# Credit Intermediation and Zombie Firms: Theory and Evidence*

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**Abstract**

Search and opportunity costs in credit intermediation generate zombie lending in equilibrium. When credit is scarce, banks readily find borrowers, maintain high lending standards, and zombie lending remains limited. As credit becomes more abundant, banks increasingly retain relationships with low-productivity firms to avoid the costs of searching for new borrowers, increasing zombie lending. However, at higher levels of credit abundance, firms face lower search and financing costs and are more willing to leave existing banking relationships in anticipation of improved productivity and easier future access to credit. As a result, zombie lending declines. These opposing forces imply an inverted U-shaped relationship between credit abundance and zombie lending. The strength of this relationship depends on firms' bargaining power vis-à-vis banks and the persistence of firm productivity. Using Japanese industry-level data and a novel model-consistent measure of credit abundance constructed from survey responses, we test this prediction empirically. Consistent with the model, we find that capital injections reduced zombie lending in industries with relatively abundant credit.

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# 1. Introduction

Zombie firms –unprofitable enterprises kept in existence through external borrowing– are pervasive across many economies. Research on zombie firms has largely examined their incidence through the lens of banks' lending behavior. Yet zombie firms have persisted despite regulatory reforms and tighter constraints on banks. This pattern is particularly salient in the period following the Global Financial Crisis, when banking regulation was substantially strengthened, most notably through the Basel III framework. Taken together, these observations suggest that the mechanisms sustaining zombie firms may be intrinsic to credit intermediation, and involve joint strategic decisions by *both* firms *and* banks that generate zombie lending as an equilibrium outcome. We study these issues by addressing the following questions: Can zombie lending emerge as an equilibrium outcome of credit intermediation? How does the issuance of credit interact with credit intermediation to influence the emergence of zombie firms?

We contribute to the literature in three dimensions. First, we show that credit intermediation between banks and firms entails search frictions and opportunity costs that generate zombie lending as an equilibrium outcome, even when banks are well capitalized. Second, by incorporating dynamic changes in firm profitability and the forward-looking relationship decisions of banks and firms, our framework is consistent with the empirical finding that several zombie firms subsequently recover, yielding testable empirical predictions on changes in zombie lending. Third, our theory introduces a novel measure of credit availability in financial markets –what we call *credit market tightness*– which we construct using Japanese data, and use it to test our theoretical results and study the effectiveness of capital injections on the share of zombie lending during the Japanese banking crisis of the late 1990s and early 2000s.

**General idea.** Our study examines the joint perspectives of banks and firms on the emergence of zombie lending arising from the costs of credit intermediation. Central to this issue is the dynamic nature of firm profitability, which can change over time, allowing low-productivity firms (zombies) to recover and become profitable. The dynamic profitability creates incentives for both banks and firms to continue their lending relationships to avoid the costs of credit intermediation while envisaging an improvement in the firm's profitability.[1]

We capture this idea by allowing firm profitability to vary over time and by modeling the costs of credit intermediation between banks and firms. These costs extend beyond contractual arrangements and regulatory procedures to include the *search* and *opportunity costs* of forming credit relationships. Avoiding *search costs*, together with the possible improvement in profitability, fosters lending to unprofitable firms: both banks and firms relax lending standards to circumvent costly search processes, while firm profitability may improve over time, thereby resolving zombie lending. The *opportunity costs* are tied to credit market conditions: when credit is abundant, banks have incentives to maintain zombie lending because the opportunity cost of severing a relationship is high, since it is more difficult to find borrowing firms, thereby increasing zombie prevalence. On the other hand, firms have incentives to avoid current losses and terminate banking relationships in expectation of productivity gains and easily finding credit in the future, thereby reducing zombie prevalence. These two countervailing forces generate an inverted U-shaped relationship between credit abundance and zombie firm prevalence and establish zombie lending as an equilibrium outcome.

**Formalization with a frictional credit market.** We formalize these concepts in a parsimonious model of frictional financial intermediation between banks and firms. We assume that intermediation costs arise from search and matching frictions that prevent costless meetings between banks and firms in credit markets. Firms differ in productivity levels. Zombie firms have insufficient productivity to generate positive profits in the current period but receive credit and may become profitable in the future. The firm-specific productivity threshold required for positive profits is endogenous to intermediation costs and credit abundance, and determines the share of

[1]Empirical evidence from Carreira et al. (2022), Fukuda and Nakamura (2011), and Hu and Varas (2021) show that a substantial fraction of firms identified as zombies based on current financial information subsequently recover and transition into non-zombie firms. In our framework, zombie firms are unprofitable but constrained-efficient: they arise in the social planner's allocation in the presence of search frictions. While in our model the result of constrained efficiency is driven by credit intermediation frictions, similar constrained efficiency arises from optimistic expectations (Albuquerque and Iyer, 2024), evergreening (Faria-e-Castro et al., 2024), policy traps (Acharya et al., 2021), or forbearance lending (Roland et al., 2024).

zombie lending.

**Inverted U-shaped relationship.** Search frictions generate two countervailing forces that shape the prevalence of zombie firms. First, they lower the firm-specific productivity threshold required for firms to obtain credit. To avoid search costs, banks optimally maintain credit relationships with low-productivity firms that generate negative profits but can improve profitability in the next period. Maintaining credit relationships with low-productivity firms increases the equilibrium share of zombie firms. Second, search frictions make the opportunity costs of financial intermediation dependent on credit market conditions (i.e., the abundance of credit). The endogenous opportunity costs generate two countervailing incentives for banks and firms regarding zombie lending.

On the banks' side, the abundance of credit intensifies competition, raising credit market *tightness* for banks –that we measure as the ratio of loan supply to loan demand.[2] In a credit market with abundant credit (i.e., high credit market tightness), banks face elevated search and opportunity costs, leading them to optimally lend to low-productivity firms to avoid these costs and thereby increasing zombie firm prevalence. On the firms' side, credit market tightness reduces firms' opportunity costs of terminating unprofitable credit relationships, since they can easily find new lenders while avoiding current losses in the expectation of improving future profitability.

Thus, increasing credit market tightness incentivizes banks while disincentivizing firm equity holders to maintain credit relationships. At low levels of credit market tightness (scarce credit), banks are selective and zombie prevalence is low. As tightness increases (credit becomes more abundant), banks' incentives to avoid search and opportunity costs by maintaining existing relationships dominate, increasing zombie prevalence. At sufficiently high tightness, firms' incentives to exit unprofitable relationships and seek new lenders in the expectation of improved profitability prevail, leading zombie prevalence to decline. These countervailing forces generate an *inverted U-shaped* relationship between credit market tightness and the share of zombie firms.

[2]We define credit market tightness from the perspective of banks that provide credit. Higher credit market tightness therefore corresponds to more abundant credit, as it is defined as the ratio of loan supply to loan demand.

**Bargaining power, productivity persistence, and capital injections.** Our framework shows that the bargaining power between banks and firms is critical in determining the relationship between the share of zombie firms and credit market tightness. When firms hold high bargaining power and retain a large share of profits through low negotiated interest rates, credit market tightness reduces firms' search costs (since firms extract most of the profits from the relationship) while simultaneously decreasing banks' benefits from maintaining unprofitable relationships. Consequently, *ceteris paribus*, the share of zombie firms decreases when firms have greater bargaining power.

Similarly, productivity persistence is critical for incentivizing firms to forego unprofitable banking relationships. Lower productivity persistence induces firms to dissolve currently unprofitable relationships, as they anticipate future productivity realizations that differ from the current low draw and may therefore restore profitability in subsequent periods. Finally, capital injections to banks lead to a substantial reduction in lending to zombie firms when the credit market tightness is high and firms are incentivized to forgo unprofitable credit relationships.

**Testable predictions.** Our theoretical framework generates the following testable predictions:

1. Credit market tightness and the share of zombie firms have an inverted U-shaped relationship.

2. An increase in a firm's bargaining power amplifies the reduction in the share of zombie firms as credit market tightness rises.

3. Greater productivity persistence reduces the sensitivity of the share of zombie firms to the credit market tightness.

4. The effectiveness of capital injections in reducing zombie lending increases with credit market tightness (credit becomes more abundant).

**Empirical results.** We empirically test our theoretical predictions by constructing model-implied measures of credit market tightness and bargaining power with industry- and firm-level datasets covering 31 industries in Japan from various data sources over the period 2000-2019. Japan provides an ideal testing ground for our theory, as the country experienced a prolonged period of zombie lending, and the cross-sectional variation in credit market tightness, bargaining power, and financial conditions across industries facilitates econometric identification.

We corroborate our first prediction –an inverted U-shaped relationship between credit market tightness and zombie firm prevalence– by estimating alternative threshold and quadratic regression models, applying the test proposed by Lind and Mehlum (2010). We validate our second prediction –that increases in credit tightness strongly reduce the share of zombie firms in industries with high firm bargaining power– by showing statistically significant differences in the relationship between credit market tightness and the share of zombie firms across industries with high versus low firm bargaining power. We validate our third theoretical prediction on the role of low productivity persistence in determining the share of zombie firms in two steps. First, we estimate the autoregressive parameter of an AR(1) process using a firm-level panel dataset of labor productivity and find it is low, ranging between 0.17 and 0.19. Second, we exploit cross-industry variation in productivity persistence to estimate differences in the steepness of the inverted U-shaped relationship. We show that industries with high productivity persistence are less likely to exhibit the inverted U-shaped pattern, consistent with our theoretical prediction.

Finally, we test our fourth prediction by examining the relationship between capital injections and zombie firm prevalence during the banking crisis in Japan in the late 1990s and early 2000s. We construct alternative indexes of exposure of firms to capital injections and show that capital injections during Japan's banking crisis were associated with greater reductions in zombie firm prevalence in industries with higher credit market tightness, consistent with our theory.

**Related literature.** Our work is closely related to the seminal study on zombie lending by Caballero et al. (2008), who establish the nexus between credit supply by banks and the prevalence of zombie firms during the 1980s and 1990s in Japan. Subsequent studies show how credit allocation and policy actions shape aggregate outcomes, showing a complex interplay between credit markets, economic policies, and zombie firms (Acharya et al., 2021). Related to our research are also the studies on bank lending and collateral constraints for the presence of low -productivity firms in the economy (Albuquerque and Mao, 2025; Faria-e-Castro et al., 2024, González et al., 2024, and Tracey, 2025), and information asymmetry and reputation accumulation (Hu and Varas, 2021). Unlike previous studies that link zombie lending to the weaknesses in the banking sector, we focus on the mutual relationship between banks and firms and study the interplay between credit market tightness and the distinct incentives of banks and firms to engage in zombie lending, focusing on Japan.

Our work also relates to the empirical research that studies the drivers of zombie lending. Prominent drivers are firm competition (Brunner et al., 2024), capitalization of banks (Peek and Rosengren, 2005; Schivardi et al., 2022), capital-market conditions (Favara et al., 2024), the size of capital injections (Giannetti and Simonov, 2013), and forbearance lending (Roland et al., 2024). In comparison with these studies, our study focuses on credit abundance, as captured by a measure of credit market tightness. We show that credit market tightness exhibits a non-monotonic relationship with the share of zombie firms, driven by opposing forces related to the opportunity costs of financial intermediation.

Finally, our results relate to the literature that studies the sources of boom and bust cycles, which shows that those are linked to either price swings in the housing market (Jermann and Quadrini, 2012; Burnside et al., 2016; Mian et al., 2017; Garriga et al., 2019), dispersed information that generates phases of optimism and pessimism (Beaudry and Portier, 2004; Benhima, 2019), credit constraints under self-fulfilling expectations (Liu and Wang, 2014), the interplay of the economy and monetary policy (Christiano et al., 2008; Schularick and Taylor, 2012), strategic complementarities (Beaudry et al., 2024; Fernandez-Villaverde et al., 2021, 2024, 2025) or the revisions of the expectations about future growth (Brianti and Cormun, 2024; L'Huillier et al., 2024). Our analysis shows that credit market tightness may also generate phases with low and high shares of unprofitable firms that are consistent with boom-bust cycles.

**Outline.** The remainder of the paper is organized as follows. Section 2 develops our parsimonious model of frictional financial intermediation and formulates testable empirical predictions. Section

3 presents model-implied measures of credit market tightness and tests our theoretical predictions using industry-level and firm-level data. Section 4 concludes.

## 2. A model of zombie firms

We develop a parsimonious model with search frictions in the credit market between banks and firms. The simple framework transparently shows that financial frictions lead banks to form relationships with unprofitable, low-productivity firms (zombies) that would not occur in a frictionless credit market. The model establishes four testable predictions: (i) the share of zombie firms has an inverted U-shaped relation with credit market tightness, (ii) an increase in the firm's bargaining power strengthens the reduction in the share of zombie firms when credit becomes abundant, (iii) low productivity persistence decreases the share of zombie firms by reducing the incentive to maintain loss-making relationships, and (iv) the effectiveness of capital injections to reduce the share of zombie firms increases with credit market tightness and elevated firm's bargaining power. We will test these predictions empirically in Section 3.

**Environment.** The economy lasts two periods, $t = 1, 2$, and payoffs in the second period are discounted at the rate $\beta < 1$. In the first period, the economy starts with a large number of firms, indexed by $i \in (0, 1]$. Each firm has idiosyncratic productivity $z_{i,t}$ drawn from distribution $G(z)$. At the beginning of each period, firms receive a random draw of idiosyncratic productivity $z_{i,t}$ from the distribution $G(z)$ and start production upon obtaining a loan from the bank. To manufacture output, the firm must finance a strictly positive fixed cost $f$ each period. Because this operational cost must be covered, the firm relies on active funding to exist. At the beginning of the first period, firms are matched with a bank, and each firm pays the interest rate $r_{i,t}$ for the loan. Output $\pi_{i,t}$ increases with the firm idiosyncratic productivity and the aggregate process $A_t$ (that represents factors determining stochastic aggregate productivity), and decreases with the fixed costs of production, hence implying the following: $\partial\pi(z_{i,t}, A_t, f)/\partial z_{i,t} > 0$, $\partial\pi(z_{i,t}, A_t, f)/\partial A_t > 0$ and $\partial\pi(z_{i,t}, A_t, f)/\partial f < 0$.

Each bank posts a loan at the cost $\kappa$, and the probability of finding a firm depends on the *tightness* in the credit market $\theta$, defined as the ratio between the number of loans offered by banks and the number of firms seeking to secure a loan. A high credit tightness (i.e., a large supply relative to the demand for loans) decreases the probability for banks to find a firm, while it increases the probability for the firm to find a bank. We define the matching probability for firms as $p(\theta)$, such that $p'(\theta) > 0$ since the availability of credit increases the firm's probability of forming a match. Similarly, the matching probability for banks is equal to $q(\theta)$, such that $q'(\theta) < 0$.[3] Moreover, we assume that firms' matching probability is strictly concave, $p''(\theta) < 0$, while banks' matching probability is weakly convex, $q''(\theta) \geq 0$, as is the case in standard matching function specifications such as Cobb-Douglas and CES under common parameter restrictions. Matching happens in period 1 and credit market tightness is known to the bank and firm.

Upon forming a match, the interest rate on the loan $r_{i,t}$ splits the joint surplus of matching that accrues to the firm and the bank. The interest rate is set according to Nash bargaining, as we describe after defining the joint surplus.

**Frictionless credit markets.** We begin by deriving the equilibrium in the economy with a frictionless credit market, where the firm and the bank can form a relationship in each period at no cost. Firms and banks maintain relationships that yield a positive surplus that requires positive profits. The surplus for the firm comprises the income from the profits in each two periods, net of the costs for the loan, amounting to $\pi(z_{i,1}, A_1, f) - r_{i,1}$ for the first period, and $\pi(z_{i,2}, A_1, f) - r_{i,2}$ for the second period. The surplus for the bank comprises the income from the interest rate paid by the firm over the initial period: $r_{i,1}$.[4] Thus, the total surplus of the match is equal to $\pi(z_{i,1}, A_1, f)$ in the first period. To obtain an analytical solution for the productivity threshold that defines mutually profitable relationships associated with a non-negative total surplus, we assume that output is equal to productivity net of the fixed cost, $\pi(z_i, A_t, f) = z_i A_t - f$.[5] Thus, the threshold of idiosyncratic productivity below which a firm will decide to terminate production

[3] These properties of the matching function imply $\theta q(\theta) = p(\theta)$, the standard assumption in the search literature, which we maintain in the numerical illustration presented in Section 2.1.

[4] Without loss of generality, the determination of the interest rate becomes irrelevant for this frictionless economy.

[5] Without loss of generality we assume this function to be $\pi(z_{i,t}, A_t, f) = z_{i,t} A_t - f$. As we show in Appendix A, this production function arises in a firm dynamics framework, as in Melitz (2003); Bilbiie et al. (2012); Hamano and Zanetti (2017). Alternative production functions with $\frac{\partial \pi}{\partial z_i} > 0$ and $\pi_i \in [-f, \infty)$ have the same implications.

in the first period is equal to:[6]

$$\tilde{z}_{\text{no frictions},1} = \frac{f}{A_1}. \tag{1}$$

Equation (1) shows that the productivity threshold consistent with a non-negative joint surplus is equal to the effective fixed costs (i.e., the fixed cost in units of aggregate productivity) in the frictionless economy. The intuition is straightforward: The bank provides the loan to the firm whose productivity is sufficiently high to cover the fixed costs of production, which ensures that the firm operates with non-negative profits. Unlike the frictional credit market that we consider in the next paragraph, the firm and bank only consider the current period in setting the threshold of productivity since the formation of a relationship is costless.

**Frictional credit markets.** We now consider an economy with search frictions between firms and banks in the credit market. As in the frictionless economy, the firms and banks establish a loan whenever the joint surplus from the match is non-negative. The frictions in the credit market are relevant to determine the threshold of idiosyncratic productivity. The joint surplus of maintaining a match is the sum of the value of the match for the firm and the bank, but it also accounts for the respective opportunity cost (or outside option) of remaining unmatched.[7] To obtain an analytical expression for the threshold of idiosyncratic productivity, we need to consider the value of being in and out of a financial relationship between firms and banks. We start by defining the value functions for the firm and the bank that constitute the joint surplus and then derive the threshold of idiosyncratic productivity in the frictional credit market that generates a non-negative joint surplus.

The value of a firm-bank match, $v^m_{1,i}$, equals:

$$v^m_{1,i} = \pi(z_{i,1}, A_1, f) - r_{i,1} + \beta E(\pi(z_{i,2}, A_2, f) - r_{i,2}), \tag{2}$$

which is the sum of the discounted profits net of the interest paid to the bank for staying in the match for periods one and two. Importantly, if a loan is not agreed upon in the first period,

[6] A similar condition holds for the cutoff level productivity in the second period.

[7] We assume that if a firm-bank relationship terminates in period 1, the firm ceases to exist. Its equity holders then enter the credit market to search for a new banking match in period 2, and establish a new firm if the match is successful.

the firm ceases to operate. Its equity holders then exit to the credit market, redeploying their resources into a new match in the second period. This outside option pins down the equity holders' continuation value when deciding whether to maintain an unprofitable lending relationship. The value of an unmatched (idle) firm is equal to:

$$v_{1,i}^u = \beta p(\theta) E(\pi(z_{i,2}, A_2, f) - r_{i,2}), \tag{3}$$

where the unmatched firm gains zero payoffs in period one but finds a bank with probability $p(\theta)$ and earns the discounted profits $\beta(\pi(z_{i,2}, A_2, f) - r_{i,2})$ in period 2. The value of a loan for the bank ($v_{1,i}^l$) is equal to:

$$v_{1,i}^l = r_{i,1} + \beta E(r_{i,2}), \tag{4}$$

which is the sum of the interest rates earned by the bank in periods one and two. The value of an unmatched bank is equal to:

$$v_{1,i}^\pi = \max\{-\kappa + q(\theta)\beta E(r_{i,2}), 0\}, \tag{5}$$

where the unmatched bank posts a loan offer at the cost $\kappa$ in the first period, and finds a firm with probability $q(\theta)$ that pays the interest rate $r_{i,2}$ in the second period. For simplicity, we assume $q(\theta)\beta E(r_{i,2}) > \kappa \geq 0$ holds, and $\kappa$ is the same across banks.

The interest rate splits the profits of production between the firm and the bank and is set according to the Nash bargaining rule. The bargaining weight for the firm is $\eta \in (0, 1)$ and the bargaining weight for the bank is $1 - \eta$. In the second period, the firm and bank split the value of production according to Nash bargaining, and therefore the interest rate is equal to the share of profits accruing to the bank that are equal to: $r_{i,2} = (1 - \eta)\pi(z_{i,2}, A_2, f)$.[8] Zombie lending arises from the draw of new productivity that may enhance the profits of currently unprofitable firms, encapsulated by the assumption that the expected profits are positive in the second period (i.e., $E(\pi(z_{i,2}, A_2, f)) > 0$).[9]

[8] Though not necessary for our results, we can also solve for the first-period interest rate $r_{i,1} = (1 - \eta)\pi(z_{i,1}, A_1, f) - \eta\kappa + \eta(1 - \eta)\beta(q(\theta) - p(\theta))E(\pi(z_{i,2}, A_2, f))$.

[9] This assumption is consistent with firms operating in a monopolistically competitive goods market with stochastic and non-autoregressive productivities in equilibrium. The assumption captures the idea that, though the current profit of a firm could be negative, the expected present discounted value of the future profits is positive, which is

The joint surplus from forming a match ($v^s_{1,i}$) is equal to:

$$v^s_{1,i} = \underbrace{(v^m_{1,i} - v^u_{1,i}(\theta))}_{\text{Firm Surplus}} + \underbrace{(v^l_{1,i} - v^\pi_{1,i}(\theta))}_{\text{Bank Surplus}} \tag{6}$$

$$= \pi(z_{i,1}, A_1, f) + \beta E(\pi(z_{i,2}, A_2, f)) + \kappa - \beta E(\pi(z_{i,2}, A_2, f))[q(\theta)(1-\eta) + p(\theta)\eta]. \tag{7}$$

Equation (6) shows that the outside options for the firm and bank, $v^u_{1,i}(\theta)$ and $v^\pi_{1,i}(\theta)$, respectively, are critical to the effect of credit market tightness on the total surplus. Equation (7) is derived by substituting the value functions $\{v^m_{1,i}, v^u_{1,i}, v^l_{1,i}, v^\pi_{1,i}\}$ in equation (6) using equations (2)-(5) and the Nash bargaining rule for the interest rate.

Equation (7) shows that the joint surplus of forming a lending relationship is equal to the sum of the profits in the two periods, plus the saving of search costs accruing to the bank if the match is preserved (represented by the term $\kappa$ in the equation). It is reduced by the expected profits of the firm and bank in the second period, which depends on the tightness in credit markets. The latter term represents the outside options for the firm and bank of leaving the current lending relationship and obtaining credit by forming a new match.

By setting the joint surplus equal to zero, we derive the threshold of productivity. Firms with idiosyncratic productivity above the threshold generate positive profits from the match; otherwise, the match is unprofitable. To obtain an analytical solution for the threshold, we assume, as in the frictionless economy, that the output is equal to $\pi(z_{i,t}, A_t, f) = z_{i,t}A_t - f$, and we derive the productivity threshold by setting the total surplus equal to zero ($v^s_{1,i} = 0$), yielding:[10]

$$\tilde{z}_{\text{frictions},1} = \frac{f - \kappa - \beta E\left\{\pi(z_{i,2}, A_2, f)[1 - (1-\eta)q(\theta) - \eta p(\theta)]\right\}}{A_1}. \tag{8}$$

Equation (8) shows that search frictions exert two distinct forces on the threshold of idiosyncratic productivity compared to the frictionless economy in equation (1). First, the *search costs* ($\kappa$) decrease the productivity threshold since the bank is prepared to match with a firm with a low

needed for the firm to desire continued operation. We empirically demonstrate in Appendix E that zombie firms hold positive expectations about future profits.

[10]Because there is no third period, the cutoff level productivity in the second period becomes the same as the one found in the frictionless economy.

productivity level to avoid a costly search. Thus, search costs generate zombie firms by lowering the threshold of idiosyncratic productivity compared to the case of the frictionless economy.

Second, the different *opportunity costs* for the bank and firm to forgo the match move the threshold in opposite directions. For the bank, the opportunity cost of being unmatched increases with tightness in the credit market, since high credit availability reduces the probability for the bank to find a loan-seeking firm. Therefore, the bank optimally decreases the required idiosyncratic productivity to increase the probability of matching. This effect is represented by the term $(1-\eta)\pi(z_{i,2}, A_2, f)q(\theta)$ (recall $q'(\theta) < 0$), thereby capturing the decrease in the share of profits accruing to the bank with tightness in the credit market. For the firm, the opportunity cost of not being in a loan contract decreases with tightness in the credit market since credit abundance increases the probability of finding credit in the next period when the firm receives a new draw of idiosyncratic productivity. This second effect is captured by the term $\eta\pi(z_{i,2}, A_2, f)p(\theta)$ (recall $p'(\theta) > 0$), which shows that the share of profits accruing to the firm increases with tightness in the credit market. Thus, the opportunity costs for the firm and the bank exert opposing forces on the threshold value, generating a non-monotonic relationship between the threshold of idiosyncratic productivity and tightness.[11]

To derive analytical solutions and formulate testable implications for the effect of financial frictions on the share of zombie firms, we normalize aggregate productivity to 1 ($A_1 = A_2 = 1$) and assume independence between aggregate productivity and tightness in the credit market.[12] With these simplifying assumptions, the expectations of the firm's profits are constant and we label them $\bar{\pi}_2$

[11] It is straightforward to verify that the threshold of idiosyncratic productivity in equation (8) nests the value in the frictionless economy in equation (1) once we remove financial frictions by setting $\kappa = 0$ and $q = p = 1$.

[12] As shown in Appendix A.4, the results hold when we relax this assumption, although at the expense of involved analytical results. Also in Appendix E we empirically examine the relationship between productivity and the credit market tightness.

to ease notation.[13] In our new notation, the productivity threshold in equation (8) is:

$$\tilde{z}_{\text{frictions},1} = f - \kappa - \beta\bar{\pi}_2[1 - (1-\eta)q(\theta) - \eta p(\theta)]. \tag{9}$$

The next proposition summarizes the differences in the threshold of idiosyncratic productivity between the frictional and frictionless credit markets.

**Lemma 1** (Productivity thresholds in frictional and frictionless credit markets)**.** *The threshold of idiosyncratic productivity required for the firm to obtain a loan in frictional credit markets is lower than the threshold of idiosyncratic productivity in the frictionless credit market that ensures non-negative profits. Search frictions allow low-productivity firms with negative profits to receive credit and produce.*

*Proof.* Direct implication from $\tilde{z}_{\text{no frictions}} > \tilde{z}_{\text{frictions}}$, as implied by equations (1) and (9). Because $q(\theta)$ and $p(\theta)$ are between 0 and 1, $\pi(z_{i,1}) < 0 \ \forall \ z_{i,1} = \tilde{z}_{\text{frictions}}$. □

Lemma 1 implies that zombie firms arising from the frictional credit market generate zombie lending in equilibrium, as their productivity is below the level required to generate positive profits.

**Interest Rate Subsidies and Zombie Lending.** The divergence between the frictional and frictionless productivity thresholds provides the theoretical foundation for our empirical measurement of zombie firms. Consider a firm with productivity $z_{i,1}$ that falls below the frictionless threshold but above the frictional threshold ($z_{i,1} \in [\tilde{z}_{frictions,1}, \tilde{z}_{nofrictions,1})$). This firm generates negative current profits. To prevent the firm from exiting and destroying the relationship's continuation value, the bank must concede a low interest rate. Using the Nash bargaining protocol, the first-period interest payment for such a firm is heavily discounted, evaluating to $r_{i,1} \leq -\kappa - (1-\eta)\beta(1-q(\theta))E(\pi(z_{i,2}, A_2, f)) \leq 0$ at the cutoff. Because the interest payment is strictly increasing in current productivity, firms in this intermediate productivity range receive

[13] The survival of the firm across the two periods relies on $\bar{\pi}_2 > 0$, such that firms that have negative profits in the first period have expectations of positive profits in the second period. This assumption is satisfied in the model, as the domain of idiosyncratic productivity is $R^+$. We show in Appendix E that the expectation of positive profits is empirically validated. At the end of this subsection, we discuss the relevance of productivity persistence for the results.

an implicit interest rate subsidy from the bank to sustain operations. This endogenous subsidy perfectly maps our search-friction mechanism to standard empirical characterizations of zombie lending, which identify zombies via below-market interest payments (e.g., Caballero et al., 2008; Fukuda and Nakamura, 2011; McGowan et al., 2017).

**Zombie firms, credit market tightness, and bargaining power.** The model allows us to study the extent to which the share of zombie firms is determined by: (i) the tightness in the credit markets ($\theta$), and (ii) the bargaining power of firms ($\eta$).

Credit market tightness is critical to the firm's productivity threshold since it determines the matching probabilities and therefore the incentives for the bank and firm to form a credit relationship. The effect of a change of credit market tightness on the threshold of idiosyncratic productivity ($\tilde{z}_{\text{frictions}}$) is equal to:[14]

$$\frac{\partial \tilde{z}_{\text{frictions}}}{\partial \theta} \begin{cases} < 0, & \text{if } \eta p'(\theta)\bar{\pi}_2 < -(1-\eta)q'(\theta)\bar{\pi}_2 \;\; \Rightarrow \text{Zombie share increases in } \theta, \\ > 0, & \text{if } \eta p'(\theta)\bar{\pi}_2 > -(1-\eta)q'(\theta)\bar{\pi}_2 \;\; \Rightarrow \text{ Zombie share decreases in } \theta, \end{cases} \tag{10}$$

where $\bar{\pi}_2 > 0$, $q(\theta) > 0$, $p'(\theta) > 0$ and $q'(\theta) < 0$.

Condition (10) shows that the relative change in the probabilities of forming a relationship for the firm and bank determines the effect of tightness in financial markets on the threshold of idiosyncratic productivity. An increase in credit market tightness leads to a reduction in the threshold when the bank's incentive to maintain financial relationships with low-productivity firms –so as to avoid search costs– dominates the firm's incentive to terminate unprofitable credit relationships (top inequality in condition 10). In this case, the share of zombie firms in the economy increases.

As tightness rises and credit becomes more abundant, firms' search costs decline, and the threshold of idiosyncratic productivity increases, since low-productivity firms choose to forgo current costly credit relationships in anticipation of a higher productivity draw in the next period. When credit

[14] The condition is obtained by differentiating equation (9) with respect to credit market tightness. When the productivity threshold increases the share of zombie firms decreases.

market tightness is sufficiently high (i.e., credit is abundant), the incentives for firms to terminate unprofitable relationships outweigh the opposing force from banks that have incentives to lower the threshold of idiosyncratic productivity to avoid search costs (bottom inequality in condition 10); therefore, the share of zombie firms declines.

The next proposition characterizes the effect of credit market tightness on the share of zombie firms.

**Proposition 1** (Credit market tightness and the share of zombie firms)**.** *Credit market tightness has an inverted U-shaped relationship with the share of zombie firms. An increase in credit market tightness has two opposing effects on the share of zombie firms: (i) it provides incentives to the bank to lower the threshold of productivity to forgo the high search costs, raising the share of zombie firms, and (ii) it decreases the search costs for firms and provides incentives for them to forgo a current unprofitable match in anticipation of receiving a new draw of high idiosyncratic productivity, decreasing the share of zombie firms.*

*Proof.* Differentiating condition (10) with respect to $\theta$ and evaluating the second-order condition confirms the existence of a unique interior maximum, establishing the inverted U-shaped relationship. □

Condition (10) also shows that bargaining power is critical to changes in the share of zombie firms in response to tightness in credit market. The next Corollary 1 establishes the link between bargaining power and the share of zombie firms, and Proposition 2 formalizes the interplay between credit tightness and the bargaining power, which we will test in the data.

**Corollary 1.** (Bargaining power and the share of zombie firms). *The increase in the firm's bargaining power decreases the share of zombie firms when the probability of forming a match for the firm is higher than the probability for the bank (i.e., $p(\theta) > q(\theta)$). Otherwise, the share of zombie firms increases.*

*Proof.* Differentiating the threshold of idiosyncratic productivity in condition (10) with respect to the bargaining power yields:

$$\frac{\partial \tilde{z}_{\text{frictions}}}{\partial \eta} \begin{cases} > 0, & \text{if } p(\theta) > q(\theta) \Rightarrow \text{Zombie share decreases in } \eta, \\ < 0, & \text{if } p(\theta) < q(\theta) \Rightarrow \text{Zombie share increases in } \eta. \quad \square \end{cases} \tag{11}$$

The intuition from Corollary 1 is straightforward. In a credit market with abundant credit, firms face low search costs while banks face high search costs. When the matching probability is higher for the firm than the bank, the firm incentives to forgo unprofitable relationships prevail over the bank incentives of retaining unprofitable relationship to avoid search costs (top inequality in condition 11). In this case, an increase in the firm's bargaining power decreases the share of zombie firms.

The next proposition shows that the effect of an increase in credit market tightness on the threshold of idiosyncratic productivity is proportional to the level of the firm's bargaining power.

**Proposition 2.** (Interplay between bargaining power and tightness for the share of zombie firms). *An increase in the level of bargaining power magnifies the increase of the threshold of idiosyncratic productivity resulting from the change in credit market tightness.*

*Proof.* Direct implication from differentiating condition (11) with respect to tightness:

$$\frac{\partial^2 \tilde{z}_{\text{frictions}}}{\partial \eta \partial \theta} > 0 \quad \text{since} \quad p'(\theta) - q'(\theta) > 0. \quad \square \tag{12}$$

Proposition 2 underpins our empirical test aimed at establishing the relevance of bargaining power for the relationship between tightness and the share of zombie firms. In particular, we test whether an increase in credit market tightness exerts a higher decrease in the share of zombie firms in industries with high bargaining power compared to industries with low bargaining power.

**Productivity persistence.** We now relax the assumption of fixed firm productivity and show that the share of zombie firms increases with lower productivity persistence.

We introduce persistence in the fundamentals of firms by assuming that the expected profit in the second period is a weighted average of the profits in periods 1 and 2 with the weight on productivity on profits in period 1 representing the degree of persistence of fundamentals. Concretely, we assume: $E[\pi(z_{i,2}, f)] = \rho\pi_1(z_{i,1}) + (1-\rho)\bar{\pi}_2$, where $\rho$ is the degree of persistence of the second-period profits to remain the same as the first-period profits. Appendix A.5 shows that this assumption yields the productivity threshold:

$$\tilde{z}^{\rho}_{\text{frictions},1} = \frac{f - \kappa - \beta[\bar{\pi}_2(1-\rho) - \rho f]\,[1-(1-\eta)q(\theta) - \eta p(\theta)]}{1 + \rho\beta\,[1-(1-\eta)q(\theta) - \eta p(\theta)]}. \tag{13}$$

Equation (13) shows that the persistence parameter increases the threshold level of productivity ($\tilde{z}^{\rho}_{\text{frictions},1}$), and when productivity has no persistence (i.e., $\rho \to 0$) the threshold becomes the same as in the benchmark model in equation (9), such that $\tilde{z}^{\rho}_{\text{frictions},1} \geq \tilde{z}_{\text{frictions},1}$. The next proposition formalizes the result. In Section 3.4, we will show that productivity persistence is low in Japan, providing empirical support to our mechanism and the relevance of zombie firms.

**Proposition 3** (Productivity persistence and the threshold of idiosyncratic productivity)**.** *A fall in productivity persistence lowers the threshold of idiosyncratic productivity, thereby raising the share of zombie firms.*

*Proof.* See Appendix A.5 □.

We will test Proposition 3 in Section 3.4.

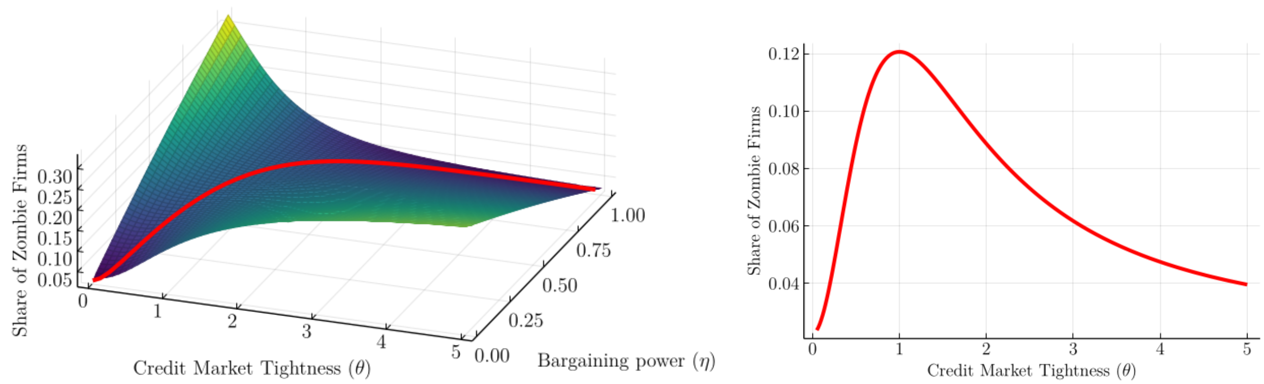
## 2.1. A numerical quantification

We illustrate the relevance of our mechanism using a calibrated version of our parsimonious model. We assume the constant elasticity of substitution (CES) matching function: $\mu V/(1+\theta^l)^{\frac{1}{l}}$, where $V$ is the number of loans offered by banks to firms.[15] The matching probabilities for the firm and bank are given by: $p(\theta) = \theta(1+\theta^{\zeta})^{-1/\zeta}$ and $q(\theta) = (1+\theta^{\zeta})^{-1/\zeta}$, respectively. We calibrate the parameter $\zeta$ to the conventional value of 0.5 and set $\eta = \theta^l/(1+\theta^l)$ such that the equilibrium satisfies the Hosios (1990) condition.[16] We assume a standard Pareto distribution for

[15] Appendix A shows that our results continue to hold with the standard Cobb-Douglas matching function.

[16] For a CES matching function this strictly speaking introduces another dimension where bargaining power is as well a function of tightness. Appendix A shows that this assumption only strengthens the U-shaped relationship.

the idiosyncratic productivity shocks with cumulative distribution function: $G(z_{i,t}) = (\underline{z}/z_{i,t})^k$, where $\underline{z}$ is the lower cutoff of the distribution and $z_{i,t} > \underline{z}$. This standard assumption for the distribution of firm productivity allows us to derive the closed-form solution for the share of zombie firms equal to $1 - (z_s/z_{zo})^k$, where $z_{zo}$ is the threshold of idiosyncratic productivity in the frictionless credit markets (determined by equation 1) and $z_s$ is the threshold of idiosyncratic productivity in the frictional credit markets (determined by equation 9). We set the distribution parameter $k$ equal to 3.4 to replicate the standard deviation of the firm turnover (see Ghironi and Melitz, 2005; Bilbiie et al., 2014; Hamano and Zanetti, 2017, 2022). We set the discount factor $\beta$ to the standard value of 0.99, the cost of posting a loan $\kappa$ to 0.01, and the fixed cost of production $f$ to 1.5.[17] In Figure 1, we consider values for credit market tightness and bargaining power within ranges $\theta \in [0.01, 5]$ and $\eta \in [0.01, 0.99]$.




**(a)** Zombie share, credit market tightness, and bargaining power.

**(b)** Zombie share and credit market tightness under the Hosios condition.

**Figure 1:** Numerical illustration of the share of zombie firms

*Notes:* Shown in Figure (a) are the zombie share (z-axes) against credit market tightness ($\theta$, x-axes) and the firm's bargaining power ($\eta$, y-axes) under a CES matching function. The red line shows the share of zombie firms when the Hosios (1990) condition holds. Shown in Figure (b) is the share of zombie firms under the Hosios condition.

Figure 1a shows the variation in the share of zombie firms (z-axes) with respect to credit market tightness ($\theta$, x-axes) and the firm's bargaining power ($\eta$, y-axes). The red line shows the points that satisfy the Hosios condition (presented individually in Figure 1b). As with Proposition 1, the increase in credit tightness significantly raises (decreases) the share of zombie firms for the levels of tightness that satisfy condition (10). As with Corollary 1, the share of zombie firms

[17] These values are chosen to generate positive expected profits in the second period.

increases with tightness when firm bargaining power is low, and decreases with tightness when firm bargaining power is high. As with Proposition 2, the share of zombie firms decreases as firm bargaining power increases, for a given level of tightness. Figure 1b shows the variation in the share of zombie firms and credit market tightness under the Hosios condition. The figures show a significant inverted U-shaped relationship between credit market tightness and the share of zombie firms.

The numerical simulations show that the theoretical predictions are quantitatively impactful. The next section empirically tests the theoretical predictions using industry-level data from Japan.

# 3. Empirical analysis

This section begins by introducing the data and constructing our variables of interest: zombie ratio, credit market tightness (defined as the loan supply-to-demand ratio, so that higher values reflect more abundant credit), productivity, and firm bargaining power (Section 3.1). We then test the key predictions of our theory. From Proposition 1, we study the inverted U-shaped relationship between the share of zombie firms and credit market tightness (Section 3.2). From Proposition 2, we investigate the extent to which high firm bargaining power reduces the share of zombie firms in response to increases in credit market tightness (Section 3.3). From Proposition 3, we show that low productivity persistence decreases the share of zombie firms (Section 3.4). Finally, we test Proposition 1 using firm-level data and show that firm exposure to capital injections is associated with greater reductions in the share of zombie firms in industries that faced tight credit markets during the Japanese crisis of the late 1990s and early 2000s (Section 3.5).

## 3.1. Data

Our main variables of interest are measures of zombie firms, credit market tightness, productivity persistence, and bargaining power. We construct model-implied measures for these variables by combining data from several sources across 31 industries in Japan over 2000–2019.[18]

[18]Appendix C provides a detailed discussion of the data sources for these variables. Since the Demand for Loans DI data –crucial for constructing credit market tightness measures– begin in 2000, our sample period starts from

**Zombie ratio.** Our theoretical model demonstrates that search frictions induce banks to offer below market interest rates (effectively an interest subsidy) to retain currently unprofitable firms that possess positive expected future continuation values. Therefore, identifying zombie firms empirically requires a measure that captures this specific pricing behavior, rather than mechanical classifications based solely on ex post profitability or raw interest coverage ratios. To tightly align our empirical analysis with our model's predictions, we adopt the interest subsidy criterion developed by Caballero et al. (2008) (CHK henceforth). This measure classifies a firm as a zombie if its annual interest payments fall below a theoretical lower bound market interest cost. By focusing on the bank's pricing concessions, the CHK measure serves as the direct empirical counterpart to the subsidised Nash bargained interest rates that sustain low productivity matches in our frictional credit market framework.

Accordingly, consistent with our theoretical framework, we construct the share of zombie firms ($\texttt{ZombieRatio}_{jt}$) for industry $j$ in period $t$ using the Nikkei Financial Quest database, which provides annual financial statements of listed firms in Japan, and classify zombie firms at the firm level $i$ using the criterion from Caballero et al. (2008) (CHK hereafter).The lower bound on interest payments is given by:

$$R^*_{i,t} = rs_{t-1} BS_{i,t-1} + \left( \frac{1}{5} \sum_{k=1}^{5} rl_{t-k} \right) BL_{i,t-1} + rcb_{\text{min over last 5 years},t} \times Bonds_{i,t-1}, \tag{14}$$

where $BS_{i,t-1}$, $BL_{i,t-1}$, and $Bonds_{i,t-1}$ are short-term bank loans (less than one year), long-term bank loans (more than one year), and total bonds outstanding (comprising convertible and warrant-attached bonds), respectively, for firm $i$ at the end of year $t-1$; and $rs_t$, $rl_t$, and $rcb_{\text{min over last 5 years},t}$ are the average short-term prime rate in year $t$, the average long-term prime rate in year $t$, and the minimum coupon rate on any convertible corporate bond issued in the last five years before $t$, respectively. We classify as zombie firms those whose annual interest payments–recorded in their profit and loss statements–fall below $R^*_{i,t}$ as defined in equation (14). Aggregating firms' zombie status at the industry level, we construct the industry-level share of

that year.

zombies using the classification in the Nikkei dataset.[19]

**Credit market tightness.** We construct model-implied measures of credit market tightness from the bank's perspective, such that higher credit market tightness corresponds to more abundant credit; empirically, we proxy this concept by the difference between loan supply and loan demand. Loan demand data come from the Loan Survey or the Tankan Survey, and loan supply data come from the Tankan Survey; both surveys are administered by the Bank of Japan.[20] We construct industry-level credit market tightness measures using the classification of the Bank of Japan and convert them into the measures based on the Nikkei industry classification. We construct two indices of credit market tightness. The first index for industry $j$ in year $t$ –that we refer to as `Tightness1`– is defined as follows:

$$\texttt{Tightness1}_{j,t} = \text{Lending Attitude DI}_{j,t} - \text{Demand for Loans DI}_{j,t},$$

where the Lending Attitude Diffusion Index (DI) is from the Tankan Survey and the Demand for Loans DI is from the Loan Survey. The Lending Attitude DI and Demand for Loans DI reflect conditions in the entire Japanese economy, and the DI scales are consistent between the two surveys.[21]

Our second index of credit market tightness –that we refer to as `Tightness2`– is defined as follows:

$$\texttt{Tightness2}_{j,t} = \text{Lending Attitude DI}_{j,t} - \text{Financial Position DI}_{j,t},$$

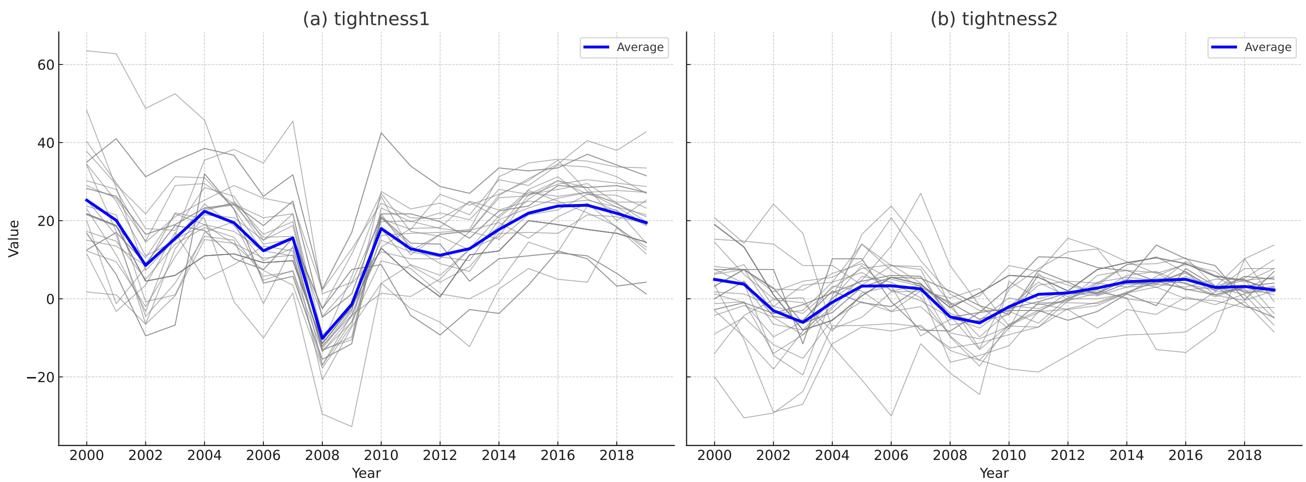
where the Lending Attitude DI and the Financial Position DI are from the Tankan Survey. The index `Tightness1` is our preferred measure since the Demand for Loans DI from the Loan Survey accurately measures firms' demand for loans. The Financial Position DI from the Tankan Sur-

[19] Appendix B shows the economy average and industry-level shares of zombie firms.

[20] The information collected by the Bank of Japan's Loan Survey and used for the Demand for Loans Diffusion Index (DI) is similar to the information reported in the Senior Loan Officer Opinion Survey (SLOOS) conducted by the Federal Reserve Board in the US. The Tankan Survey is a short-term economic survey of enterprises conducted quarterly. See Appendix C for details on both surveys.

[21] See Appendix C for definitions of the Diffusion Indexes (DIs). Both the Loan Survey and the Tankan cover representative bank and firm activities in Japan; the former surveys bank loan officers, while the latter surveys firms potentially seeking bank loans. Therefore, subtracting one DI from the other is appropriate for constructing our credit market tightness measure.

vey is a broader indicator that measures companies' assessment of their own cash management conditions.[22] We convert the series to annual frequency to align with the annual frequency of the zombie ratio series. The thick lines in panels (a) and (b) of Figure 2 show aggregate measures of `Tightness1` and `Tightness2`, respectively, across 31 industries over 2000–2019. We observe a small drop in 2003 and a large decline in 2008 for `Tightness1`. Similarly, for `Tightness2`, we observe two small decreases: one during 2002–2003 and another during 2008–2009. The thin lines in panels (a) and (b) of Figure 2 show industry-level measures of `Tightness1` and `Tightness2`, respectively, across the 31 industries. The data show substantial dispersion in both tightness measures across industries, allowing us to study their impact on zombie firm prevalence in our empirical analysis.




*Notes:* Time series for the cross-industry series (thin lines) and economy-wide average (thick line) for `Tightness1` (panel a) and `Tightness2` (panel b). The data cover 31 industries over 2000-2019.

**Figure 2:** Time series plot for alternative credit market tightness (`Tightness1` and `Tightness2`)

**Productivity at the industry level.** To control for the firm performance at the industry level in the estimations, we construct a measure of the productivity from two vintages of the Japan Productivity Database, `JIP2014` and `JIP2023`, which covers the period of 1970-2011 and 1994-2020, respectively. For our analysis we employ `JIP2014` for 2000-2011 and `JIP2023` for 2012-2019. We obtain a measure of nominal labor productivity from the ratio of nominal value added produced in industry $j$ to labor-hours in the same industry. We include this control to isolate

[22] The Demand for Loans DI primarily contains information on loan demand. The Financial Position DI reflects firms' judgments on three different aspects of their financing: the level of liquidity holdings, the lending attitude of financial institutions, and the terms and conditions of financing, some of which are unrelated to loan demand.

the impact of credit market tightness from fundamental improvements in industry performance, which mechanically reduce the share of zombie firms by boosting profits and interest coverage ratios.

**Firms' bargaining power.** Our model defines bargaining power as the firm's outside option in the credit market, i.e., the ability to switch lenders without incurring substantial search costs. We proxy for a firm's bargaining power with loan concentration, since it directly maps onto our theoretical concept: firms borrowing from multiple banks can credibly threaten to reallocate borrowing, while firms dependent on a single lender face a bilateral monopoly. This interpretation is well established in the banking literature (Sharpe, 1990; Rajan, 1992; Ongena and Smith, 2000), and is consistent with the Nash bargaining protocol in our model.[23]

We use information on the outstanding amount of bank loans to listed firms from the Nikkei Financial Quest database, and calculate each bank's share of total loans to the firm and measure the bargaining power of each firm $i$ with banks ($\texttt{BP}_{it}$) by constructing the concentration of bank loans for the firm using the Herfindahl-Hirschman Index (HHI):

$$\text{BP}_{it} = 1 - HHI_{it} = 1 - \sum_{b=1}^{B} \left( \frac{loan_{ibt}}{loan_{it}} \right)^2,$$

where $loan_{ibt}$ is the amount of loans outstanding at end of year $t$ extended by bank $b$ to firm $i$, and $loan_{it}$ is the total amount of loans outstanding at end of year $t$ extended to firm $i$. If a firm transacts exclusively with one bank that holds a 100 percent share, the HHI is equal to one. This indicates that the firm will incur search costs to change banks and that bargaining most closely resembles the ideal case of a bilateral monopoly. In these cases we expect the firm holds comparatively less bargaining power with the bank than in cases where the firm is matched

[23]While financial distress may affect loan concentration by reducing the *volume* of total credit, our measure captures the *distribution* of borrowing across lenders that is consistent with the notion of firm bargaining power. To ensure that our results are not driven by distressed firms mechanically losing access to multiple banks, we conduct several checks. First, we show that our bargaining power measure is only weakly correlated with standard indicators of financial distress, such as interest coverage ratios and leverage. Second, our baseline results are robust to controlling for firm- and industry-level productivity and profitability. Third, the interaction between credit market tightness and bargaining power remains statistically and economically significant even when we exclude firms in the lowest decile of performance. Taken together, these findings suggest that our bargaining power measure captures variation in firms' outside options rather than distress-induced credit rationing.

with multiple banks. Thus, if a firm borrows funds from several banks, the HHI is low and approaches zero as the number of banks increases. In this scenario, the firm can without search turn to a competitor, granting the firm higher bargaining power with the banks. To construct an industry-level indicator that is positively correlated with the firm's bargaining power, we use the complement of the $HHI_{it}$ (i.e., $1 - HHI_{it}$) aggregated at the industry level.[24]

## 3.2. Credit market tightness and zombie firms

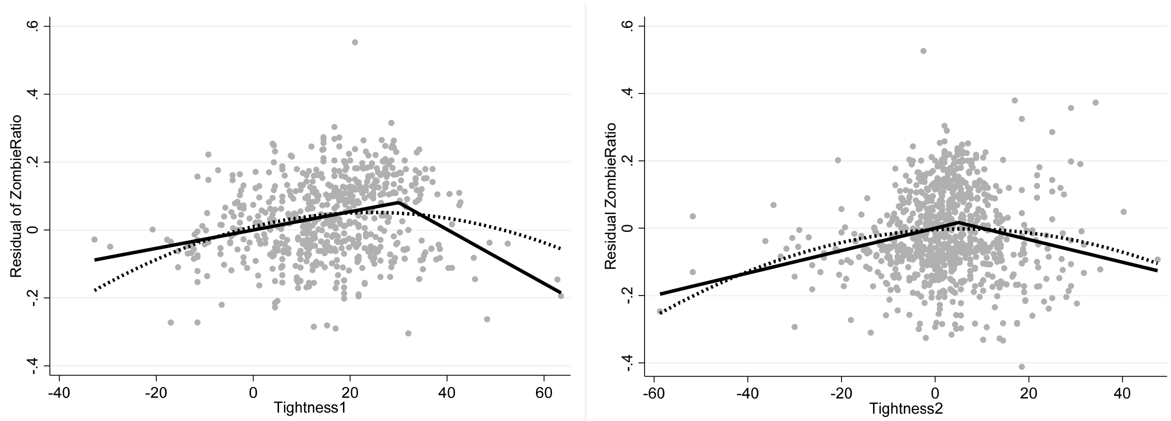
In this section, we test the first prediction regarding the inverted U-shaped relationship between the share of zombie firms and credit market tightness.

**Preliminary evidence.** Figure 3 shows the scatterplot of the share of zombie firms and our measures of credit market tightness `Tightness1` (left panel) and `Tightness2` (right panel), fitting a quadratic polynomial (dotted line) and a kinked line (solid line). Since our measures of credit market tightness are constructed from the bank's perspective, higher values capture greater credit abundance. The fitted lines show an inverted U-shaped relationship between credit market tightness and the share of zombie firms, consistent with the model's prediction that the zombie share initially rises with credit market tightness and subsequently declines beyond a threshold level. We test the relationship empirically using the two alternative econometric approaches based on: (i) threshold, and (ii) quadratic regression models.

**Threshold regression model.** To test the inverted U-shaped relationship and the non-monotonicity between credit market tightness and the share of zombie firms, we estimate the following threshold regression model:

$$\texttt{ZombieRatio}_{jt} = \beta_0 + \beta_1 \theta_{jt} + \beta_2 (\theta_{jt} - \theta^*) \times I(\theta_{jt} > \theta^*) + \beta_3 A_{jt} + \phi_j + \varepsilon_{jt}, \quad (15)$$

[24] Sharpe (1990) and Rajan (1992) show that when a firm transacts with only one bank, the bank gains monopoly power, which worsens the firm's financing environment. These studies also demonstrate that the problems caused by this monopoly power can be mitigated by transacting with multiple banks. Ongena and Smith (2000) focus on the number of banks with which a firm transacts and examine the determinants of bank relationships in European countries. Bank monopoly power can be more accurately measured using the Herfindahl-Hirschman Index (HHI), which accounts for each bank's loan share, rather than simply counting the number of banks. For this reason, we use the HHI based on each financial institution's share of a firm's borrowing as a proxy for bargaining power.




*Notes:* The left panel shows the scatter plot for credit market tightness (`Tightness1`) and the share of zombie firms (`ZombieRatio`), after controlling for other determinants, along with fitted quadratic (dotted line) and kinked (solid line) polynomials. The right panel shows the scatter plot for our alternative measure of credit market tightness (`Tightness2`) and the share of zombie firms (`ZombieRatio`), after controlling for other determinants, along with fitted quadratic (dotted line) and kinked (solid line) polynomials.

**Figure 3:** Credit market tightness and share of zombie firms

where $\texttt{ZombieRatio}_{jt}$ is share of zombie firms, $\theta_{jt}$ is credit market tightness (measured by one of our variables, either `Tightness1` or `Tightness2`), $\theta^*$ is the threshold value for credit market tightness, $A_{jt}$ is the labor productivity, $\phi_j$ is the industry-specific effect, and $\varepsilon_{jt}$ is the error term. We select the threshold value of credit market tightness ($\theta^*$) that generates the highest fit of the regression and is within the range of values for tightness in our sample.[25] Our baseline specifications include industry fixed effects ($\phi_j$) and time-varying industry-level productivity controls ($A_{jt}$).

We test the inverted U-shaped relationship between the zombie ratio and credit market tightness from the values of the parameters $\beta_1$ and $\beta_2$. To validate empirically the inverted U-shaped relationship between credit market tightness and the share of zombie firms we need a positive estimate for $\beta_1$ and a negative estimate for $\beta_1 + \beta_2$. Using these estimates, the rise in credit market tightness increases the share of zombie firms when tightness is below the estimated threshold $\theta^*$, and it reduces the share of zombie firms when tightness exceeds the threshold.

[25] The threshold value of credit market tightness, $\theta^*$, is estimated by searching for a value over the entire range of sorted observations $\theta_{it}$ that minimizes the sum of the squared residuals. We estimate the model following the procedure in Hansen (1999). The range for the threshold value $\theta^*$ in `Tightness1` is between -32.75 and 63.50 and that for `Tightness2` is between -30.50 and 27.00, as shown in Table C.1 in Appendix C.

**Table 1:** Zombie ratio and tightness: threshold regression model

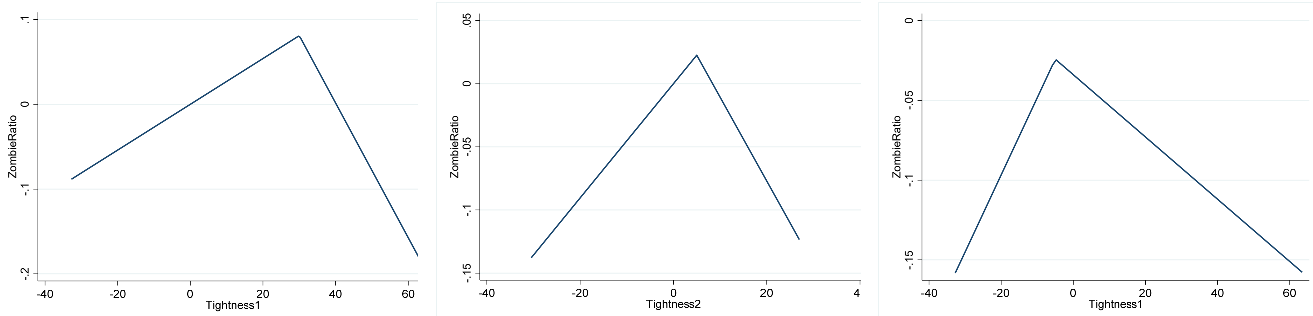
| Dependent variable: `ZombieRatio` | | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| CMT measure: | `Tightness1` | `Tightness1` | `Tightness2` | `Tightness1` |
| $\beta_1$ | 0.00270*** | 0.00327*** | 0.00436*** | 0.00524*** |
| | (0.000476) | (0.000471) | (0.000937) | (0.00113) |
| $\beta_2$ | -0.0106*** | -0.0110*** | -0.0118*** | -0.00716*** |
| | (0.00202) | (0.00205) | (0.00207) | (0.00143) |
| Control | Yes | No | Yes | Yes |
| | | | | |
| $\theta^*$ | 30.00 | 29.00 | 5.75 | -5.75 |
| Sample period | Full | Full | Full | 2000-2009 |
| Observations | 620 | 620 | 620 | 310 |
| R-squared | 0.550 | 0.527 | 0.540 | 0.692 |

*Notes:* Robust standard errors clustered at the industry level are in parentheses. The symbols ***, **, and * denote statistical significance at the one percent, five percent, and ten percent levels, respectively. The estimation period is from 2000 to 2019, except for column (4) where the estimation period is from 2000 to 2009.

Column (1) of Table 1 shows the baseline results when we control the regression with labor productivity.[26] The entries reveal that the coefficient $\beta_1$ on `Tightness1` is positive for values below the estimated threshold value of 30, thereby establishing that the zombie ratio increases by 0.27 percentage points in response to a one-point increase in our tightness index when tightness is lower than the estimated threshold. Consistent with our theoretical results, the change in tightness above the threshold negatively contributes to the share of zombie firms, thus reducing it by a 0.79 percentage points for a one-point increase in the tightness index ($-0.0079 = 0.00270 - 0.0106$). These estimates establish that an increase of one standard deviation in credit market tightness *increases* the zombie ratio by about 3.5 percentage points when the tightness is lower than the estimated threshold but that the same increase in tightness *decreases* the share of zombie firms by about 10 percentage points when tightness is higher than the threshold. Central to our results, the magnitude of the changes in the share of zombie firms is statistically significant and economically relevant. Figure 4 (left panel) shows the relationship between the zombie share and credit market tightness from our estimates in column 1 of the table. The positive slope below the threshold of tightness is determined by the estimate of $\beta_1$, the negative slope above the threshold is determined

[26] We obtain similar results using the real labor productivity or nominal unit labor costs as control variables.

by the sum of the estimates of $\beta_1$ and $\beta_2$; and the value at the kink is from the estimated threshold $\theta^*$.




*Notes:* The left, middle, and the right panels show the relationship between the share of zombie firms using the estimates in columns (1), (3) and (4) of Table 1, respectively. The positive slope before the threshold of tightness is from the estimate of $\beta_1$, negative slope after the threshold is sum of the estimates of $\beta_1$ and $\beta_2$, and the maximum value of the zombie ratio is obtained by setting tightness at the estimated threshold $\theta^*$.

**Figure 4:** The credit market tightness and the zombie ratio in the threshold specification

Column (2) of Table 1 shows the estimates for the regression that omits the control variables. The estimates are similar to our benchmark estimation in column (1), showing same significance and magnitude for the coefficients $\beta_1$ and $\beta_2$ that capture the effect of credit market tightness on the zombie share. These findings corroborate the central result of the inverted U-shaped relationship between tightness and the zombie ratio. The estimated threshold of the tightness is equal to 29 and is slightly lower than the benchmark estimation.

Column (3) shows the results when we use the alternative measure of credit market tightness `Tightness2`. The estimated threshold value is 5.75 and the relationship between credit market tightness and the zombie ratio robustly remains an inverted U-shape. A one standard deviation increase in tightness generates a 3.5 percentage point rise in the share of zombie firms when tightness is lower than the threshold. The same rise in tightness generates a 5.1 percentage point decrease in the share of zombie firms when tightness exceeds the threshold. The middle panel of Figure 4 shows the estimated inverted U-shaped relation for the alternative tightness measure `Tightness2`.

Finally, column (4) in Table 1 shows the estimates for the shorter period 2000-2009, which excludes the second half of the sample period when the zombie ratio rose steadily in response to the global financial crisis. The estimates show that the inverted U-shaped relationship between credit market tightness and the zombie ratio is robust and that the estimated threshold is equal to -5.75. The lower estimate for the threshold is expected. This situation arises because the share of zombie firms is substantially higher in the second half of the sample as a result of the financial crisis. The right panel of Figure 4 shows that the estimates for the shorter sample period are similar to the benchmark results.

**Quadratic regression model.** To ensure that our results are independent from the econometric approach and the specification of the threshold regression model, we use a quadratic regression model that allows us a direct econometric test for the inverted U-shaped relationship between credit market tightness and the share of zombie firms. To formally test the inverted U-shaped relationship, we estimate the following regression:

$$\texttt{ZombieRatio}_{jt} = \beta_0 + \beta_1\theta_{jt} + \beta_2\theta_{jt}^2 + \beta_3 A_{jt} + \phi_j + \varepsilon_{jt}. \tag{16}$$

To interpret the results of our estimation, we rewrite the equation (16) as follows:[27]

$$\texttt{ZombieRatio}_{jt} = \beta^* + \beta_2(\theta_{jt} - \theta^*)^2 + \beta_3 A_{jt} + \phi_j + \varepsilon_{jt}, \tag{17}$$

where $\beta^* = \beta_0 - \beta_2(\theta^*)^2$ and $\theta^* = -\beta_1/(2\beta_2)$.

Equations (16) and (17) nest the same model and have the same degrees of freedom. We estimate equation (16) but reparametrize the estimated equation to equation (17), which provides a more intuitive interpretation on the shape of the nonlinear function. For example, the presence of the industry-specific effect $\phi_j$ in equation (17) implies that the extremum of (the predicted) zombie ratio varies across industries, which corresponds to $\beta^* + \phi_j$.

We are interested in the estimate for $\theta^*$ that maximizes, or minimizes, the share of zombie firms.

[27]We derive the equation as follows:

$$\begin{aligned}\beta_0 + \beta_1\theta_{jt} + \beta_2\theta_{jt}^2 &= \beta_0 - \beta_2 2(-\beta_1/(2\beta_2))\theta_{jt} + \beta_2\theta_{jt}^2 = \beta_0 - \beta_2 2\theta^*\theta_{jt} + \beta_2\theta_{jt}^2 = \beta_0 + \beta_2(\theta_{jt}^2 - 2\theta^*\theta_{jt}) \\ &= \beta_0 - \beta_2(\theta^*)^2 + \beta_2(\theta_{jt}^2 - 2\theta^*\theta_{jt} + (\theta^*)^2) = \beta_0 - \beta_2(\theta^*)^2 + \beta_2(\theta_{jt} - \theta^*)^2 = \beta^* + \beta_2(\theta_{jt} - \theta^*)^2\end{aligned}$$

The estimate for $\theta^*$ in equation (17) is the empirical counterpart to the threshold of credit market tightness in our threshold regression model in equation (15). The estimate can also be negative, in principle, implying a U-shaped (rather than an inverted U-shaped) relationship between share of zombie firms and credit market tightness. Thus, our empirical test is agnostic on whether the non-monotonic relationship has a U- or an inverted U-shape.

Practically, if the estimate for $\beta_2$ in equation (16) is positive, the model implies that the share of zombie firms is a (strictly) convex function of credit market tightness. In this case, the estimate $\theta^*$ corresponds to the minimum point, indicating a U-shaped relationship between the share of zombie firms and credit market tightness. In contrast, if the estimate for $\beta_2$ is negative, the estimate $\theta^*$ corresponds to the maximum point, and equations (16) and (17) imply that the share of zombie firms is a (strictly) concave function of credit market tightness. In this case, the share of zombie firms and credit market tightness has an inverted U-shape relationship, as our theory predicts. We test the hypothesis of the inverted U-shape using the test in Lind and Mehlum (2010) that requires the following: (i) a positive coefficient for $\beta_1$, (ii) a negative coefficient for $\beta_2$, and (iii) the estimate for $\theta^*$ to be within the range of values for tightness in our sample.[28]

Table 2 shows the estimates for equation (16). Column (1) shows that the test satisfies the conditions for an inverted U-shape: the coefficient on the linear term, $\beta_1$, is positive, while the coefficient on the squared term, $\beta_2$, is negative, and the estimated turning point $\theta^*$ lies within the range of observed tightness values in the sample. The last row, labeled 'U-shape test,' reports the statistics for the Lind and Mehlum (2010) test. It shows that the null hypothesis that the relationship between tightness and zombie share is U-shaped is strongly rejected in favor of the alternative hypothesis of an *inverted* U-shaped relationship, consistent with our theoretical prediction. Columns (2)-(4) consider alternative specifications of the regression, showing that findings of the test robustly support the inverted U-shaped relationship between credit market tightness and share of zombie firms.

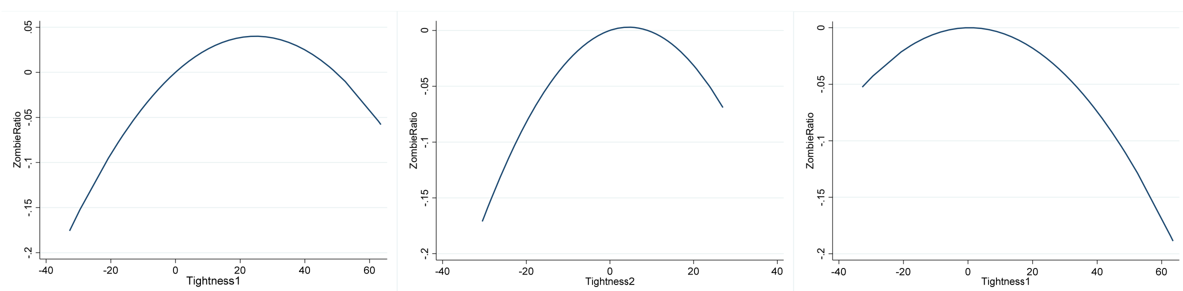
[28]To establish the inverted U-shaped relation, Lind and Mehlum (2010) propose a test for the null hypothesis of a non-positive slope at the lower end of the explanatory variable and/or a non-negative slope at the higher end of the explanatory variable against the combined alternative hypothesis of a positive and a negative slope at the lower and higher end of the explanatory variable, respectively.

**Table 2:** Zombie ratio and tightness: quadratic regression model

| Dependent variable: `ZombieRatio` | | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| CMT measure: | `Tightness1` | `Tightness1` | `Tightness2` | `Tightness1` |
| $\beta_1$ | 0.00323*** | 0.00381*** | 0.00128* | 4.61e-05 |
| | (0.000725) | (0.000785) | (0.000737) | (0.000517) |
| $\beta_2$ | -6.52e-05*** | -7.15e-05** | -0.000142*** | -4.75e-05*** |
| | (2.64e-05) | (2.80e-05) | (6.59e-05) | (1.90e-05) |
| Control | Yes | No | Yes | Yes |
| | | | | |
| $\theta^*$ | 24.758 | 26.635 | 4.495 | 0.485 |
| U-shape test | 2.52*** | 2.55*** | 2.47*** | 2.49*** |
| Sample period | Full | Full | Full | 2000-2009 |
| Observations | 620 | 620 | 620 | 310 |
| R-squared | 0.539 | 0.508 | 0.530 | 0.688 |

*Notes:* Robust standard errors clustered at the industry level are in parentheses. ***, **, and * denote statistical significance at the one percent, five percent, and ten percent levels, respectively. The estimation period is from 2000 to 2019, except for column (4) where the estimation period is from 2000 to 2009. The U-shape test of Lind and Mehlum (2010) shows t-test for the null hypothesis of monotone or U-shaped function against the alternative hypothesis of an inverted U-shaped function.

Figure 5 shows the estimated inverted U-shaped relation between credit market tightness and the zombie ratio from the estimates of the quadratic regression model. The left, middle, and right panels show the plots from estimates in column (1), (3), and (4) of Table 2, respectively.




*Notes:* The left, middle, and right panels display the quadratic functions based on the estimates in columns (1), (3), and (4) of Table 2, respectively.

**Figure 5:** The credit market tightness and the zombie ratio in the quadratic specification

## 3.3. Bargaining power and zombie firms

We empirically test our second prediction and examine whether an increase in firm bargaining power amplifies the reduction in the share of zombie firms as credit market tightness increases.

We test the link between zombie firm prevalence and firm bargaining power by exploiting cross-sectional variation in bargaining power across industries in our sample. Specifically, we examine whether the relationship between credit market tightness and the share of zombie firms differs statistically between industries with high and low firm bargaining power.

We pool industry-year observations belonging to the highest tail of the bargaining power above the 90th or 75th percentile (indicator variable $I(\texttt{BP}_{jt} = High)$) and those belonging to the lowest tail below the 10th or 25th percentile (indicator variable $I(\texttt{BP}_{jt} = Low)$) and estimate the following regression model:

$$\texttt{ZombieRatio}_{jt} = \beta_0 + \beta_1 \theta_{jt} + \beta_2 \times \theta_{jt} \times I(\texttt{BP}_{jt} = High) + \beta_3 I(\texttt{BP}_{jt} = High) + \beta_4 A_{jt} + \phi_j + \varepsilon_{jt}, \quad (18)$$

where $\texttt{BP}_{jt}$ denotes firm bargaining power aggregated at the industry level. For our prediction in Proposition 2 to hold empirically, industries with high firm bargaining power should exhibit a negative relationship with credit market tightness. This requires the estimate of $\beta_2$ to be negative, indicating that the share of zombie firms declines in response to an increase in tightness in industries with high bargaining power. Conversely, the estimate of $\beta_1$ should be positive if the share of zombie firms increases in response to an increase in tightness in industries with low bargaining power.

Table 3 shows the estimation results. Tightness exhibits a positive and significant relationship with the share of zombie firms across varying degrees of the firm's bargaining power, as indicated by the positive coefficients for `Tightness1` and `Tightness2` in columns (1)-(4). The coefficient on the interaction terms, $\beta_2$, is negative and significant in all columns, which is consistent with our theoretical prediction that firm's high bargaining power is associated with a lower share of zombie firms. Thus, industries with firm's high bargaining power have a lower incidence of zombie firms for an increase in credit market tightness than industries with low firm bargaining power.

**Table 3:** Zombie ratio regression results: Impact of bargaining power in the linear specification

| Dependent variable: `ZombieRatio` | | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| CMT measure: | `Tightness1` | `Tightness1` | `Tightness2` | `Tightness2` |
| Threshold for BP: | 90th/10th | 75th/25th | 90th/10th | 75th/25th |
| $\beta_1$ | 0.00576*** | 0.00333*** | 0.00946*** | 0.00337** |
| | (0.00191) | (0.000836) | (0.00177) | (0.00138) |
| $\beta_2$ | -0.00627** | -0.00443*** | -0.0124*** | -0.00596** |
| | (0.00293) | (0.000971) | (0.00341) | (0.00222) |
| $\beta_3$ | -0.0444 | -0.0458* | -0.0453 | -0.0981*** |
| | (0.0535) | (0.0241) | (0.0683) | (0.0243) |
| Control | Yes | Yes | Yes | Yes |
| Observations | 124 | 310 | 124 | 310 |
| R-squared | 0.610 | 0.585 | 0.613 | 0.567 |

*Notes:* Robust standard errors clustered at the industry level are in parentheses. ***, **, and * denote statistical significance at the one percent, five percent, and ten percent levels, respectively. The estimation period is from 2000 to 2019.

## 3.4. Productivity persistence and zombie firms

Our third prediction suggests that environments with low productivity persistence exhibit a high presence of zombie firms. We study the degree of productivity persistence and its impact on the inverted U-shaped relationship using two approaches. First, we study the degree of productivity persistence in Japan by estimating the autoregressive parameter of an AR(1) process for productivity. Second, we exploit the cross-sectional variation in persistence across industries to estimate differences in the steepness of the inverted U-shape across industries, and we show that industries with high productivity persistence are less likely to exhibit the inverted U-shaped relationship.

We construct a firm-level panel dataset of labor productivity using data on value added and the number of workers for individual listed firms from the Nikkei Financial Quest database.[29] We estimate an AR(1) process for productivity with firm fixed effects and obtain the estimate for the autoregressive coefficient, using the Arellano-Bond estimator to address endogeneity issues. The estimation results show that the coefficient on the one-period lag of productivity ranges

[29] Note that this firm-level labor productivity here is different from the industry-level labor productivity explained in the previous subsection in its granularity. It is also different in that the denominator is the number of employees rather than labor-hours due to the data availability.

between 0.17 and 0.19, indicating that productivity persistence is low in Japanese firms. These estimates are consistent with prior studies documenting lower persistence for labor productivity compared to TFP (Bartelsman and Doms, 2000; Foster et al., 2001), for Japanese firms during periods of financial distress (Fukao and Kwon, 2006; Nishimura et al., 2005), and in environments characterized by resource misallocation and zombie lending (Gopinath et al., 2017; Schivardi et al., 2022). Studies using labor productivity typically find AR(1) coefficients in the range of 0.2-0.5, compared to 0.6-0.8 for TFP, as labor productivity reflects short-run adjustment costs and capacity utilization in addition to fundamental productivity shocks.

The cross-sectional variation of productivity persistence across industries allows us to test the predicted negative relationship between productivity persistence and the steepness of the inverted U-shaped relationship between credit market tightness and the share of zombie firms. Consistent with our theory, we expect the inverted U-shaped relationship between credit market tightness and the share of zombies to weaken in industries with high productivity persistence and to strengthen in those with low productivity persistence.

To test our theory, we split the sample into industries with low and high productivity persistence and perform the U-shape test using the quadratic regression model outlined in equation (16).[30] We expect that the null hypothesis of a non-positive slope at the lower end and a non-negative slope at the higher end of the explanatory variable will be rejected more frequently in industries with low productivity persistence.

Table 4 shows the results. In column (1), the estimate for $\beta_2$ using the measure of credit market tightness `Tightness1` is negative and significant in industries with low productivity persistence, and the statistics from the U-test indicate an inverted U-shaped relationship. In contrast, in column (2), both the coefficient and the U-test statistics are not statistically significant. The results with the alternative measure of tightness, `Tightness2`, in columns (3) and (4), corroborate the signs of the estimates albeit with lower statistical significance.

[30] Appendix D shows the fit of an AR(1) model to each industry, dividing the 31 industries into two groups based on the magnitude of the coefficients on the lagged productivity term.

**Table 4:** Productivity persistence and the inverted U-shaped relationship

| Dependent variable: `ZombieRatio` | | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| CMT measure: | `Tightness1` | `Tightness1` | `Tightness2` | `Tightness2` |
| Productivity persistence: | Low persistence | High persistence | Low persistence | High persistence |
| $\beta_1$ | 0.00355*** | 0.00303** | 0.000720 | 0.00151 |
| | (0.000800) | (0.00117) | (0.000944) | (0.000982) |
| $\beta_2$ | -7.41e-05** | -5.76e-05 | -0.000167 | -0.000119* |
| | (2.87e-05) | (4.63e-05) | (0.000117) | (6.28e-05) |
| Control | Yes | Yes | Yes | Yes |
| | | | | |
| $\theta^*$ | 23.942 | 26.332 | 2.152 | 6.335 |
| U-shape test | 1.93** | 0.84 | 1.31 | 1.32 |
| Observations | 300 | 320 | 300 | 320 |
| R-squared | 0.546 | 0.543 | 0.533 | 0.535 |

*Notes:* Robust standard errors clustered at the industry level are in parentheses. ***, **, and * denote statistical significance at the one percent, five percent, and ten percent levels, respectively. The estimation period is from 2000 to 2019. The U-shape test of Lind and Mehlum (2010) shows t-test for the null hypothesis of monotone or U-shaped function against the alternative hypothesis of an inverted U-shaped function.

To sum up, the results indicate an inverted U-shaped relationship in industries with low productivity persistence, whereas no significant relationship is found in industries with high productivity persistence, consistent with Proposition 3.

## 3.5. Capital injections and zombie firms with firm-level data

In this final section, we study the differential impact of capital injections on the prevalence of zombie firms across industries during the Japanese banking crisis in the late 1990s and early 2000s.

Bank recapitalization by the Japanese government during the banking crisis provides a setting to examine the relationship between firm exposure to capital injections and zombie firm prevalence across industries with varying credit market tightness for two important reasons. First, capital injections during the crisis were purposely implemented to stimulate credit supply, which increased credit market tightness for firms transacting with recapitalized banks.[31] The Japanese government legally mandated that increased credit supply from recapitalized banks be passed on to firms, and the expansion of loan volumes was an explicit target of Japan's recapitalization policy.[32] Our approach to studying the effects of bank recapitalization on the share of zombie firms is complementary to Giannetti and Simonov (2013), who show that capital injections in Japan led to an expansion of bank credit to the private sector –evidence consistent with an increase in credit market tightness.[33]

Second, the Japanese government recapitalized banks through targeted policy interventions during the banking crisis, with the magnitude of support and the financial conditions of recipient banks varying significantly across institutions. This heterogeneity in policy interventions and recipient institutions allows us to identify the impact of exogenous changes in credit market tightness –induced by government recapitalization– on the prevalence of zombie firms.

Our identification strategy exploits predetermined cross-industry exposure to bank capital injections during the Japanese banking crisis. Capital injections were implemented at the bank level and driven primarily by regulatory and systemic stability considerations rather than by the contemporaneous performance of specific industries. Industry exposure is constructed using banks' pre-injection lending shares, which are fixed prior to the intervention and therefore predetermined with respect to subsequent changes in zombie prevalence.

Based on our theory (Proposition 1), we expect that capital injections have differential impacts on zombie firm prevalence depending on industry-level credit market tightness. Specifically, firms transacting with recapitalized banks are more likely to become zombies if credit market tightness in their industry is below an industry-specific threshold, but are less likely to become zombies if

[31] In our terminology, explained in Section 2, an increase in credit abundance increases credit market tightness. In other words, tightness is defined from the bank's perspective as the ratio of loan supply to loan demand.

[32] The explicit objective of the policy is stated in the "Considerations and Review Results Regarding Capital Enhancement for Applicant Financial Institutions" by the Financial Reconstruction Committee of the Japanese government on March 12, 1999.

[33] In the U.S., numerous studies have analyzed the impact of bank recapitalization policies implemented during the global financial crisis under the Troubled Asset Relief Program (TARP). In a comprehensive review of this literature, Berger (2018) and Liu et al. (2019) conclude that the evidence reasonably supports the positive effect of TARP on banks' credit supply.

industry-level tightness exceeds this threshold. To test this mechanism, we use firm-level granular data to study whether firms in industries with credit market tightness above the threshold are less likely to remain zombies and vice versa.

**Empirical specification.** The estimation period spans 1994 to 2007, beginning four years before the first capital injection and ending four years after the last one. Between 1998 and 2003, the Japanese government enacted 54 capital injections, as documented in Appendix F. We examine whether, and to what extent, firm-level exposure to capital injections correlates with zombie status differentially across industries with varying credit market tightness by estimating the following regression separately for firms in industries with credit market tightness above and below the industry-specific threshold:[34]

$$\texttt{ZombieDum}_{it+k} = \beta_0 + \beta_1\,\texttt{Injection-Exposure}_{it} + \gamma\,\texttt{Controls}_{it} + \texttt{FirmFE}_i + \texttt{YearFE}_t + u_{it}, \tag{19}$$

where $\texttt{ZombieDum}_{it+k}$ is an indicator variable for zombie status that takes the value of one if firm $i$ is classified as a zombie firm in year $t$ according to the CHK criterion and zero otherwise. We consider $k = 0, 1, 2,$ and 3 since firms may take time to change their zombie status after bank capital injections. $\texttt{Injection-Exposure}_{it}$ is a generic regressor representing the exposure of firm $i$ to capital injections into banks that the firm transacts with in year $t$, and we consider the following three alternative measures. First, $\texttt{Inject}_{it}$ is an indicator variable equal to one if at least one of the banks that firm $i$ transacts with in year $t$ received a capital injection from the government, and zero otherwise. Second, $\texttt{Inject Loanshare}_{it}$ represents the share of loans extended by recapitalized banks to firm $i$ relative to the firm's total loans in year $t$. Third, $\texttt{Inject Size}_{it}$ represents the total size of capital injections to banks transacting with firm $i$ in year $t$. This variable measures the relative size of a capital injection to the total risk assets for each bank that firm $i$ transacts with and then selects the maximum injection size among these banks. Each of these three variables measures the extent to which a firm transacting with recapitalized banks

[34] We construct the variables using the Nikkei Financial Quest database. Although Giannetti and Simonov (2013), Nakashima (2016), and Montgomery and Shimizutani (2009) examine the effects of bank capital injections on lending in Japan, we are the first to investigate the link between capital injections and zombie status through credit market tightness.

experiences increased credit market tightness resulting from those injections.

The variable $\texttt{Controls}_{it}$ comprises the following firm-level control variables: (i) size measured by the number of employees, (ii) interest coverage ratio measured by dividing operating profits before tax by interest payments, and (iii) sales growth. We also include firm and year fixed effects to control for firm-level and year-level unobservable heterogeneity (`FirmFE` and `YearFE`, respectively). Standard errors are clustered at the firm level. For the estimations with a binary dependent variable, we alternately use the pooled logit model, the linear probability model with firm fixed effects, and the panel logit model, as indicated in the text.

We split the sample into two parts depending on whether `Tightness2` is above or below the threshold value estimated in Section 3.2.[35] From Proposition 1, we expect capital injections to reduce (increase) zombie firm prevalence when industry-level credit market tightness is above (below) the estimated threshold. From the perspective of our regression specification in equation (19), this implies that the coefficient $\beta_1$ should be negative (positive) for firms in industries with tightness above (below) the threshold to support the theoretical prediction.

Importantly, our key test relies on the interaction between capital injection exposure and credit market tightness, rather than on the direct effect of injections alone. Identification therefore comes from differential responses across industries with varying levels of credit market tightness, consistent with the model's prediction that capital injections are more effective at reducing zombie lending when firms' incentives to exit unproductive relationships are stronger. This interaction-based design limits the scope for unobserved industry-specific trends to drive the results.

**Estimation results.** Table 5 shows the estimation results using the pooled logit model. In our benchmark analysis, we use `Inject` as the measure of exposure to capital injections. Across the dependent variables with different timing for zombie status measurement (i.e., in periods $t$, $t+1$, and $t+3$), the coefficient $\beta_1$ that captures the impact of the firm's exposure to capital injections on zombie status is negative and statistically significant for the sample of firms in industries with

[35] For the threshold value of `Tightness2`, we use $\theta^*$ from our estimation results in column (3) of Table 2. We use the measure of tightness `Tightness2` since its sample period is longer than that of `Tightness1` and more comprehensively covers the major capital injections in Japan during our period of interest, 1998-2003.

**Table 5:** Zombie firms, credit market tightness, and capital injections

| Dependent variable: | `ZombieDum`$_{it}$ | | `ZombieDum`$_{it+1}$ | | `ZombieDum`$_{it+3}$ | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Injection-Exposure: | `Inject` | | `Inject` | | `Inject` | |
| CMT above threshold: | below | above | below | above | below | above |
| $\beta_1$ | 0.00800 | -0.222* | -0.0716 | -0.368*** | -0.0801 | -0.411*** |
| | (0.0634) | (0.121) | (0.0658) | (0.131) | (0.0694) | (0.131) |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm FE | No | No | No | No | No | No |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Period of analysis | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 |
| Observations | 23,035 | 10,831 | 21,863 | 10,417 | 19,873 | 9,632 |
| Pseudo $R^2$ | 0.011 | 0.026 | 0.009 | 0.018 | 0.011 | 0.021 |

*Notes:* Estimation results using the pooled logit model. Standard errors are clustered at the firm level and shown in parentheses. The symbols ***, **, and * denote statistical significance at the one percent, five percent, and ten percent levels, respectively. The estimation period is 1994 to 2007. "Below" indicates that the sample is restricted to firms in industries with `Tightness2` below $\theta^*$ estimated in Table 2, while "above" indicates that the sample is restricted to firms in industries with `Tightness2` at or above $\theta^*$.

credit market tightness above the threshold (columns 2, 4, and 6). On the other hand, for the sample of firms in industries with credit market tightness below the threshold, the estimate of the coefficient $\beta_1$ is statistically insignificant (columns 1, 3, and 5). These results are consistent with Proposition 1: firm exposure to capital injections correlates with lower zombie prevalence specifically in industries where credit market tightness exceeds the threshold, while showing no significant relationship (or positive relationship in some specifications) in industries below the threshold. This differential pattern accords with our theory's prediction that the effectiveness of credit supply in reducing zombie lending depends on the prevailing level of credit market tightness.

To ensure that the results are robust, we consider alternative specifications of our baseline model. We replace `Inject` with alternative measures of exposure to capital injections –`InjectLoanShare` and `InjectSize`– and find similar results. Table 6 presents the estimation results from the alternative specifications. Columns (1)-(4) use `InjectLoanShare` as the measure of exposure to bank recapitalization and show positive and significant coefficients of $\beta_1$ when the sample is limited to firms in industries with tightness below the threshold. By contrast, they show insignificant coefficients when the sample is limited to firms in industries with tightness above the threshold. Columns (5)-(8) use `InjectSize` as the measure of exposure to bank recapitalization and show

**Table 6:** Zombie firms, credit market tightness, and capital injections - Robustness

| Dependent variable: | $\texttt{ZombieDum}_{it}$ | | $\texttt{ZombieDum}_{it+1}$ | | $\texttt{ZombieDum}_{it}$ | | $\texttt{ZombieDum}_{it+1}$ | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Injection-Exposure: | `InjectLoanShare` | | `InjectLoanShare` | | `InjectSize` | | `InjectSize` | |
| CMT above threshold: | below | above | below | above | below | above | below | above |
| $\beta_1$ | 0.542*** | 0.250 | 0.531*** | 0.418 | -0.859 | -4.285* | -2.956*** | -6.249*** |
| | (0.121) | (0.499) | (0.126) | (0.519) | (0.774) | (2.222) | (0.807) | (2.410) |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm FE | No | No | No | No | No | No | No | No |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Period of analysis | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 |
| Observations | 23,035 | 10,831 | 21,863 | 10,417 | 23,035 | 10,831 | 21,863 | 10,417 |
| Pseudo $R^2$ | 0.012 | 0.025 | 0.009 | 0.018 | 0.011 | 0.026 | 0.009 | 0.018 |

*Notes:* Estimation results using the pooled logit model. Standard errors are clustered at the firm level and shown in parentheses. The symbols ***, **, and * denote statistical significance at the one percent, five percent, and ten percent levels, respectively. The estimation period is 1994 to 2007. "Below" indicates that the sample is restricted to firms in industries with `Tightness2` below $\theta^*$ estimated in Table 2, while "above" indicates that the sample is restricted to firms in industries with `Tightness2` at or above $\theta^*$.

negative and significant coefficients of $\beta_1$ when the sample is limited to firms in industries with tightness above the threshold. By contrast, they show an insignificant coefficient when the sample is limited to firms in industries with tightness below the threshold (column 5) or a significant and negative coefficient that is smaller in absolute value than the coefficient for firms in industries with tightness above the threshold (column 7). We implement additional estimations for robustness by employing linear probability and panel logit models with firm fixed effects in place of the pooled logit model. The results are qualitatively similar, as shown in Appendix F.

**Summary and policy considerations.** To summarize our results, increases in credit market tightness from capital injections have distinct impacts on zombie firm prevalence depending on whether industry-level credit market tightness is below or above the threshold value. The evidence shows that firm exposure to capital injections is associated with lower zombie prevalence in industries where credit market tightness exceeds our estimated threshold, but not in industries with lower tightness. This differential relationship is consistent with our theoretical mechanism.

These empirical results have important policy implications. Capital injection policies intended to counteract credit crunches are effective if conducted in financial markets with sufficiently abundant credit (i.e., with high credit market tightness) such that firms can forgo high costs of financial intermediation. Enabling such outcomes requires policymakers to carefully evaluate credit market tightness relative to the threshold and implement sufficiently large capital injections that raise credit market tightness above the threshold characterizing the inverted U-shaped relationship between credit abundance and zombie firm prevalence.

# 4. Conclusion

This paper shows that zombie lending emerges as an equilibrium outcome of credit intermediation. We develop a model of frictional credit intermediation in which search and opportunity costs generate an inverted U-shaped relationship between credit market tightness and the share of zombie firms. The shape of this non-monotonic relationship depends critically on firms' bargaining power and the degree of productivity persistence: higher firm bargaining power and lower productivity persistence amplify the reduction in zombie prevalence with increasing credit abundance.

Our theoretical framework introduces a novel measure of credit market tightness that captures credit availability and yields several testable predictions. We empirically evaluate these predictions by constructing model-implied measures of credit market tightness using industry- and firm-level data from multiple Japanese sources. Studying statutory capital injections during the Japanese banking crisis in the late 1990s and early 2000s, we find that firm exposure to recapitalized banks is associated with lower zombie prevalence in industries with high credit market tightness but not in industries with low tightness –a differential relationship consistent with our theory's predictions.

Our results suggest several interesting directions for future research. First, the model shows that the countervailing opportunity costs of the bank and firm in response to changes in credit abundance are central to the incidence of zombie firms. When the discount on future payoffs is low –as during the period of ultra-low interest rates in Japan since the late 1990s– the incidence of opportunity costs weakens, suggesting the strengthening of our mechanism with the departure of monetary policy from the zero lower bound of the interest rate as it is currently happening in Japan.[36] Second, our simple model can be extended to a fully dynamic system to study

[36] Ikeda et al. (2024) provide an overview of the monetary policy framework in Japan, showing that the effectiveness of monetary policy weakens in a zero-interest rate environment, consistent with the role of discounting in our theoretical framework.

the cyclical variation of the share of zombie firms over the business cycle and investigate the interplay between credit injections and business cycle fluctuations. The extended framework will also enable the study of optimal credit provision and the role of credit market tightness in the effectiveness of credit market policies and the incidence of boom-bust cycles originating from financial markets.[37] Third, our analysis abstracts from issues of firm overindebtedness and bank under-capitalization, which may play an important role in the proliferation of zombie firms and, in principle, significantly interact with credit market tightness. We plan to pursue some of these extensions in future research.

[37] Bai et al. (2025), Ghassibe and Zanetti (2022), Eichenbaum et al. (2022) and Liu et al. (2019) show that the effectiveness of fiscal and monetary policies depend on the state of the economy which is linked to credit market policies.

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# Online Appendix
# "Credit Intermediation and Zombie Firms: Theory and Evidence"

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## A. Model

This appendix provides details on our theoretical model and presents several important extensions that demonstrate the robustness of our findings. In Appendix A.1 we show how our simplified firm production function, $\pi = Az_i - f$, connects to standard production functions used in general equilibrium models with firm dynamics. Appendix A.2 relaxes the assumption of exogenous bargaining power by developing an extension where firm bargaining power becomes an endogenous function of credit market tightness. In Appendix A.3 we demonstrate that our core theoretical predictions remain robust when we replace the constant elasticity of substitution (CES) matching function with an alternative specification, the Cobb-Douglas matching function. This analysis confirms that our results are not dependent on specific functional form assumptions. Appendix A.4 examines an extension where future expected firm profits depend on current credit market tightness, rather than being independent as assumed in our baseline model. We show that the inverted U-shaped relationship between zombie firm share and credit market tightness persists under this more general specification. Under the plausible scenario where credit market tightness positively correlates with expected future profits, banks and firms face stronger incentives to preserve their credit relationships, as both parties anticipate higher future returns from continued collaboration. Consequently, firms become less likely to terminate these relationships when expecting high future profits, leading to an increase in zombie firm prevalence. This mechanism effectively "extends" the ascending portion of the inverted U-shaped relationship, creating a broader range of credit market conditions under which zombie firms proliferate. Finally, in Appendix A.5 we show details on the impact of idiosyncratic firm productivity persistence.

## A.1. Firm production function

In this section, we demonstrate that our simplified profit function $\pi = Az_i - f$ can be derived from standard production functions used in general equilibrium models with tractable firm dynamics. To illustrate the case, we begin with the conventional firm profit function under monopolistic competition, following Melitz (2003) and Hamano and Zanetti (2017):

$$\pi_i = CP\left(\frac{PZ}{W}z_i\frac{\sigma-1}{\sigma}\right)^{\sigma-1}\frac{1}{\sigma} - \tilde{f}\frac{W}{PZ} \tag{A.1}$$

where $C$ represents aggregate consumption, $P$ is the aggregate price level, $Z$ captures aggregate productivity, $W$ denotes the wage rate, $z_i$ represents firm $i$'s idiosyncratic productivity, $\sigma > 1$ is the elasticity of substitution between varieties, and $\tilde{f}$ is the base fixed cost parameter.

**First Simplification.** Define the composite parameter $\nu \equiv \frac{W}{PZ}$ to capture the real wage relative to aggregate productivity. Substituting it into equation (A.1) and re-arranging terms yields:

$$\pi_i = CP\left(\frac{\sigma-1}{\sigma}\nu\right)^{\sigma-1} z_i^{\sigma-1} - \tilde{f}\nu. \tag{A.2}$$

**Second Simplification.** We introduce two convenient redefinitions: $\psi \equiv \left(\frac{\sigma-1}{\sigma}\frac{1}{\nu}\right)^{\sigma-1}$ and $f \equiv \tilde{f}\nu$. This transforms our profit function in equation (A.2) to:

$$\pi_i = CP\psi z_i^{\sigma-1} - f. \tag{A.3}$$

**Final Step: Linear Specification.** Under the commonly used assumption of $\sigma = 2$, and defining $A \equiv CP\psi$ into equation (A.3), it yields:

$$\pi_i = Az_i - f. \tag{A.4}$$

The derivation shows that our simplified linear profit function in equation (A.4) arises from standard monopolistic competition models. The parameter $A$ captures aggregate factors affecting firm profitability, while $z_i$ represents firm-specific productivity differences. The linear form enables analytical tractability while preserving the economic intuition that more productive firms earn higher profits.

## A.2. Tightness and bargaining power

In this section, we relax the assumption that credit market tightness and firm bargaining power are independent. We examine the case where bargaining power is an endogenous function of credit market tightness. This extension is motivated by the directed search literature, which shows that offer terms satisfy the Hosios (1990) efficiency condition in one-shot games (Rogerson et al., 2005) and more generally achieve efficiency when matching parties engage in directed competitive search (Acemoglu and Shimer, 1999; Wright et al., 2021).

**Proposition 4** (Credit market tightness and zombie firms)**.** *The inverted U-shaped relationship between credit market tightness and zombie firms persists when efficient bargaining power is a positive function of tightness, as occurs with the CES matching function. Moreover, when bargaining power increases with tightness, this amplifies the inverted U-shape. The underlying mechanism is that as bargaining power and credit market tightness rise together, banks have weaker incentives to maintain credit relationships while firms have stronger incentives to terminate existing relationships and seek new matches.*

Assuming bargaining power depends on credit market tightness, $\eta(\theta)$, where $\eta'(\theta) > 0$, we obtain:

$$\frac{\partial \tilde{z}_{\text{frictions}}}{\partial \theta} \begin{cases} < 0, & \text{if } \eta(\theta)p'(\theta) + \eta'(\theta)p(\theta) < \eta'(\theta)q(\theta) - (1-\eta(\theta))q'(\theta) \\ & \quad \Rightarrow \text{Zombie share increases in } \theta, \\ > 0, & \text{if } \eta(\theta)p'(\theta) + \eta'(\theta)p(\theta) > \eta'(\theta)q(\theta) - (1-\eta(\theta))q'(\theta) \\ & \quad \Rightarrow \text{Zombie share decreases in } \theta. \end{cases} \tag{A.5}$$

In a CES matching function, efficient firm bargaining power takes the form $\eta(\theta) = \frac{\theta^l}{1+\theta^l}$, which gives $\eta'(\theta) = \frac{l\theta^{l-1}}{(1+\theta^l)^2} > 0$. Equation (A.5) reveals an important property: Even when we hold the matching probabilities $p(\theta)$ and $q(\theta)$ and their derivatives constant, the derivative $\eta'(\theta)$ declines faster than the level $\eta(\theta)$ as tightness increases under efficient bargaining in the CES case. This outcome demonstrates two key results. First, when we make firm bargaining power a positive function of credit market tightness –as efficiency requires for standard matching functions such as the CES specification– the inverted U-shaped relationship continues to hold. Second, efficient bargaining actually strengthens the non-linear forces that create the inverted U-shaped pattern in the zombie firm share.

## A.3. Cobb-Douglas matching function

This section shows that our main theoretical predictions regarding the inverted U-shaped relationship between the zombie firm share and credit market tightness are robust to alternative specifications of the matching technology. Specifically, we show that replacing the constant elasticity of substitution (CES) matching function from our baseline model with a Cobb-Douglas (CD) matching function yields qualitatively identical results.

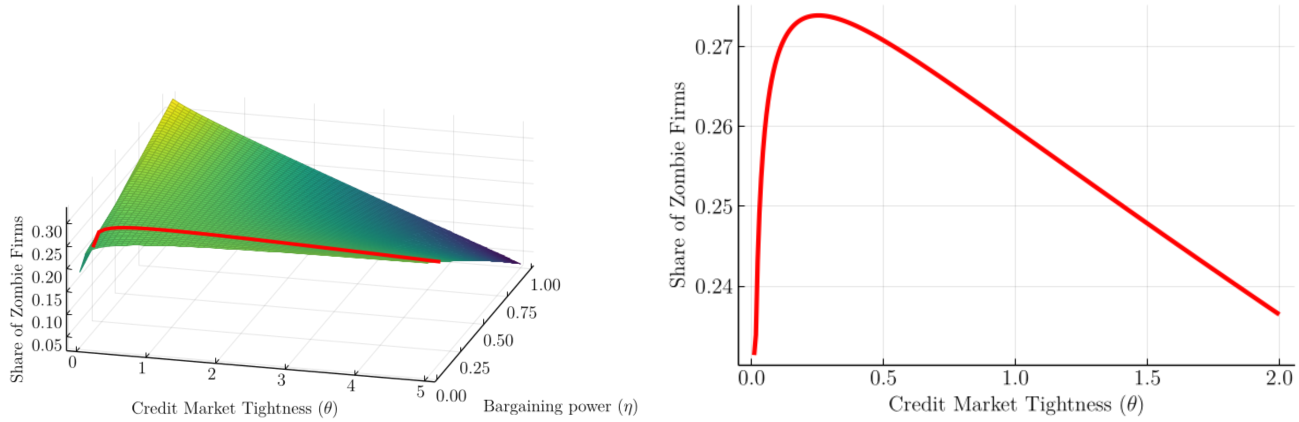
Under the Cobb-Douglas specification, the matching probabilities are given by:

$$p(\theta) = \min(\mu\theta^{1-\zeta}, 1) \quad \text{(firms finding loans) and} \tag{A.6}$$

$$q(\theta) = \min(\mu\theta^{-\zeta}, 1) \quad \text{(banks finding firms),} \tag{A.7}$$

where $\theta$ represents credit market tightness (the ratio of banks offering loans to firms seeking credit), $\mu$ is the matching efficiency parameter, and $\zeta \in (0, 1)$ determines the elasticity of the matching function with respect to tightness. We calibrate the CD matching function using standard values: $\zeta = 0.66$ and $\mu = 0.25$. These parameters ensure that matching probabilities remain comparable to our baseline CES specification. A crucial distinction between the CD and CES matching functions lies in the determination of efficient bargaining power. Under the Cobb-Douglas specification, the Hosios (1990) efficiency condition implies that the efficient degree of bargaining power is constant and equal to the elasticity of the matching function, in this case $\eta = \zeta = 0.66$. This outcome contrasts with the CES case where efficient bargaining power varies endogenously with credit market tightness. Figure A.1 presents numerical illustrations confirming that our central theoretical predictions hold under the Cobb-Douglas matching specification. Panel (a) shows the three-dimensional relationship between the zombie firm share, credit market tightness, and bargaining power, while panel (b) focuses on the relationship when bargaining power is set to its efficient level.

The results show that the inverted U-shaped relationship between the zombie share and credit market tightness persists and the qualitative effects of bargaining power on zombie firm prevalence are preserved.




**(a)** Three-dimensional relationship: Zombie share, credit market tightness, and bargaining power

**(b)** Zombie share and credit market tightness under efficient bargaining power

**Figure A.1:** Numerical illustration of the zombie firm share under Cobb-Douglas matching function

*Notes:* Panel (a) displays the zombie firm share (z-axis) as a function of credit market tightness $\theta$ (x-axis) and firm bargaining power $\eta$ (y-axis) under the Cobb-Douglas matching specification. The red line traces the zombie share when bargaining power satisfies the Hosios (1990) efficiency condition. Panel (b) shows the relationship between the zombie share and credit market tightness when bargaining power is set to the efficient level $\eta = \zeta = 0.66$. Both panels confirm the persistence of the inverted U-shaped relationship under alternative matching function specifications.

## A.4. Relaxing the independence assumption between tightness and firm profits

If we think of credit market tightness as being driven by economic policies, then future firm productivity and credit market tightness may be correlated. To show that our results are robust, we relax the assumption $\frac{\partial E(A_2)}{\partial \theta} = 0$ that the aggregate component in future profits is uncorrelated with current credit market tightness. More concretely, we assume that future expected aggregate productivity is a function of credit market tightness; i.e., $E(A_2(\theta))$.

Under the revised assumption, we solve $E(\pi(z_{i,2}, A_2(\theta)))$ to find $\tilde{z}_{\text{frictions}}$. To do so, we need to calculate the expectations for current idiosyncratic *and* aggregate productivity $E(z_{i,2}, A_2(\theta))$, given current credit market tightness $\theta$. Hence, future expected profits in the second period are a function of current credit market tightness $\bar{\pi}_2(\theta)$. The sign of $\frac{\partial E(A_2)}{\partial \theta}$ determines whether higher tightness increases or decreases expected profits. Equation (9) in the main text then changes to the following equation:

$$\tilde{z}_{\text{frictions}} = f - \kappa - \beta\bar{\pi}_2(\theta)[1 - (1-\eta)q(\theta) - \eta p(\theta)]. \tag{A.8}$$

Profits become a function of credit market tightness conditions, and condition (11) changes to the following equation:

$$\frac{\partial \tilde{z}_{\text{frictions}}}{\partial \theta} \begin{cases} < 0, & \text{if } \eta\left[\frac{\bar{\pi}_2'(\theta)}{\bar{\pi}_2(\theta)}p(\theta) + p'(\theta)\right] < \frac{\bar{\pi}_2'(\theta)}{\bar{\pi}_2(\theta)}(1-(1-\eta)q(\theta)) - (1-\eta)q'(\theta) \\ & \Rightarrow \text{Zombie share increases in } \theta, \\ > 0, & \text{if } \eta\left[\frac{\bar{\pi}_2'(\theta)}{\bar{\pi}_2(\theta)}p(\theta) + p'(\theta)\right] > \frac{\bar{\pi}_2'(\theta)}{\bar{\pi}_2(\theta)}(1-(1-\eta)q(\theta)) - (1-\eta)q'(\theta) \\ & \Rightarrow \text{Zombie share decreases in } \theta. \end{cases} \tag{A.9}$$

The new terms $\frac{\bar{\pi}_2'(\theta)}{\bar{\pi}_2(\theta)}\eta p(\theta)$ and $\frac{\bar{\pi}_2'(\theta)}{\bar{\pi}_2(\theta)}(1-(1-\eta)q(\theta))$ enter in the condition. These terms capture the elasticity of expected profits with respect to credit market tightness, weighted by the firm's matching probability and the bank's effective bargaining position, respectively. Both terms exhibit monotonic relationships with tightness that parallel the behavior of the standard matching function derivatives $p'(\theta)$ and $-q'(\theta)$. When $\frac{\partial A_2}{\partial \theta} > 0$, both terms increase with $\theta$, while when $\frac{\partial A_2}{\partial \theta} < 0$, both terms decrease with $\theta$. The relative magnitude of these terms—and hence which dominates the optimality condition—depends on the bargaining power parameter and the functional form of the matching technology, as characterized in equation (10).

Note that the relationship between tightness and the next period's expected profits determines the sign of $\frac{\bar{\pi}_2'(\theta)}{\bar{\pi}_2(\theta)}$. When this relationship is positive then $\frac{\partial \tilde{z}_{\text{frictions}}}{\partial \theta} < 0$ for high levels of credit market tightness. This situation means that for higher levels of tightness, the bank's and firm's incentive to subsidize the match dominates the incentive to terminate the match. Mapping this into the zombie firm share–credit market tightness space implies that the upward-sloping segment to the left of the peak in the inverted U-shaped relationship becomes steeper and shifts to the right, as illustrated by the brown line in Figure A.2. This outcome is the result of the positive correlation between credit market tightness and aggregate productivity, which implies that the prospects of future expected match profits increase for each level of credit market tightness. The risk of losing future expected matched profits in the next period increases the incentive to maintain unproductive matches in the current period.

The reverse holds when aggregate productivity $A_2$ is a negative function of $\theta$ and hence $\frac{\bar{\pi}_2'(\theta)}{\bar{\pi}_2(\theta)} < 0$. In this case, the incentive to maintain an unproductive match weakens as credit market tightness increases. Higher credit market tightness enables equity holders to form new productive matches outside the current match with a high likelihood. At the same time, the payoff from maintaining and financing a match into the next period is reduced, while the risk of failing to secure a new match and missing out on production in the next period is lower. Consequently, the share of zombie firms increases less with credit market tightness and reaches its peak earlier. This development results in a less pronounced inverted U-shape and the peak shifts to the left in the credit market tightness–zombie firm share space, as illustrated by the yellow line in Figure A.2.

When the next period's profits are a function of credit market tightness and hence the predictions above hold, conditions (11) and (12) remain unchanged.

Allowing $\frac{\partial A_2}{\partial \theta} \neq 0$, which relaxes the assumption that credit market tightness $\theta$ is independent of the future aggregate component of firm profits $A_2$, yields an additional empirical prediction. When $A_2$ and future expected profits $E[\pi(\theta, A_2)]$ are increasing in $\theta$, an increase in credit market tightness further lowers the minimum cutoff under financial frictions, resulting in a larger increase in the share of zombie firms. In other words, the upward-sloping portion of the inverted U-shaped relationship between credit market tightness and the zombie firm share becomes steeper, and the peak shifts rightward to higher levels of tightness. In contrast, when the aggregate component $A_2$ is a negative function of credit market tightness $\theta$ –and hence firm future expected profits and future expected profits $E(\pi(\theta, A_2))$ are lower when credit market tightness is higher– then the incentive to terminate the match becomes stronger as credit market tightness increases. This outcome occurs because the expected benefit of maintaining the match for the next period declines while the probability of securing a new productive match remains high. As a result, the zombie firm share peaks at a lower level of credit market tightness, and the overall inverted U-shaped relationship becomes flatter with an earlier peak.

Figure A.2 plots the relationship between the share of zombie firms and credit market tightness for the cases of positive, zero, or negative functional relationships between current credit market tightness and future firm profits. As explained, the positive relationship increases the zombie firm share for every level of credit market tightness and lengthens the left slope of the inverted U-shape. The opposite is true for a negative relationship. Finally, when future expected profits

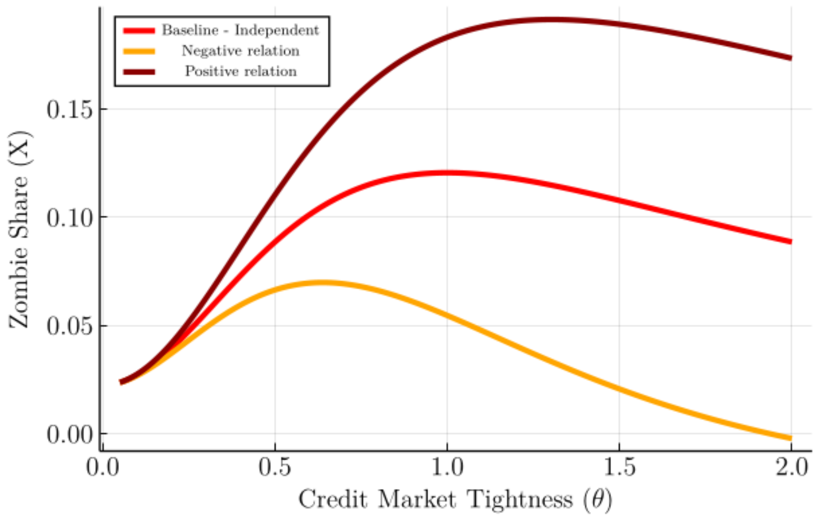



**Figure A.2:** The zombie firm share and credit market tightness for different functional relations between $A_2$ and $\theta$.

*Notes:* The figure shows the relationship between credit market tightness and the zombie firm share for a positive, none, and a negative functional relation between firm profits and credit market tightness. For each scenario, firm bargaining power is set to the efficient level. The figure demonstrates that the correlation between current tightness and future productivity alters both the slope and peak location of the tightness-zombie firm relationship.

react very strongly positively (negatively) to changes in credit market tightness, then the right (left) slope of the inverted U may disappear and the relationship between credit market tightness and share of zombie firms may be monotonically positive (negative). To sum up, this extension demonstrates that our main theoretical predictions remain robust to relaxing the independence assumption between current credit conditions and future aggregate productivity, while generating additional testable implications about how the relationship affects firm exit decisions.

Note that in Appendix E we empirically examine the correlation between the industry-level credit market tightness and firms' future profit forecasts aggregated at the industry level. We find a positive and significant correlation for the tightness measure we primarily use.

## A.5. Productivity persistence, proof of Proposition 3

We relax the independence assumption of idiosyncratic firm productivity and embed productivity persistence in the model and provide proofs to Proposition 3. We assume: $E[\pi(z_{i,2}, f)] = \rho\pi_1(z_{i,1}) + (1-\rho)\bar{\pi}_2$, where $\rho$ is the degree of persistence of the second-period profits to remain the same as the first-period profits. With the new productivity process the total surplus in equation

(7) becomes:

$$v^s_{1,i} \;=\; \pi(z_{i,1}, A_1, f) + \beta E(\pi(z_{i,2}, A_2, f)) + \kappa - \beta E(\pi(z_{i,2}, A_2, f))[q(\theta)(1-\eta) + p(\theta)\eta] \quad \text{(A.10)}$$

To find the cutoff in period 1 we set $v^s_{1,i} = 0$ and we substitute our productivity assumption $\pi_1(z_i) = z_i - f$, which then turns second period expected productivity to $\rho\pi_1(z_{i,1}) + (1-\rho)\bar{\pi}_2 = \rho z_{i,1} + (1-\rho)\bar{z}_2 - f$. The cutoff $\tilde{z}_{\text{frictions},1}$ is then defined by the following equation:

$$0 \;=\; z_{i,1} - f + \beta[\rho z_{i,1} + (1-\rho)\bar{z}_2 - f] + \kappa - \beta[\rho z_{i,1} + (1-\rho)\bar{z}_2 - f][q(\theta)(1-\eta) + p(\theta)\eta]\ .$$

Solving this equation for $z_{i,1}$, we can write the idiosyncratic productivity threshold as equal to:

$$\tilde{z}^{\rho}_{\text{frictions},1} = \frac{f - \kappa - \beta[\bar{\pi}_2(1-\rho) - \rho f]\,[1-(1-\eta)q(\theta) - \eta p(\theta)]}{1 + \rho\beta\,[1-(1-\eta)q(\theta) - \eta p(\theta)]}. \tag{A.11}$$

Proposition 3 comprises two parts, showing that a rise in the persistence of productivity: (i) increases the threshold of idiosyncratic productivity, and (ii) decreases the sensitivity of the threshold of idiosyncratic productivity to credit market tightness.

We begin by proving (i). To study the impact of productivity persistence on the threshold of idiosyncratic productivity, we derive equation (A.11) with respect to $\rho$, yielding:

$$\frac{\partial \tilde{z}^{\rho}_{\text{frictions},1}}{\partial \rho} = \frac{\beta C(\theta)\,[\kappa + \bar{\pi}_2\,(1+\beta C(\theta))]}{[1+\rho\beta C(\theta)]^2} > 0,$$

where $C(\theta) = 1-(1-\eta)q(\theta) - \eta p(\theta)$. Thus, a rise in the persistence of productivity increases the threshold of idiosyncratic productivity.

We now prove (ii). To study the impact of productivity persistence on the sensitivity of the threshold of idiosyncratic productivity to credit market tightness, we derive equation (A.11) with respect to $\theta$, yielding:

$$\begin{aligned}
\frac{\partial \tilde{z}^{\rho}_{\text{frictions},1}}{\partial \theta} &= \frac{[(1-\eta)q'(\theta) + \eta p'(\theta)]\,[B(1+DC(\theta)) + D(A - BC(\theta))]}{(1+DC(\theta))^2} = \\
&= [(1-\eta)q'(\theta) + \eta p'(\theta)] \times \frac{B + DA}{(1+DC(\theta))^2} \qquad \text{(A.12)} \\
&= \frac{[(1-\eta)q'(\theta) + \eta p'(\theta)]\,\beta[(1-\rho)\bar{\pi}_2 - \rho\kappa]}{(1+\rho\beta[1-(1-\eta)q(\theta) - \eta p(\theta)])^2}, \qquad \text{(A.13)}
\end{aligned}$$

where $A = f - \kappa$, $B = \beta[\bar{\pi}_2(1-\rho) - \rho f]$, $C(\theta) = 1 - (1-\eta)q(\theta) - \eta p(\theta)$, and $D = \rho\beta$. Note that the derivation without persistence for the threshold $\tilde{z}_{\text{frictions},1}$ in equation (9) is equal to $[(1-\eta)q'(\theta) + \eta p'(\theta)]\, \beta\bar{\pi}_2$. Equation (A.13) can therefore be written as:

$$\frac{\partial \tilde{z}^{\rho}_{\text{frictions},1}}{\partial \theta} = [(1-\eta)q'(\theta) + \eta p'(\theta)]\, \beta\bar{\pi}_2 \times \frac{\bar{\pi}_2 - \rho(\kappa + \bar{\pi}_2)}{\bar{\pi}_2} \times \frac{1}{(1+\rho\beta C(\theta))^2}.$$

By "less sensitive" we mean a reduction in the *absolute* responsiveness of the cutoff to tightness, measured by $\left|\frac{\partial \tilde{z}^{\rho}_{\text{frictions},1}}{\partial \theta}\right|$. Note that $\frac{\partial \tilde{z}^{\rho}_{\text{frictions},1}}{\partial \theta}$ can change sign as $\rho$ varies because the term $\bar{\pi}_2 - \rho(\kappa + \bar{\pi}_2)$ becomes negative when $\rho > \frac{\bar{\pi}_2}{\kappa + \bar{\pi}_2}$. If one wants to rule out this possibility, it suffices to impose $\rho \leq \frac{\bar{\pi}_2}{\kappa + \bar{\pi}_2}$, which is a mild restriction under a conventional parameterization where $\kappa$ is small relative to $\bar{\pi}_2$. Finally, if $\kappa \leq \bar{\pi}_2$ and $C(\theta) \geq 0$, then $|\bar{\pi}_2 - \rho(\kappa + \bar{\pi}_2)| \leq \bar{\pi}_2$ for all $\rho \in [0,1]$ and $(1+\rho\beta C(\theta))^2 \geq 1$, implying that productivity persistence weakly reduces $\left|\frac{\partial \tilde{z}^{\rho}_{\text{frictions},1}}{\partial \theta}\right|$ relative to the no-persistence case ($\rho = 0$). $\square$

Recall the cutoff $\tilde{z}^{\rho}_{\text{frictions},1}$, and the definition $C(\theta) \equiv 1 - (1-\eta)q(\theta) - \eta p(\theta)$. From the derivation above (equation A.13), the derivative with respect to credit market tightness can be expressed in terms of $C(\theta)$. We now derive the mixed partial derivative with respect to productivity persistence and credit market tightness:

$$\frac{\partial^2 \tilde{z}^{\rho}_{\text{frictions},1}}{\partial \rho\, \partial \theta} = \frac{\partial}{\partial \theta}\left(\frac{\partial \tilde{z}^{\rho}_{\text{frictions},1}}{\partial \rho}\right).$$

This derivative defines the change in sensitivity of the zombie cutoff to credit market tightness as $\rho$ increases. Using the chain rule with respect to $C(\theta)$, we obtain

$$\frac{\partial^2 \tilde{z}^{\rho}_{\text{frictions},1}}{\partial \rho\, \partial \theta} = C'(\theta)\, \frac{\beta\left[\kappa + \bar{\pi}_2 + \beta C(\theta)\left(2\bar{\pi}_2 - \rho(\kappa + \bar{\pi}_2)\right)\right]}{(1+\rho\beta C(\theta))^3}, \tag{A.14}$$

where $C'(\theta) = -(1-\eta)q'(\theta) - \eta p'(\theta)$. Substituting back yields the fully written expression:

$$\frac{\partial^2 \tilde{z}^{\rho}_{\text{frictions},1}}{\partial \rho\, \partial \theta} = -\left[(1-\eta)q'(\theta) + \eta p'(\theta)\right]\ \frac{\beta\left[\kappa + \bar{\pi}_2 + \beta\left(1 - (1-\eta)q(\theta) - \eta p(\theta)\right)\left(2\bar{\pi}_2 - \rho(\kappa + \bar{\pi}_2)\right)\right]}{\left(1 + \rho\beta\left[1 - (1-\eta)q(\theta) - \eta p(\theta)\right]\right)^3}. \tag{A.15}$$

**Sign of the cross-derivative.** Define $M(\theta) \equiv (1-\eta)q'(\theta) + \eta p'(\theta)$ and $K \equiv \kappa + \bar{\pi}_2$. Then the mixed partial can be written compactly as:

$$\frac{\partial^2 \tilde{z}^{\rho}_{\text{frictions},1}}{\partial \rho\, \partial \theta} = -\,M(\theta)\, \frac{\beta\left[K + \beta C(\theta)\left(2\bar{\pi}_2 - \rho K\right)\right]}{(1+\rho\beta C(\theta))^3}. \tag{A.16}$$

Since $\beta > 0$ and $(1+\rho\beta C(\theta))^3 > 0$, the sign depends on $-M(\theta)$ and on the bracketed term. Under the standard matching restrictions $q(\theta) \in [0,1]$ and $p(\theta) \in [0,1]$ (so that $C(\theta) \in [0,1]$), together with $\bar{\pi}_2 > 0$, $\kappa \geq 0$, and $\rho \in [0,1]$, we have

$$K + \beta C(\theta)\,(2\bar{\pi}_2 - \rho K) = K\,(1 - \rho\beta C(\theta)) + 2\beta C(\theta)\bar{\pi}_2 > 0,$$

so the sign is pinned down by $M(\theta)$ alone. In particular,

$$\frac{\partial^2 \tilde{z}^{\rho}_{\text{frictions},1}}{\partial\rho\,\partial\theta} < 0 \quad\Longleftrightarrow\quad (1-\eta)q'(\theta) + \eta p'(\theta) > 0 \quad\Longleftrightarrow\quad \eta p'(\theta) > (1-\eta)\big(-q'(\theta)\big). \tag{A.17}$$

Equivalently, given $p'(\theta) > 0$ and $q'(\theta) < 0$ (so that $p'(\theta) - q'(\theta) > 0$), the condition $M(\theta) > 0$ can be written as the bargaining-power threshold

$$M(\theta) > 0 \quad\Longleftrightarrow\quad \eta > \frac{-q'(\theta)}{p'(\theta) - q'(\theta)}.$$

That is, the mixed partial is negative exactly when the (bargaining-weighted) responsiveness of the firm's matching probability in $\theta$ dominates the (bargaining-weighted) responsiveness of the bank's matching probability. Else it is positive. Thus, the sign of the cross derivative flips from positive to negative exactly as the impact of credit market tightness on the cutoff flips from negative to positive. As a result increases in $\rho$ dampen the effect of credit market tightness on the zombie share.□

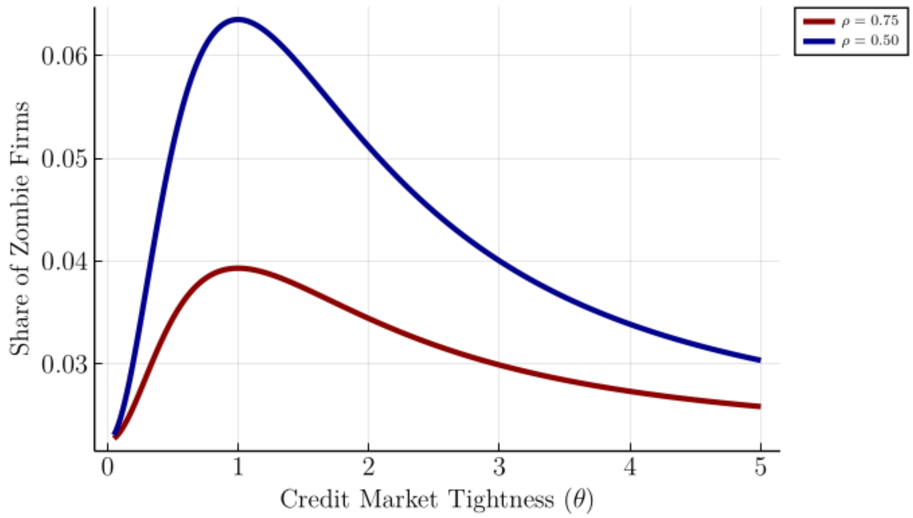
We next examine the case where productivity persistence outside the current credit relationship is lower than persistence within the relationship, that is $\rho_n < \rho$. This assumption reflects the idea that exiting the credit match may lead to a restructuring of the company. As a result, the company's new productivity draw following the restructuring will be less affected by past issues without restructuring occurring and the firm continuing in the current match. In this case, the productivity threshold $\tilde{z}_{\text{frictions},1}$ is:

$$\tilde{z}_{\text{frictions},1} = \frac{f - \kappa - \beta[\bar{\pi}_2(1-\rho) - \rho f] + \beta[\bar{\pi}_2(1-\rho_n) - \rho_n f]\,[(1-\eta)q(\theta) + \eta p(\theta)]}{1 + \beta\,[\rho - \rho_n\,((1-\eta)q(\theta) + \eta p(\theta))]}, \tag{A.18}$$

and the derivative of the threshold with respect to credit market tightness is equal to:

$$\frac{\partial \tilde{z}^{\rho}_{\text{frictions},1}}{\partial\theta} = \frac{[(1-\eta)q'(\theta) + \eta p'(\theta)]\,\beta\,[\bar{\pi}_2\,(1 - \rho_n + \beta(\rho - \rho_n)) - \rho_n\kappa]}{(1 + \beta\,[\rho - \rho_n\,((1-\eta)q(\theta) + \eta p(\theta))])^2}. \tag{A.19}$$

This equation exhibits the same sensitivity properties with respect to credit market tightness as




We illustrate the impact of different persistence in figure A.3.

**Figure A.3:** The zombie firm share and credit market tightness for high ($\rho = 0.75$, red line) and low ($\rho = 0.50$, blue line) persistence of idiosyncratic firm productivity.

*Notes:* The figure shows the relationship between credit market tightness and the zombie firm share for different levels of persistence of idiosyncratic firm productivity.

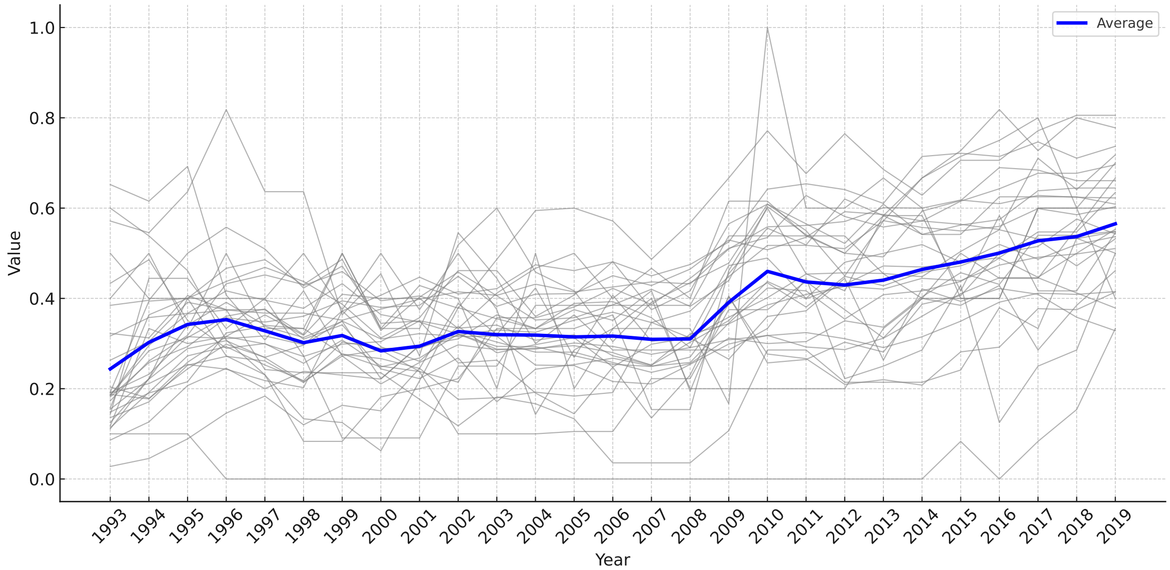
equation A.13. Therefore, our main theoretical result remains robust: Even when exit from a credit relationship triggers restructuring that alters firm productivity, the fundamental economic mechanisms driving continuation decisions still generate the inverted U-shaped relationship between credit market tightness and the zombie firm share. Differential productivity persistence inside versus outside credit relationships ($\rho$ versus $\rho_n$) does not change how credit market conditions affect the prevalence of zombie firms.

# B. Economy average and industry-level shares of zombie firms

Figure B.4 shows the economy average and industry-level shares of zombie firms (thick and thin lines, respectively) measured across 31 industries.

# C. Data

In this Appendix, we describe data sources and construction of our variables of interest.




*Notes:* Time series for the industry-level series (thin lines) and the economy average (thick line) for the share of zombie ratio. The data covers 31 industries for the period 1993-2019.

**Figure B.4:** Time series for the zombie ratio (`ZombieRatio`)

### Nikkei Financial Quest Database

The Nikkei Financial Quest database is a large database that accumulates various information, mainly on listed companies in Japan. The database includes information on firms' balance sheets, major shareholders, borrowings from individual financial institutions, and human resource allocations. In this study, we use financial information (balance sheets and income statements) of listed companies based on their annual securities reports (Yuka-Shoken-Houkokusho), earnings forecasts made by the firms themselves, and information on companies' borrowing amount outstanding from financial institutions. Financial information is used to construct zombie firm dummies and firm-level labor productivity variables. Firm performance forecasts are used to examine how firms themselves forecast their future profitability and how these forecasts are related to the credit market tightness. Firm borrowings from financial institutions are used to calculate a firm's bargaining power with financial institutions and to identify the relationship between firms and financial institutions when identifying the firms that are affected by the capital injections into financial institutions.

### The Loan Survey

For the construction of the variable that measures credit market tightness, we employ the Senior

Loan Officer Opinion Survey on Bank Lending Practices at Large Japanese Banks (i.e., the Loan Survey) that the Bank of Japan (BOJ) reports. The Loan Survey is a quarterly statistical survey undertaken in January, April, July, and September of each year. This survey aims to quantitatively measure the perspectives of senior loan officers at major Japanese banks regarding the loan market. A multiple-choice questionnaire is utilized to gather information on respondents' views regarding the demand for loans from firms and other borrowers, as well as standards and terms of loans, among other considerations. Respondents consist of senior loan officers at 50 large private banks. Bank size is determined by lending volume. The combined loan size of these banks represents approximately 75 percent of the loan market among Japanese private banks, including city banks, regional banks, regional banks II, trust banks, long-term credit banks, and shinkin banks (cooperative regional financial institutions serving small and medium enterprises and local residents).

In the Loan Survey, the Demand for Loans Diffusion Index (DI) captures the trend in responses to questions regarding changes in loan officers' perspectives compared to the previous quarter's survey. Specifically, the survey asks respondents about the changes in demand for loans from borrowers (i.e., firms, local governments, and households) over the past three months, excluding normal seasonal variations. The DI is calculated as the sum of the percentage of respondents selecting "substantially stronger" and those selecting "moderately stronger" to the survey item, with the latter weighted by 0.5. This sum is then subtracted from the sum of the percentage of respondents selecting "substantially weaker" to the survey item and those selecting "moderately weaker," also with the latter weighted by 0.5.

The Demand for Loans DI is reported for the following five industries: (1) manufacturing, (2) non-manufacturing, (3) construction and real estate, (4) finance and insurance, and (5) other non-manufacturing. It is also reported by three firm size categories: large, medium-sized, and small firms.

### The Tankan Survey

We also employ the Short-Term Economic Survey of Enterprises in Japan (i.e., the Tankan Survey) for construction of the tightness measure. The Tankan Survey is a quarterly statistical survey conducted by the BOJ in March, June, September, and December each year. The BOJ solicits responses from selected private enterprises in Japan with a capital of 20 million yen or more.

In the Tankan Survey, one important variable for our analysis is the Lending Attitude (of Financial Institutions) Diffusion Index (DI). It reports the respondents' judgments of financial institutions' attitude toward lending, as perceived by responding enterprises. Respondents are required to select one of three options: (1) "accommodative," (2) "not so severe," and (3) "severe." The Lending Attitude DI is calculated by subtracting the percentage share of those responding with "severe" from those responding with "accommodative." This index is reported by industry (about 40 industries) and by firm size.

Another useful variable in the Tankan Survey is the Financial Position DI. It captures respondents' judgments of the overall cash position of the participating enterprises in terms of three potential responses: "easy," "not so tight," and "tight." This index is also reported by industry (about 40 industries) and by firm size.

**The JIP Database**

For the productivity of firms that are aggregated at the industry level, we use the JIP Database (Japan Industrial Productivity Database). The JIP database contains annual data on 108 sectors from 1970 that can be used for total factor productivity analyses. These sectors cover the entire Japanese economy. The database includes detailed information on sectoral capital service input indices and labor service input indices. It includes annual information from input-output tables on the real capital stocks and the nominal cost of capital by type of capital and by industry, in nominal and real units. The statistics are regularly updated. Therefore, we use JIP2023 that covers the period 1994-2020 and JIP2014 that covers the period 1970-2011.

**Descriptive statistics**

We present descriptive statistics of the variables that we use in our industry-level analysis in Table C.1.

**Table C.1:** Descriptive statistics

| | $N$ | $T$ | mean | sd | min | p25 | p50 | p75 | max |
|---|---|---|---|---|---|---|---|---|---|
| `ZombieRatio` | 31 | 20 | 0.40 | 0.17 | 0.00 | 0.29 | 0.4 | 0.52 | 1.00 |
| `Tightness1` | 31 | 20 | 15.55 | 13.05 | -32.75 | 7.75 | 16.75 | 24.25 | 63.50 |
| `Tightness2` | 31 | 20 | 1.13 | 7.67 | -30.50 | -3.00 | 2.00 | 5.75 | 27.00 |
| `BP` | 31 | 20 | 0.69 | 0.07 | 0.23 | 0.66 | 0.69 | 0.73 | 0.87 |
| *Productivity* | 31 | 20 | 8.90 | 12.87 | 1.33 | 3.41 | 4.90 | 8.88 | 81.59 |

*Notes:* Mean, standard deviation (sd), minimum (min), 25th percentile (p25), median (p50), 75th percentile (p75), and maximum (max). Sample period is from 2000 to 2019.

# D. Persistence of firm productivity

We examine productivity persistence for all listed firms in the Nikkei Financial Quest database for the period 2000-2019, both for the entire sample and by industry. Based on these findings, we classify industries into low and high productivity persistence groups and estimate equation (16) separately for each group to test whether the inverted U-shaped relationship is steeper in low persistence industries.

**Measuring firm-level labor productivity.** Using the information included in annual financial statements of listed firms, we calculate the labor productivity at the firm level, in which value added is divided by the number of employees. For the value added, we have two alternative definitions depending on the items included. For the variable in the first definition, we add the following items to (1) operating profits:

In the category of manufacturing costs: (2) Labor costs and welfare expenses; (3) Rents; (4) Taxes; (5) Depreciation and Amortization

In the category of sales, general, and administrative expenses: (6) Executive compensation; (7) Personnel Expenses and Welfare Benefits; (8) Depreciation and Amortization; (9) Rents; (10) Taxes; (11) Employee benefits expenses and allowance for employee benefits expenses; (12) Executive retirement benefits and allowance for executive retirement benefits; (13) Allowance for executive bonuses

For the variable of value added in the second definition, we sum all of the above items except for the last three items (11)-(13), which are the expenses for the allowance. For each of the variables

**Table D.1:** Productivity persistence regression results

| Dependent variable | LP1 | LP1 | LP2 | LP2 |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Extreme values | No cutoff | Cutoff at [0.01, 0.99] | No cutoff | Cutoff at [0.01, 0.99] |
| $\beta$ | 0.1778 | 0.1872 | 0.1783 | 0.1875 |
| | (0.0062) | (0.0039) | (0.0062) | (0.0039) |
| Observations | 82943 | 80733 | 82943 | 80726 |
| Groups | 6101 | 6057 | 6101 | 6058 |
| Wald chi2 statistics | 826.81 | 2296.22 | 831.05 | 2300.47 |
| Prob > chi2 | 0.000 | 0.000 | 0.000 | 0.000 |

*Notes:* Standard errors in parentheses. ***, ** and *denote statistical significance at the one percent, five percent, and ten percent levels, respectively. The estimation period is from 2000 to 2019.

for value added, we calculate the labor productivity for firm $i$ in year $t$ as in below:

$$LP1_{it} = \frac{\text{Sum from (1) to (13)}}{\text{Number of employees}}, \text{ and } LP2_{it} = \frac{\text{Sum from (1) to (10)}}{\text{Number of employees}} \tag{D.20}$$

**Estimation of the productivity persistence.** After calculating the firm-level labor productivity in the two different definitions, we examine the firm's productivity persistence. Specifically, we apply the following AR(1) model with firm fixed effects and apply the Arellano-Bond estimator as in below:

$$LP1or2_{it} = \alpha + \beta LP1or2_{it-1} + u_i + \epsilon_{it} \tag{D.21}$$

Since there are some observations with extreme values for the labor productivity, we employ two alternative ways for the sample construction: (1) use the entire set of observations and (2) omit observations whose labor productivity is below the 1st percentile or above the 99th percentile. Table D.1 shows the results. There are four estimations since there are two alternative dependent variables and two alternative datasets.

All the coefficients of $\beta$ fall below 0.19, indicating low productivity persistence for listed firms in Japan during our sample period. While these estimates are below the 0.6–0.8 range typically reported for TFP persistence, they align with several features of our empirical setting. First, we measure *labor productivity* rather than TFP. Labor productivity exhibits significantly lower persistence (AR(1) coefficients of 0.2–0.5) because it confounds fundamental productivity with short-run factor adjustment and capacity utilization (Bartelsman and Doms, 2000; Foster et al., 2001). Second, our 2000–2019 sample encompasses the Global Financial Crisis and Japan's prolonged stagnation. Studies document that productivity persistence declines substantially during financial crises and periods of credit misallocation (Bloom et al., 2018; Gopinath et al., 2017). Third, Japan-specific studies find lower persistence than US or European benchmarks, particularly during the Lost Decades (Fukao and Kwon, 2006; Nishimura et al., 2005). Finally, environments with prevalent zombie lending endogenously reduce measured productivity persistence by distorting resource allocation (Schivardi et al., 2022), suggesting our estimates may partially reflect the phenomenon we study.

### Comparison with Existing Literature

Our estimated productivity persistence ($\rho \approx 0.17$–$0.19$) is lower than the 0.6–0.8 range commonly reported for TFP, but consistent with several strands of literature:

*Labor productivity vs TFP:* Studies consistently find that labor productivity exhibits significantly lower persistence than TFP. Foster et al. (2001) report AR(1) coefficients of 0.2–0.5 for labor productivity in US manufacturing, while Bartelsman and Doms (2000) document that labor productivity persistence is approximately half that of TFP persistence because it conflates true productivity shocks with adjustment costs and capacity utilization.

*Japanese context:* Japan-specific studies find lower productivity persistence than US or European benchmarks. Fukao and Kwon (2006) document reduced persistence during the Lost Decades, while Nishimura et al. (2005) show that the natural selection mechanism weakened during Japan's 1990s recession, reducing the link between current and future productivity.

*Crisis periods:* Our sample spans the Global Financial Crisis. Bloom et al. (2018) show that productivity persistence falls substantially during recessions and uncertainty shocks. Similarly, Gopinath et al. (2017) find lower persistence in South European economies experiencing credit misallocation.

*Endogeneity:* The prevalence of zombie lending may itself reduce measured productivity persistence. Schivardi et al. (2022) argue that credit misallocation weakens the relationship between current and future firm performance by sustaining inefficient firms and distorting competitive dynamics.

**Measurement errors.** A potential concern is that firm-level productivity measures may be subject to transitory shocks or measurement error, which would bias autoregressive coefficients downward. Importantly, such a bias would work against our mechanism. Lower measured persistence mechanically increases incentives to maintain loss-making relationships in anticipation of productivity improvements, thereby amplifying the inverted U-shaped relationship between credit market tightness and zombie prevalence predicted by the model. If true productivity persistence were higher than our estimates suggest, the sensitivity of zombie prevalence to credit market tightness would be attenuated rather than strengthened. Consistent with this interpretation, we find that industries with higher estimated persistence exhibit a substantially flatter relationship between credit market tightness and the zombie share. Moreover, our persistence measures are constructed at the industry level using large firm panels, which mitigates idiosyncratic firm-level measurement error.

Our estimates are consistent with prior empirical work on labor productivity persistence. Lee and Mukoyama (2015) report AR(1) coefficients of 0.3–0.4 for continuing manufacturing establishments, while Foster et al. (2001) document labor productivity persistence in the range of 0.2–0.5, substantially below TFP persistence estimates. For Japanese firms specifically, Fukao and Kwon (2006) find relatively low persistence during the 1990s–2000s stagnation period, attributing this to increased turbulence and resource misallocation.

## E. Expected firm profits

As shown in Section 2, we assume that the incentive to maintain a zombie firm relationship is a bid for resurrection. Hence, stakeholders involved in the firm's financial performance have a positive expectation about future profitability. In this appendix, we show that these positive expectations of future profits of firms are observed in our data. In Appendix A.4 we discuss the consequences of a correlation between current credit market tightness and future expected firm profits. We show that a positive correlation between current credit market tightness and future expected profits expands the range of values for credit market tightness in which the share of zombie firms increases. Within this range, on the left side of the inverted U-relationship between credit market tightness and zombie firm share, the incentive to forbear on loans and maintain the relationship dominates the option to sever the relationship and for the matching parties to be dormant in the current period and search in the next period. In this Appendix, we show that our baseline measure of credit market tightness is positively correlated with future firm profits.

We use the Nikkei Financial Quest for profitability forecasts, which also provides information on listed companies' own forecasts for their annual current profits. Most listed companies in Japan customarily announce their forecasts for their sales, operating profits, current profits, net income, and dividends per share for the next fiscal year when they officially present their financial statements. Among the forecasts, we use the initial ones for each firm-fiscal year, most of which are announced one year in advance. Based on the theoretical prediction presented in the previous section, we examine whether firms issue positive earnings forecasts and whether the correlation between profitability forecasts and credit market tightness is positive.[1]

First, we examine whether listed firms in Japan make positive profitability forecasts. For the fiscal years 2000-2019, we calculate the ratio of firms that reported negative current profits to those that reported profit forecasts. We also calculate the ratio of firms that ended up reporting negative actual current profits to those that reported actual profits. We perform the same exercise by aggregating the information at the industry level. Tables E.1 and E.2 show the results. Table E.1, which depicts summary statistics at the firm level, shows that only a small fraction of firms forecast negative current profits, but a larger fraction of firms actually reported negative current profits. For example, in fiscal year 2000, 1.6 percent of firms forecast negative current profits, yet 7.2 percent of them actually report negative current profits. Throughout the period, less than 3 percent of firms reported negative current profit forecasts, except in fiscal year 2009 when the Global Financial Crisis hit the economy. These findings are consistent with the theoretical model's assumption of the positive expected profits. We have a similar result in Table E.2. Specifically, as shown in the table, statistics aggregated at the industry level, indicate that a very limited number of industries forecast negative current profits.

[1] To the best of our knowledge, we are the first to use empirically the information of firm profitability forecasts and their relation to zombie firm status.

**Table E.1:** Current profit at firm level: Forecast and actual

| Fiscal year | Forecast | | Actual | |
|---|---|---|---|---|
| | Number of firms | Ratio of firms with negative profit | Number of firms | Ratio of firms with negative profit |
| 2000 | 1520 | 1.6% | 1605 | 7.2% |
| 2001 | 1645 | 1.6% | 1687 | 15.4% |
| 2002 | 1734 | 1.8% | 1755 | 9.9% |
| 2003 | 1795 | 1.3% | 1842 | 6.1% |
| 2004 | 1875 | 1.1% | 1935 | 5.2% |
| 2005 | 1891 | 1.0% | 1954 | 5.7% |
| 2006 | 2082 | 1.5% | 2114 | 7.4% |
| 2007 | 2147 | 1.6% | 2164 | 8.6% |
| 2008 | 2178 | 1.8% | 2191 | 20.0% |
| 2009 | 2196 | 9.1% | 2205 | 18.7% |
| 2010 | 2213 | 2.4% | 2231 | 8.4% |
| 2011 | 2248 | 2.3% | 2282 | 9.0% |
| 2012 | 2282 | 2.3% | 2320 | 9.3% |
| 2013 | 2333 | 1.8% | 2398 | 6.5% |
| 2014 | 2377 | 1.3% | 2471 | 6.6% |
| 2015 | 2446 | 1.5% | 2527 | 7.1% |
| 2016 | 2505 | 1.6% | 2603 | 6.8% |
| 2017 | 2563 | 1.8% | 2679 | 5.6% |
| 2018 | 2623 | 1.7% | 2765 | 7.0% |
| 2019 | 2691 | 2.2% | 2851 | 9.6% |

*Notes*: In the majority of cases, firm forecasts are made one year prior to the end of the fiscal year.

Second, we examine whether the correlation between credit market tightness and expected profits is positive. Because tightness is measured at the industry level, we aggregate expected profits at the industry level to estimate the correlations. Table E.3 shows the results. When we use `Tightness1` for the tightness measure –which is our main tightness variable– the correlations are always positive. However, that they are insignificant or negative when we use `Tightness2`.

All these results indicate that the first assumption of positive profitability forecasts is satisfied and that the second assumption of positive covariance between tightness and forecasts is also generally met.

**Table E.2:** Sum of current profits at industry level: Forecast and actual

| Fiscal year | Forecast | | Actual | |
|---|---|---|---|---|
| | Number of industries | Ratio of industries with negative profit | Number of industries | Ratio of industries with negative profit |
| 2000 | 31 | 0.0% | 31 | 0.0% |
| 2001 | 31 | 0.0% | 31 | 6.5% |
| 2002 | 31 | 0.0% | 31 | 6.5% |
| 2003 | 31 | 0.0% | 31 | 0.0% |
| 2004 | 31 | 0.0% | 31 | 0.0% |
| 2005 | 31 | 0.0% | 31 | 0.0% |
| 2006 | 31 | 0.0% | 31 | 0.0% |
| 2007 | 31 | 0.0% | 31 | 0.0% |
| 2008 | 31 | 0.0% | 31 | 6.5% |
| 2009 | 31 | 3.2% | 31 | 6.5% |
| 2010 | 31 | 0.0% | 31 | 0.0% |
| 2011 | 31 | 3.2% | 31 | 6.5% |
| 2012 | 31 | 3.2% | 31 | 3.2% |
| 2013 | 31 | 3.2% | 31 | 3.2% |
| 2014 | 31 | 0.0% | 31 | 3.2% |
| 2015 | 31 | 0.0% | 31 | 3.2% |
| 2016 | 31 | 0.0% | 31 | 3.2% |
| 2017 | 31 | 0.0% | 31 | 0.0% |
| 2018 | 31 | 0.0% | 31 | 3.2% |
| 2019 | 31 | 0.0% | 31 | 9.7% |

*Notes*: In the majority of cases firm forecasts are made one year prior to the end of the fiscal year.

**Table E.3:** Correlation coefficients between tightness measures and profit forecasts

| | CMT measures | |
|---|---|---|
| | Tightness Measure 1 | Tightness Measure 2 |
| Profit Forecasts | 0.2534 | -0.0004 |
| | (0.0000) | (0.9925) |
| Profit Forecasts/Assets | 0.1159 | -0.1197 |
| | (0.0049) | (0.0036) |

*Notes*: The tightness measure of an industry is for year $t$. The profit forecast is the sum of the current profit forecast for year $t+1$ in an industry. The asset is the sum of assets in an industry in year $t+1$. The numbers in parentheses are p-values.

# F. Impact of capital injections on the presence of zombie firms

This appendix provides supplementary materials for our examination of the impact of capital injections on firms' zombie status. We first provide a list of capital injections to banks in the late 1990s and the early 2000s in Japan. Then we provide summary statistics and the estimation results which supplement the contents of the main text but were not presented there.

We first show the list of capital injections to banks by the Japanese government during the period 1998-2003. In Appendix table F.1, we show names of recapitalized banks, the year of each capital injection, the amount of injected capital, and the relative size of the injected capital to the amount of the bank's risk assets. We also show summary statistics used in estimations in Appendix table F.2.

We then show the robustness estimation results in Appendix Table F.3. We employ the linear probability model with firm fixed effects instead of the pooled logit model. The other specifications are the same as in Table 5. The results indicate that two out of three coefficients of $\beta_1$ are negative and significant for the sample of firms whose credit market tightness is above the threshold, which is generally consistent with Proposition 1. It should be noted that estimated coefficients of $\beta_1$ are larger in absolute values as we use the zombie dummy for later years. We obtain qualitatively similar results when we use the panel logit model in Appendix Table F.4.

Appendix Table F.5 presents additional robustness results. We use zombie status one year after capital injections as the dependent variable, and replace `Inject` with two alternative measures of exposure to capital injections: `InjectLoanShare` and `InjectSize`. The results are overall consistent with Proposition 1 in that a negative and marginally significant coefficient of $\beta_1$ for the sample of firms above the tightness threshold (Column (4)); a positive and marginally significant coefficient of $\beta_1$ for the sample of firms below the threshold (Column (5)); and a negative and significant coefficient for the sample of firms below the threshold but its magnitude in absolute values is smaller than that for the sample of firms above the threshold (Columns (7) and (8)).

**Table F.1:** Bank Capital Injections (1998–2003)

| Year | Bank | Injection amt (billion yen) | Size | Year | Bank | Injection amt (billion yen) | Size |
|---|---|---|---|---|---|---|---|
| 1998 | Industrial Bank of Japan | 100 | 0.0036 | 2000 | SBI Shinsei Bank | 240 | 0.0417 |
| 1998 | Long-term Credit Bank of Japan | 1766 | 0.0895 | 2000 | Aozora Bank | 260 | 0.0626 |
| 1998 | Nippon Credit Bank | 600 | 0.0617 | 2000 | Hokkaido Bank | 45 | 0.0214 |
| 1998 | Dai-ichi Kangyo Bank | 99 | 0.0024 | 2000 | Chiba Kogyo Bank | 60 | 0.0493 |
| 1998 | Sakura Bank | 100 | 0.0027 | 2000 | Kumamoto Family Bank | 30 | 0.0319 |
| 1998 | Fuji Bank | 100 | 0.0026 | 2000 | Yachiyo Bank | 35 | 0.0340 |
| 1998 | Tokyo Mitsubishi Bank | 100 | 0.0017 | 2001 | Kinki Osaka Bank | 60 | 0.0220 |
| 1998 | Asahi Bank | 100 | 0.0049 | 2001 | Higashinihon Bank | 20 | 0.0186 |
| 1998 | Sanwa Bank | 100 | 0.0026 | 2001 | Gifu Bank | 12 | 0.0321 |
| 1998 | Sumitomo Bank | 100 | 0.0024 | 2001 | Kansai Sawayaka Bank | 12 | 0.0141 |
| 1998 | Daiwa Bank | 100 | 0.0090 | 2002 | Wakayama Bank | 12 | 0.0477 |
| 1998 | Tokai Bank | 100 | 0.0046 | 2002 | Fukuoka City Bank | 70 | 0.0351 |
| 1998 | Ashikaga Bank | 30 | 0.0067 | 2002 | Kyushu Bank | 30 | 0.0401 |
| 1998 | Yokohama Bank | 20 | 0.0026 | 2003 | Risona Bank | 1960 | 0.0851 |
| 1998 | Hokuriku Bank | 20 | 0.0037 | | | | |
| 1998 | Mitsui Trust Bank | 100 | 0.0107 | | | | |
| 1998 | Mitsubishi Trust Bank | 50 | 0.0038 | | | | |
| 1998 | Yasuda Trust Bank | 150 | 0.0240 | | | | |
| 1998 | Toyo Trust Bank | 50 | 0.0073 | | | | |
| 1998 | Chuo Trust Bank | 60 | 0.0207 | | | | |
| 1998 | Sumitomo Trust Bank | 100 | 0.0084 | | | | |
| 1999 | Industrial Bank of Japan | 600 | 0.0208 | | | | |
| 1999 | Dai-ichi Kangyo Bank | 900 | 0.0254 | | | | |
| 1999 | Sakura Bank | 800 | 0.0240 | | | | |
| 1999 | Fuji Bank | 1000 | 0.0243 | | | | |
| 1999 | Asahi Bank | 500 | 0.0254 | | | | |
| 1999 | Sanwa Bank | 700 | 0.0198 | | | | |
| 1999 | Sumitomo Bank | 501 | 0.0128 | | | | |
| 1999 | Daiwa Bank | 408 | 0.0382 | | | | |
| 1999 | Tokai Bank | 600 | 0.0291 | | | | |
| 1999 | Ashikaga Bank | 105 | 0.0264 | | | | |
| 1999 | Yokohama Bank | 200 | 0.0267 | | | | |
| 1999 | Hokuriku Bank | 75 | 0.0173 | | | | |
| 1999 | Ryukyu Bank | 40 | 0.0446 | | | | |
| 1999 | Mitsui Trust Bank | 400.2 | 0.0513 | | | | |
| 1999 | Mitsubishi Trust Bank | 300 | 0.0253 | | | | |
| 1999 | Toyo Trust Bank | 200 | 0.0323 | | | | |
| 1999 | Chuo Trust Bank | 150 | 0.0375 | | | | |
| 1999 | Sumitomo Trust Bank | 200 | 0.0187 | | | | |
| 1999 | Hiroshima Sogo Bank | 40 | 0.0270 | | | | |

**Table F.2:** Summary Statistics

| Variable names | N | Mean | Std. Dev. | Min | p25 | p50 | p75 | Max |
|---|---|---|---|---|---|---|---|---|
| `ZombieDum` | 33,637 | 0.369 | 0.482 | 0 | 0 | 0 | 1 | 1 |
| `Inject` | 33,637 | 0.195 | 0.396 | 0 | 0 | 0 | 0 | 1 |
| `Inject Loanshare` | 33,637 | 0.098 | 0.245 | 0 | 0 | 0 | 0 | 1.0 |
| `Inject Size` | 33,637 | 0.008 | 0.021 | 0 | 0 | 0 | 0 | 0.09 |
| Size | 33,637 | 6.356 | 1.294 | 0.693 | 5.537 | 6.293 | 7.123 | 12.281 |
| InterestCoverage | 33,637 | 33.255 | 297.024 | -1012.143 | 1.480 | 5.077 | 16.286 | 26010.500 |
| SalesGrowth | 33,637 | 0.006 | 0.201 | -4.681 | -0.053 | 0.010 | 0.070 | 6.317 |

**Table F.3:** Regression results: Linear probability with fixed effect estimations

| Estimation method: | Linear probability | | | | | |
|---|---|---|---|---|---|---|
| Dependent variable: | `ZombieDum`$_{it}$ | | `ZombieDum`$_{it+1}$ | | `ZombieDum`$_{it+3}$ | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Injection-Exposure: | `Inject` | | `Inject` | | `Inject` | |
| CMT above threshold: | below | above | below | above | below | above |
| $\beta_1$ | -0.0130 | -0.0210 | -0.0161 | -0.0547** | 0.000637 | -0.0689*** |
| | (0.0113) | (0.0223) | (0.0116) | (0.0237) | (0.0122) | (0.0248) |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Period of analysis | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 |
| Observations | 22,760 | 10,628 | 21,545 | 10,225 | 19,546 | 9,373 |
| $R^2$ | 0.519 | 0.525 | 0.525 | 0.523 | 0.557 | 0.527 |

*Notes:* Standard errors are clustered at the firm level and shown in parentheses. The symbols ***, ** and * denote statistical significance at the one percent, five percent, and ten percent levels, respectively. The estimation period is from 1994 to 2007. "Below" indicates that the sample is restricted to firms whose `Tightness2` is smaller than $\theta^*$ estimated in Table 2, while "above" indicates that the sample is restricted to firms whose `Tightness2` is equal to or greater than $\theta^*$.

**Table F.4:** Regression results: Panel logit estimations

| Estimation method: | Panel logit | | | | | |
|---|---|---|---|---|---|---|
| Dependent variable: | `ZombieDum`$_{it}$ | | `ZombieDum`$_{it+1}$ | | `ZombieDum`$_{it+3}$ | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Injection-Exposure: | `Inject` | | `Inject` | | `Inject` | |
| CMT above threshold: | below | above | below | above | below | above |
| $\beta_1$ | -0.107 | -0.147 | -0.138 | -0.411** | 0.0158 | -0.525*** |
| | (0.0935) | (0.172) | (0.0973) | (0.180) | (0.104) | (0.191) |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Period of analysis | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 |
| Observations | 13,795 | 5,827 | 13,120 | 5,601 | 11,169 | 5,324 |
| Number of groups | 1,873 | 1,026 | 1,813 | 999 | 1,569 | 953 |
| Pseudo $R^2$ | 0.009 | 0.031 | 0.008 | 0.020 | 0.015 | 0.039 |

*Notes:* Standard errors are clustered at the firm level and shown in parentheses. The symbols ***, ** and * denote statistical significance at the one percent, five percent, and ten percent levels, respectively. The estimation period is from 1994 to 2007. "Below" indicates that the sample is restricted to firms whose `Tightness2` is smaller than $\theta^*$ estimated in Table 2, while "above" indicates that the sample is restricted to firms whose `Tightness2` is equal to or greater than $\theta^*$.

**Table F.5:** Regression results: Linear probability and panel logit estimations- Robustness

| Estimation method: | Linear probability | | | | Panel logit | | | |
|---|---|---|---|---|---|---|---|---|
| Dependent variable: | $\texttt{ZombieDum}_{it+1}$ | | $\texttt{ZombieDum}_{it+1}$ | | $\texttt{ZombieDum}_{it+1}$ | | $\texttt{ZombieDum}_{it+1}$ | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Injection-Exposure: | `InjectLoanShare` | | `InjectSize` | | `InjectLoanShare` | | `InjectSize` | |
| CMT above threshold: | below | above | below | above | below | above | below | above |
| $\beta_1$ | 0.0378 | -0.0241 | -0.236 | -0.762* | 0.315* | -0.106 | -1.947* | -5.471* |
| | (0.0240) | (0.111) | (0.145) | (0.443) | (0.172) | (0.746) | (1.127) | (3.238) |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Period of analysis | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 | 1994–2007 |
| Observations | 21,545 | 10,225 | 21,545 | 10,225 | 13,120 | 5,601 | 13,120 | 5,601 |
| Number of groups | | | | | 1,813 | 999 | 1,813 | 999 |
| (Pseudo) $R^2$ | 0.525 | 0.522 | 0.525 | 0.523 | 0.008 | 0.019 | 0.008 | 0.019 |

*Notes:* Standard errors are clustered at the firm level and shown in parentheses. The symbols ***, ** and * denote statistical significance at the one percent, five percent, and ten percent levels, respectively. The estimation period is from 1994 to 2007. "Below" indicates that the sample is restricted to firms whose `Tightness2` is smaller than $\theta^*$ estimated in Table 2, while "above" indicates that the sample is restricted to firms whose `Tightness2` is equal to or greater than $\theta^*$.

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