.0116)	-0.3418 (0.0922)	-0.0987 (0.0364)	-0.0283 (0.0108)
Non-Zombie * Industry Zombie%	-0.0885 (0.0330)	-0.0232 (0.0102)	0.2183 (0.0756)	-0.0678 (0.0297)	-0.0163 (0.0088)
Sales growth				0.1152 (0.0318)	0.1078 (0.0097)
Non-Zombie * Sales Growth				0.1436 (0.0376)	0.0160 (0.0116)
Industry Zombie% * Sales Growth				1.1002 (0.1402)	0.1674 (0.0427)
Non-Zombie * Sales Growth * Industry Zombie%				-0.5823 (0.1733)	-0.0912 (0.0535)
$\bar{R}^2$	0.0537	0.0895	0.3599	0.1083	0.1700

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% of observations (based on the dependent variable). White (1980) standard errors are reported in parentheses under each coefficient estimate. Industry and year dummies are also included in each regression. Any firm with actual interest payments below the hypothetical minimum is considered a zombie and any firm where this is not true is a non-zombie ($\gamma=\infty$ 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. Sales growth is the log difference of each firm's sales. 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.

Table 3
Impact of Zombie Firms on the Investment, Employment and Productivity of Non-Zombies Using Alternative Zombie Estimates

Dependent Variable	I/K		ΔLog E		Log Sales – ⅔ Log E – ⅓ Log K		I/K		ΔLog E	
γ in equation (1)	2	10	2	10	2	10	2	10	2	10
Constant	0.2547 (0.0092)	0.2399 (0.0085)	0.0174 (0.0027)	0.0137 (0.0025)	3.3801 (0.0216)	3.3810 (0.0198)	0.2601 (0.0091)	0.2476 (0.0085)	0.0198 (0.0027)	0.0163 (0.0025)
Non-Zombie Dummy	0.0322 (0.0073)	0.0272 (0.0058)	0.0028 (0.0022)	0.0017 (0.0018)	0.0386 (0.0173)	0.0202 (0.0139)	0.0308 (0.0073)	0.0251 (0.0060)	0.0016 (0.0022)	0.0012 (0.0018)
Industry Zombie %	-0.2338 (0.0343)	-0.1482 (0.0377)	-0.0643 (0.0103)	-0.0457 (0.0116)	-0.2780 (0.0808)	-0.3229 (0.0907)	-0.1947 (0.0320)	-0.1128 (0.0359)	-0.0531 (0.0095)	-0.0308 (0.0106)
Non-Zombie * Industry Zombie%	-0.0393 (0.0280)	-0.0824 (0.0323)	-0.0121 (0.0085)	-0.0234 (0.0099)	0.1148 (0.0654)	0.1974 (0.0741)	-0.0349 (0.0257)	-0.0586 (0.0289)	-0.0042 (0.0076)	-0.0146 (0.0086)
Sales growth							0.1188 (0.0348)	0.1062 (0.0319)	0.1134 (0.0108)	0.1073 (0.0097)
Non-Zombie * Sales Growth							0.1453 (0.0470)	0.1539 (0.0386)	-0.0024 (0.0148)	0.0172 (0.0119)
Industry Zombie% * Sales Growth							0.6529 (0.1080)	1.0771 (0.1332)	0.1312 (0.0334)	0.1746 (0.0404)
Non-Zombie * Sales Growth * Industry Zombie%							-0.2585 (0.1530)	-0.5923 (0.1677)	-0.0659 (0.0477)	-0.1154 (0.0517)
$\overline{R}^2$	0.0564	0.0540	0.0899	0.0894	0.3631	0.3626	0.1099	0.1087	0.1711	0.1701

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% of observations (based on the dependent variable). White (1980) standard errors are reported in parentheses under each coefficient estimate. Industry and year dummies are also included in each regression. The zombie probabilities are calculated as described in the text using 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. Sales growth is the log difference of each firm's sales. 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. Sample period is 1993 to 2002.

Table 4
Cumulative Impact of Zombie Firms on Non-Zombies

A. Cumulative investment losses (1993-2002) of the median non-zombie firm in the high zombies industries

Industry	Wholesale	Retail	Construction	Real Estate	Services
Actual Average I/K: 1993-2002	0.1184	0.1871	0.1373	0.0920	0.2215
Cumulative Lost I/K Case 1	0.1206	0.0525	0.0833	0.0793	0.0842
Cumulative Lost I/K Case 2	0.0963	0.0399	0.0503	0.1117	0.1408

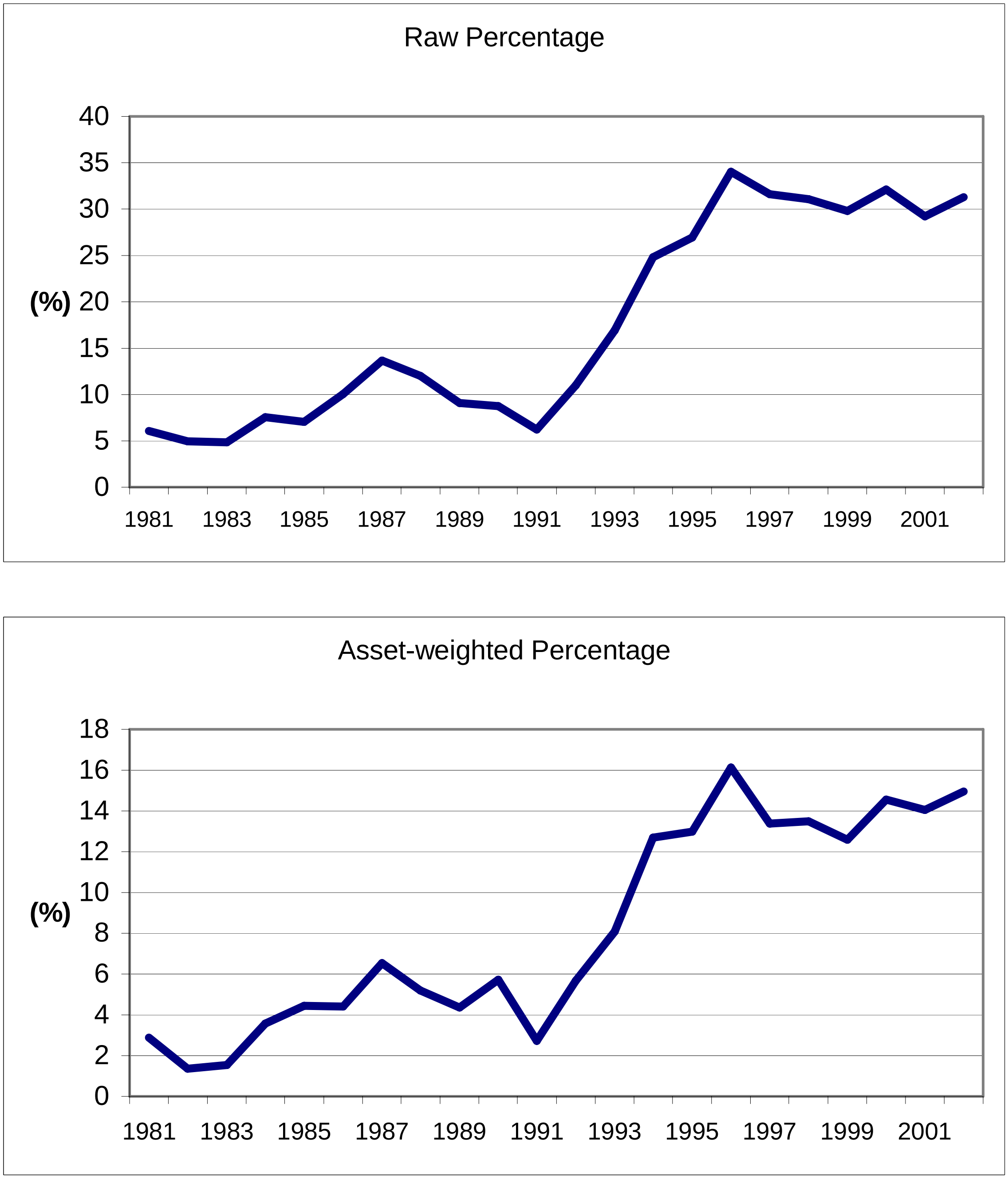
"Actual Average I/K: 1993-2002" shows the actual average investment rate (I/K) of the median non-zombie firm in the industry for 1993-2002. "Cumulative Lost I/K Case 1" shows the total amount of investment (I/K) of the typical non-zombie that was depressed during the period compared with the hypothetical 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 the column 2 of Table 2 were used for the calculation.

B. Cumulative employment change (1993-2002) of the median non-zombie firm in the high zombies industries

Industry	Wholesale	Retail	Construction	Real Estate	Services
Average Actual Employment growth: 1993-2002	-0.0136	0.0015	-0.0043	0.0062	0.0134
Cumulative lost employment -- Case 1	0.0381	0.0190	0.0285	0.0301	0.0381
Cumulative lost employment -- Case 2	0.0303	0.0144	0.0172	0.0427	0.0641

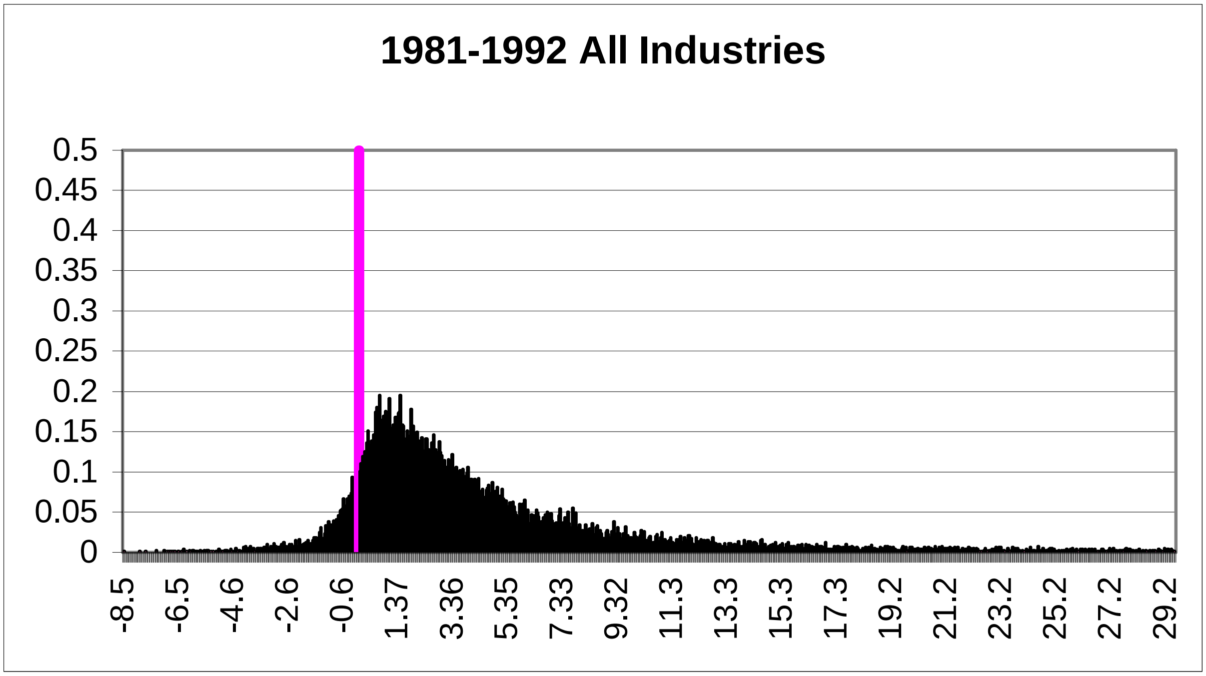
"Average Actual Employment Growth: 1993-2002" shows the actual average annual rate of change in the employment at the median non-zombie in the industry for 1993-2002. "Cumulative lost employment Case 1" shows the total rate of new hiring at the typical non-zombie that was depressed during this period 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 the column 3 of Table 2 were used for the calculation.

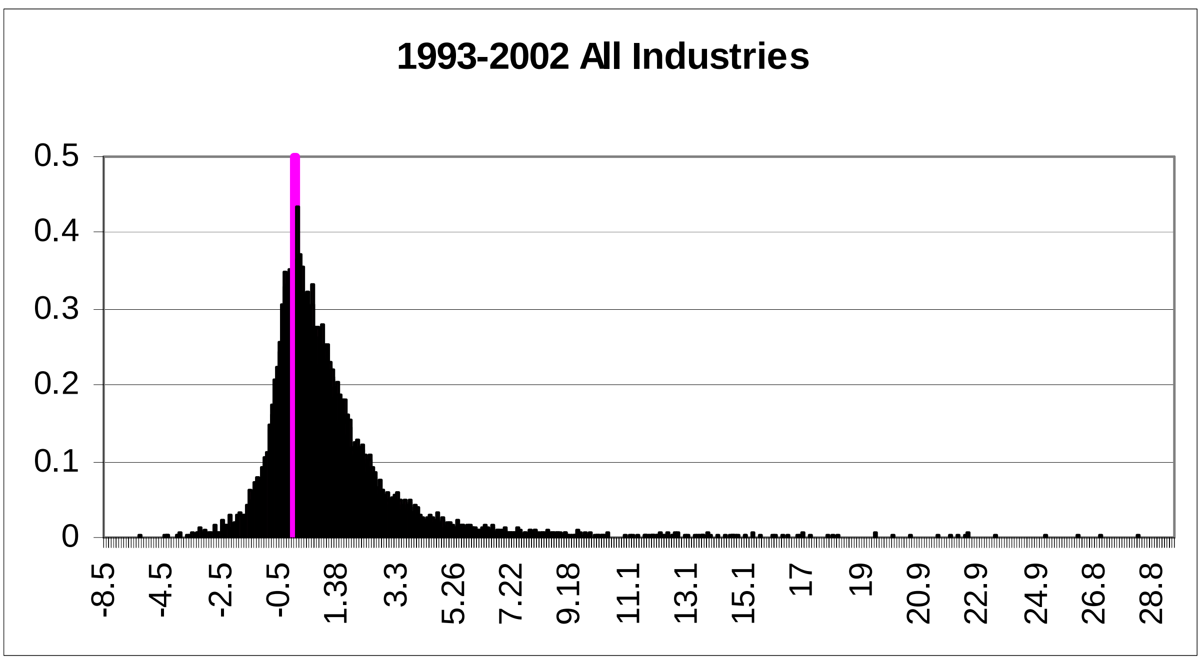
Figure 1: Prevalence of Firms Receiving Subsidized Loans in Japan



Note: Percentages calculated as described in the text, with $\gamma=\infty$ in equation 1.

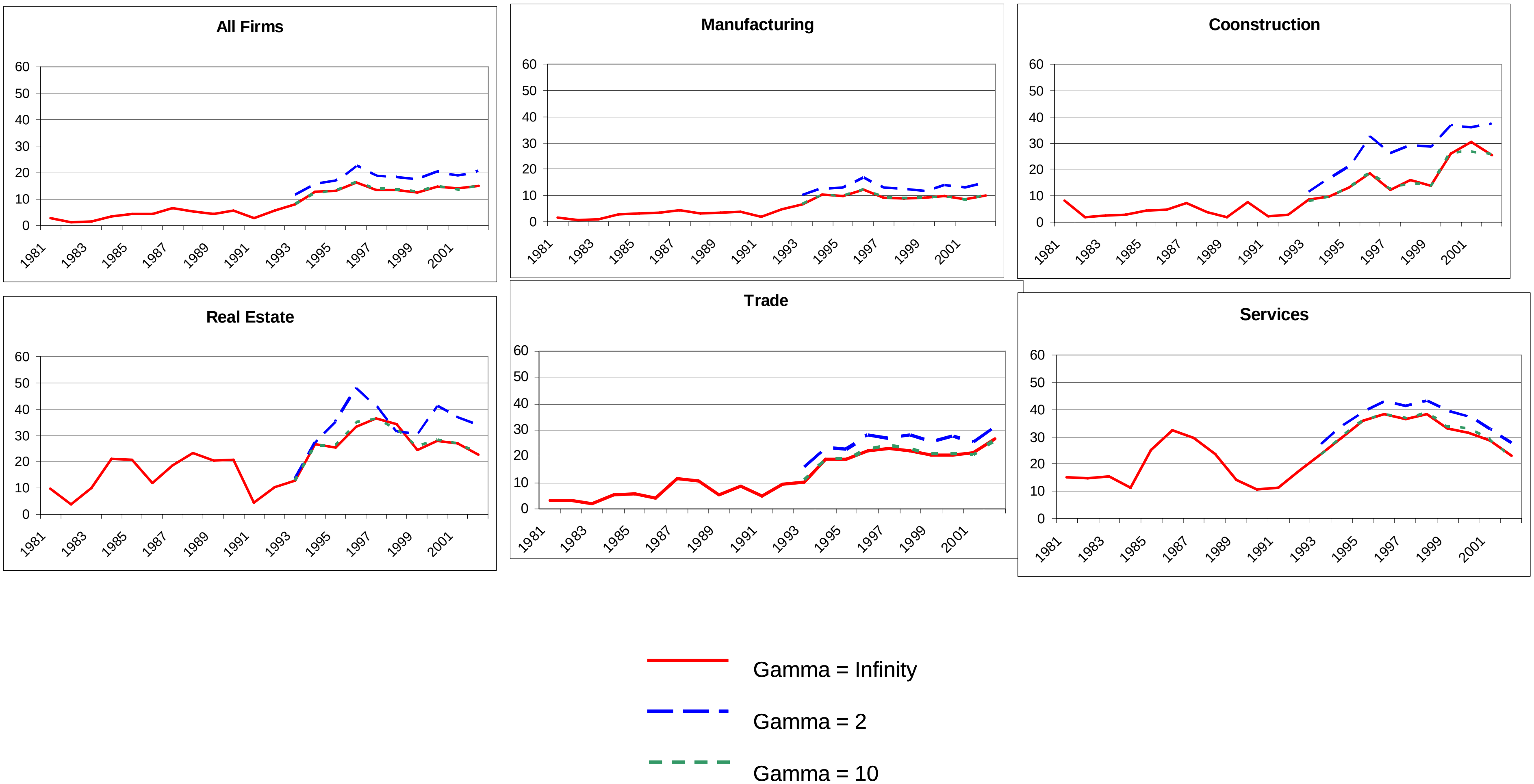
Figure 2: Gap Between Actual Interest Payments and Lower Bound Estimated Payments
(in percentage points)





Note: Calculations as described in the text.

Figure 3: Cross-Industry Incidence of Asset Weighted Zombie Percentage for Three Zombie Definitions



Note: Alternative zombie definitions computed according to equation 1, see text for details.

Figure 4: Asset Weighted Zombie Percentages by Profitability
(Solid lines show zombie percentage for firms whose profits are above the median for the industry, dashed show below median)

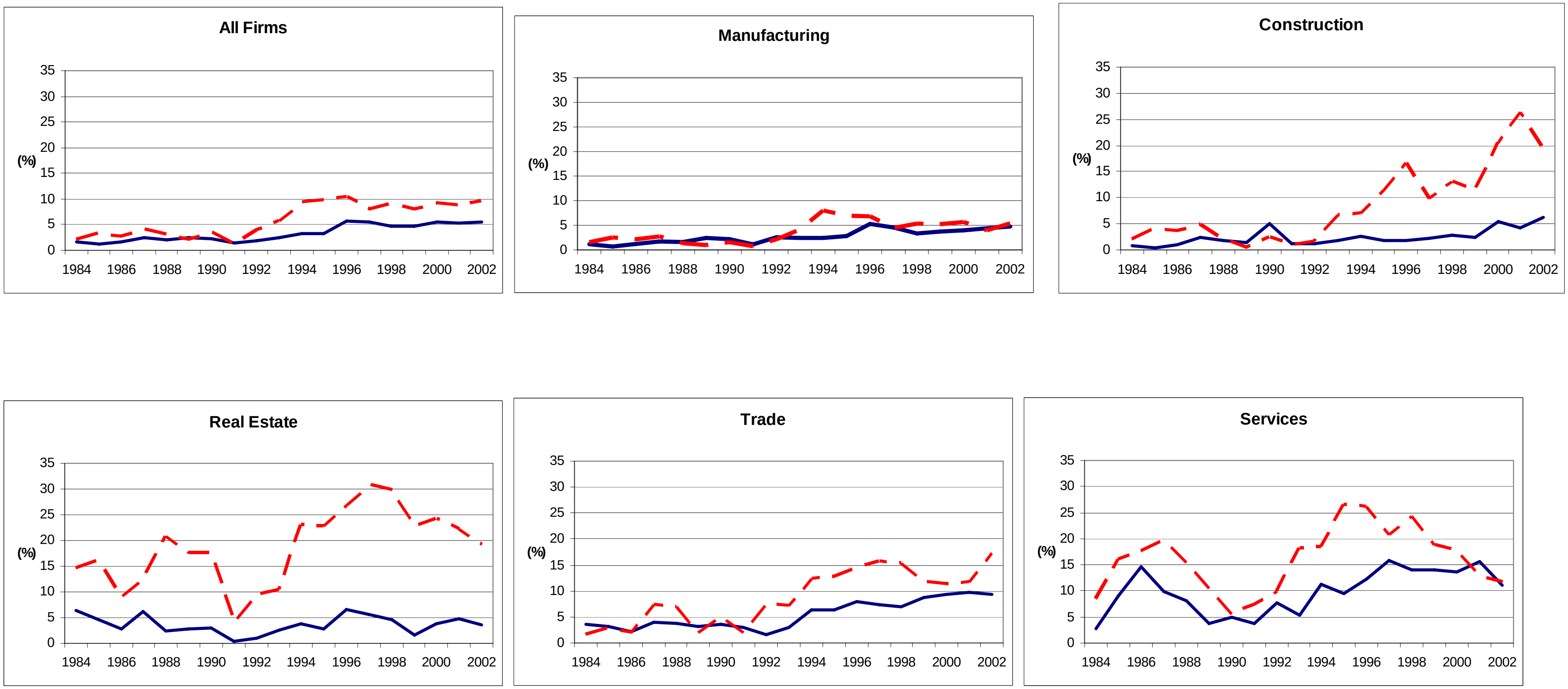
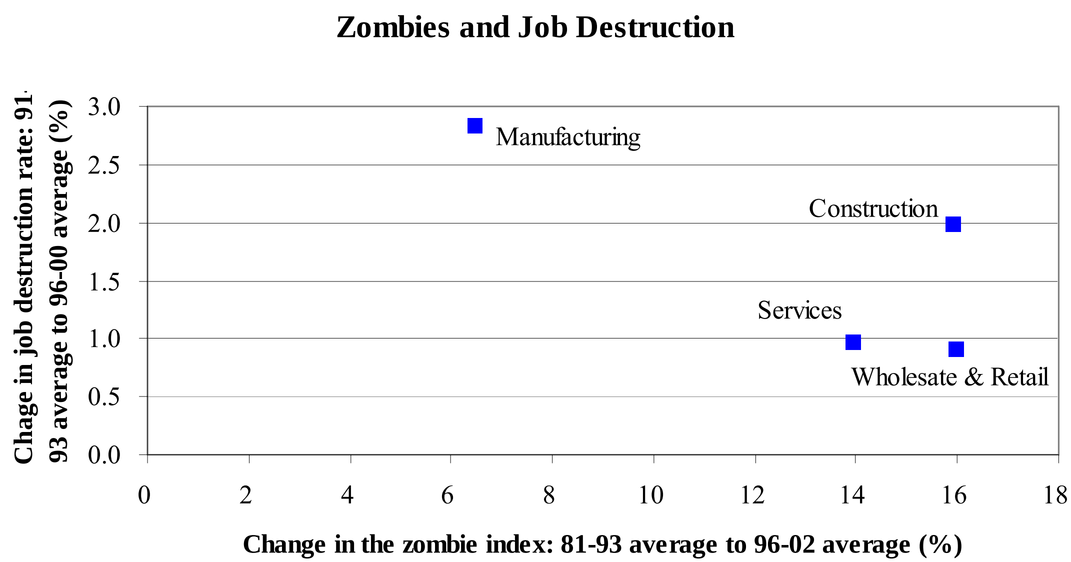


Figure 5


Zombies and Job Destruction
Chage in job destruction rate: 91-93 average to 96-00 average (%)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Manufacturing
Construction
Services
Wholesate & Retail
0
2
4
6
8
10
12
14
16
18
Change in the zombie index: 81-93 average to 96-02 average (%)

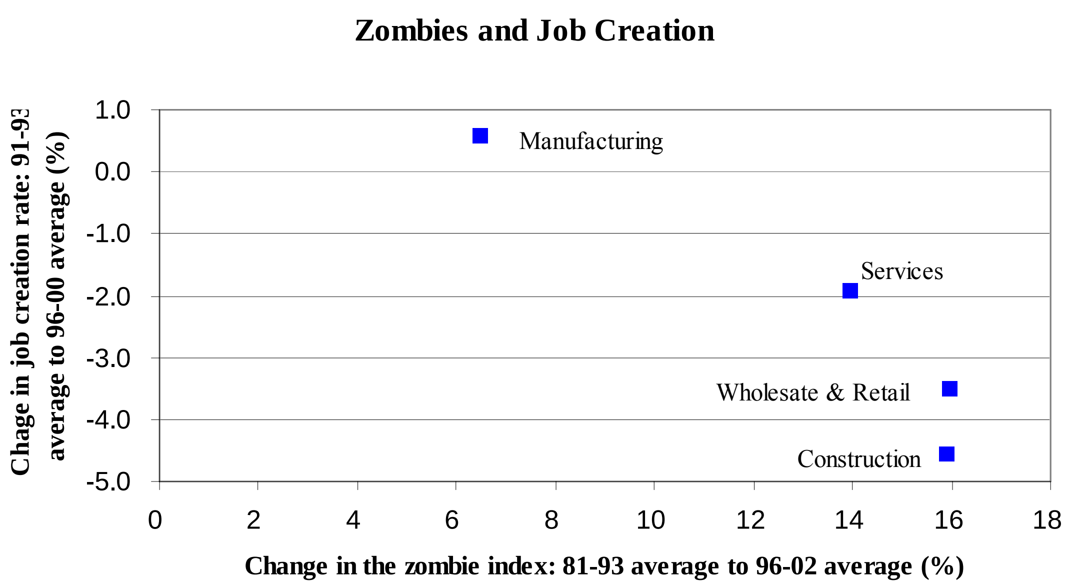

Zombies and Job Creation
Chage in job creation rate: 91-93 average to 96-00 average (%)
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
Manufacturing
Services
Wholesate & Retail
Construction
0
2
4
6
8
10
12
14
16
18
Change in the zombie index: 81-93 average to 96-02 average (%)

Figure 6

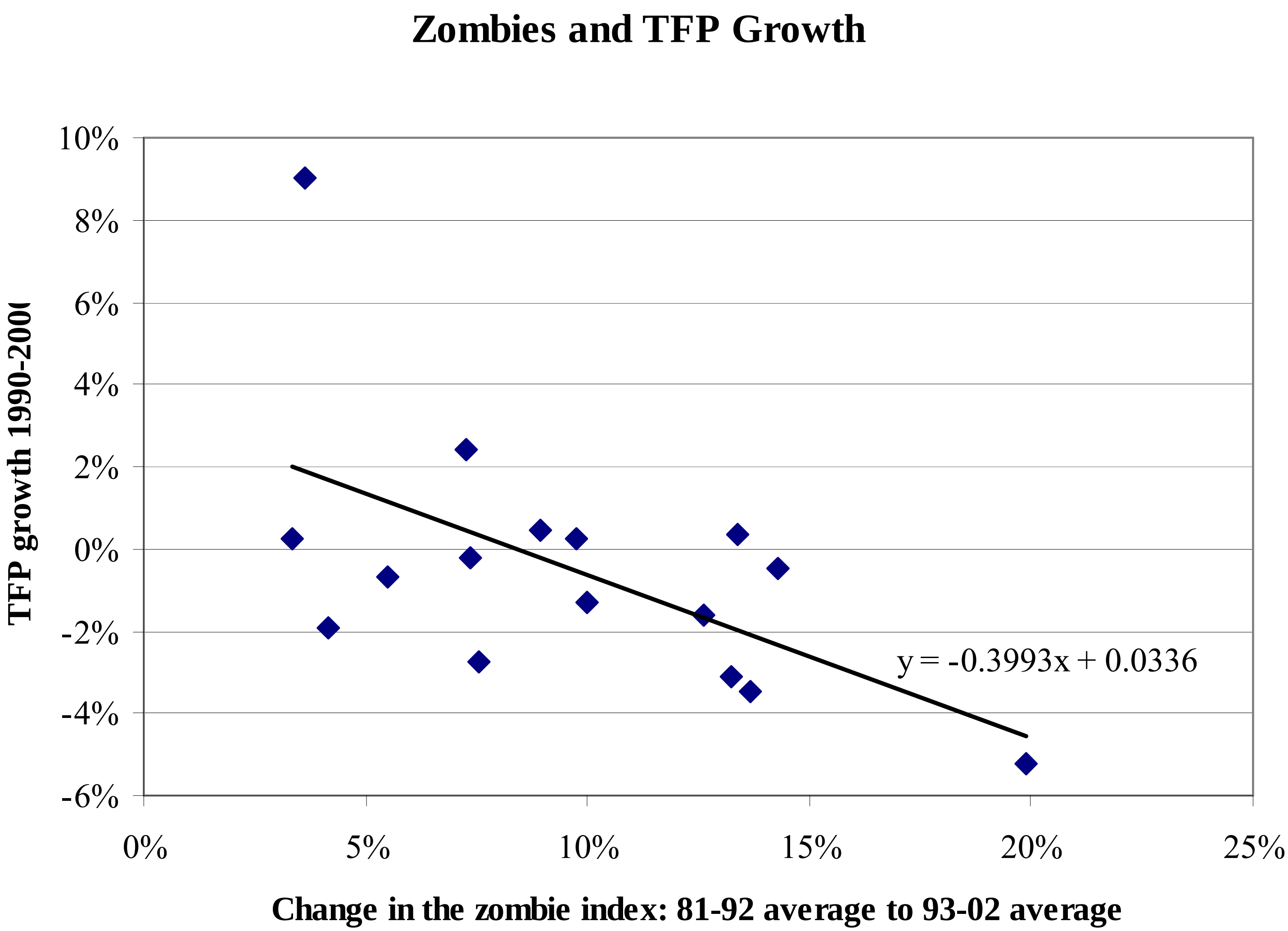

Zombies and TFP Growth
10%
8%
6%
4%
2%
0%
-2%
-4%
-6%
TFP growth 1990-200
y = -0.3993x + 0.0336
0%
5%
10%
15%
20%
25%
Change in the zombie index: 81-92 average to 93-02 average

Figure 7: Marginal Effect of the Industry Zombie Percentage for Non-Zombie Firms with Different Levels of Sales Growth

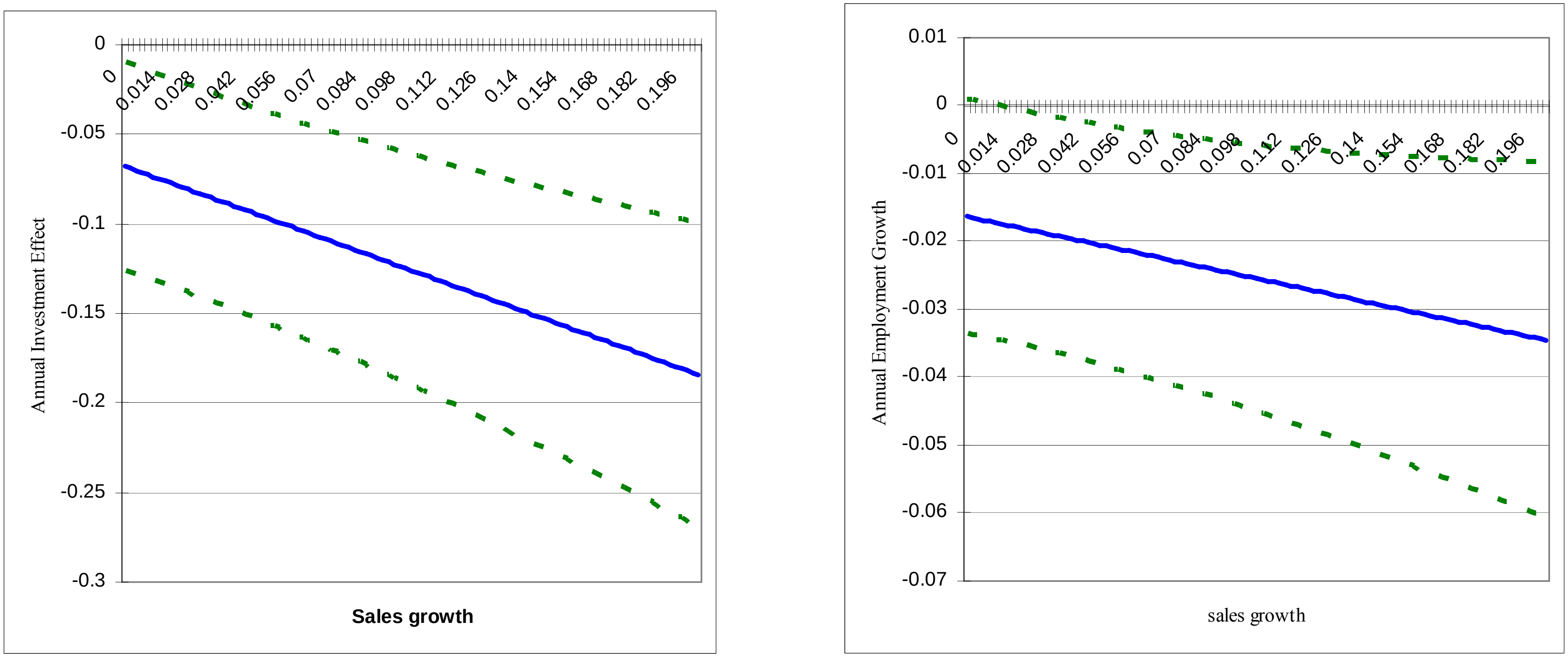


Figure A-1: Gap Between Actual Interest Payments and Lower Bound Estimated Payments, , Shown Separately for Firms That Do and Do Not Issue Corporate Bonds
(in percentage points)

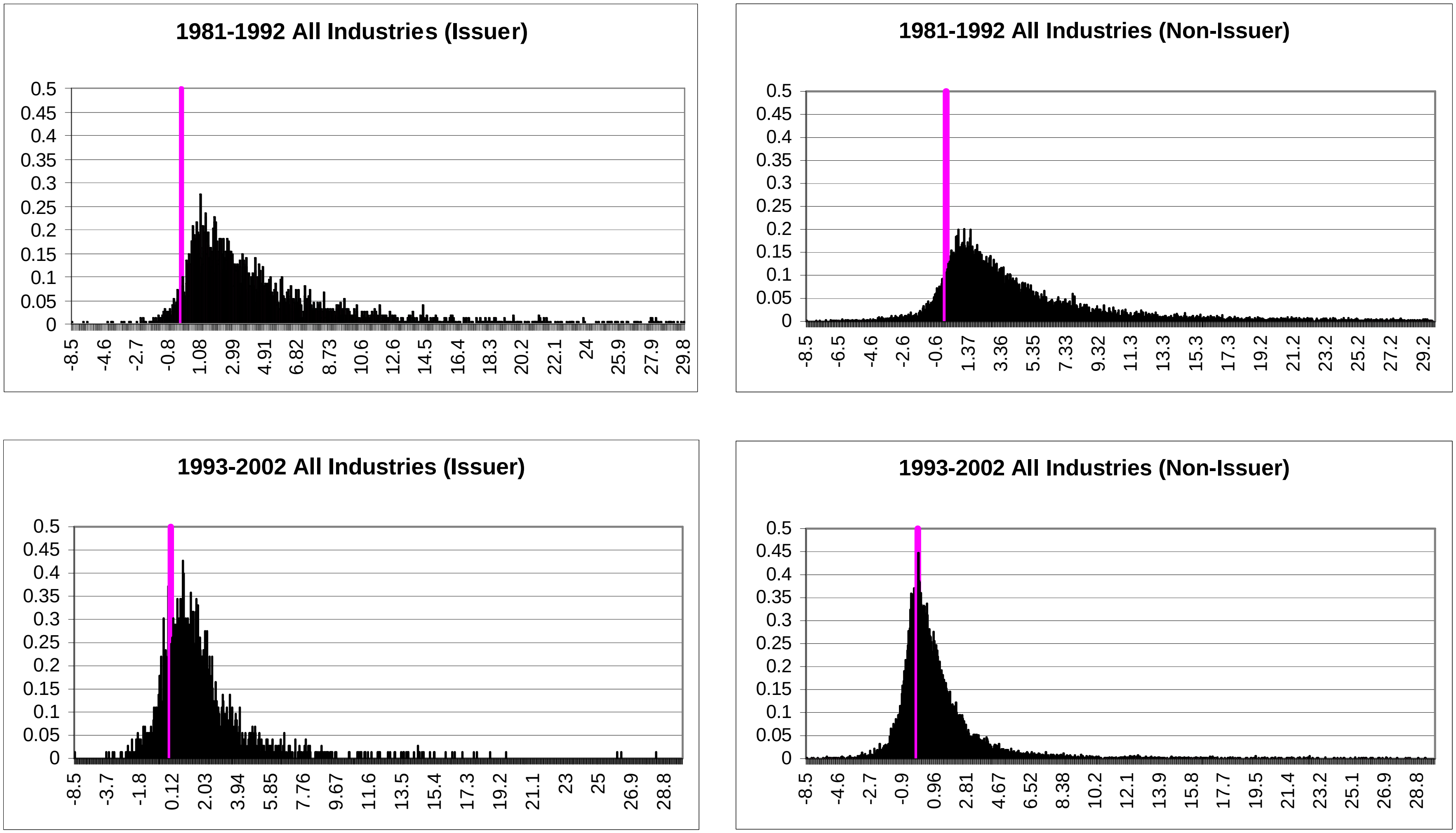


Figure A-2: Variation in zombie probabilities across interest rate gaps for different values of gamma