Internet Appendix for "Zombie Credit and (Dis-)Inflation: Evidence from Europe"

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ABSTRACT

This appendix is structured as follows. Appendix I presents a model of the zombie lending channel. Appendix II shows how we obtain firm-level markups following De Loecker and Warzynski (2012). Appendix III presents additional tables. Appendix IV presents additional figures. Appendix V presents the IV diagnostic tests outlined in Goldsmith-Pinkham, Sorkin, and Swift (2020). Appendix VI discusses the survey data collected for the bank supervision intensity analysis. Appendix VII presents the supply chain results. Appendix VIII shows that our results are not explained by alternative supply-side channels.

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I. Model

In this appendix, we present our framework to analyze the relationship between zombie lending and inflation. Section I.1 presents a model where zombie lending affects aggregate supply by causing too many firms to produce at any given point in time, namely the extensive margin effect. Section I.2 extends the extensive margin model to allow zombie lending to also affect the decision of individual firms about their production scale at any given point in time, thus adding an intensive margin effect.

I.1. Extensive Margin Model

Since our objective is to characterize the effect of zombie credit on CPI growth, we include zombie credit as an exogenous force in our model that prevents some (zombie) firms from defaulting, and focus our analysis on its effect on product prices.

To this end, we rely on an extensive theoretical literature that shows that weakly-capitalized banks can have an incentive to extend advantageous loans to non-viable firms (see, e.g., Bruche and Llobet (2014), Homar and van Wijnbergen (2017), Begenau et al. (2023), and Acharya, Lenzu, and Wang (2022)).

Zombie credit. This literature has highlighted (at least) two different zombie lending incentives: avoidance of regulatory costs and risk-shifting. While sharing the same zombie lending outcome (i.e., a weak bank provides a non-viable firm with credit at advantageous terms), these two frictions operate in different ways.

The *avoidance of regulatory costs* incentive has three necessary ingredients. First, the bank needs to be sufficiently weak such that there is a non-negligible probability that the bank falls below a minimum regulatory capital level. Second, the bank incurs regulatory costs when it falls below this level. For example, because of a capital shortfall, the regulator restricts bank behavior or requires a costly recapitalization. Third, the bank has a preexisting exposure to a non-viable borrower that has a positive likelihood of not being able to meet its debt payments.

By providing the borrower with funds at advantageous terms (i.e., subsidized credit), the bank can then help the borrower meet its loan payments, lowering the probability that the borrower defaults on its outstanding debt payments (at least in the short-term) and that, in turn, the bank has to recognize a loan loss. This loan loss would decrease the bank's capital level and increase the likelihood of having to incur regulatory costs.

Providing subsidized credit to a zombie firm thus allows a weak bank to "buy time", hoping that its balance sheet *as a whole* recovers (a recovery of the zombie firm of course helps at the margin). Specifically, even if the zombie firm eventually defaults but a sufficient portion of the bank's investments turns out to be successful, the bank can avoid the regulatory costs since it can build-up a sufficient equity buffer. Hence, the provision of zombie credit can pay off for the bank irrespective of whether the zombie firm recovers.

Finally, a zombie loan needs to include a subsidy to make continuing operating for the zombie firm positive NPV. This value transfer from the bank to the zombie ensures that the firm does not shut down, which would lead to a loss realization for the bank. Blattner, Farinha, and Rebelo (2023) provides empirical evidence for this zombie lending incentive, showing that weakly-capitalized banks reallocate credit to distressed firms with under-reported loan losses.

The *risk-shifting* incentive also has three necessary ingredients. First, the bank needs to be sufficiently weak such that there is a non-negligible probability of becoming insolvent. Second, a loan to a zombie firm yields a higher expected return in the bank's solvency states than its other outside investment options (e.g., a loan to a firm in a different sector). This ingredient requires that the zombie loan has a higher payoff if successful and/or that the performance of the zombie loan is more highly positively correlated with the performance of the bank's preexisting portfolio (e.g., because the bank has a material preexisting exposure to the zombie firm, or, more generally, the bank is highly exposed to the industry in which the zombie firm operates). Third, the bank's debt is not fairly priced (i.e., not appropriately adjusted for risk). For example, the bank might be protected by implicit or explicit government guarantees or by limited liability and bank creditors might not adjust their pricing in response to a change in the bank's risk profile.

Zombie lending behavior then originates from the resulting risk-shifting incentive. Specifically, a bank with debt not appropriately priced for risk has an incentive to invest in assets that allow the bank to "shift" additional returns in solvency states and any potential losses in insolvency states. These assets are investment opportunities that only cause substantial losses in states of the world in which the bank is insolvent anyway (e.g., due to a poor performance of its preexisting asset holdings).

A prime risk-shifting opportunity for a weak bank is thus to further increase its exposure to weak firms (zombies) to which it already has a large exposure. Increasing its exposure to these firms raises the bank's return whenever the firms are successful (and, as a result, the bank stays solvent) without significantly affecting its default probability (when the loans to these firms fail, the bank is likely in default anyway).

By engaging in zombie lending, a weak bank can thus "double down" on its existing risk exposures. If the gamble succeeds, the bank wins. If the gamble fails, the bank creditors and/or the government insurance scheme lose. For example, Chopra, Subramanian, and Tantri (2021) provides empirical evidence for this driver of zombie lending.

This risk-shifting incentive leads to advantageous interest rates for zombie firms because a zombie loan constitutes a risk-shifting asset that the borrowing firm "negotiates" with the bank. The participation constraint of the firm requires the bank to include a sufficiently large value transfer in the zombie loan such that continuing business turns from negative to positive NPV for the zombie firm. Moreover, a zombie firm with bargaining power vis-a-vis the bank can capture additional rents from the bank risk-shifting behavior, in turn allowing the firm to get an even more advantageous interest rate.

Setup. We define an equilibrium with and without zombie credit (including zombie credit as an exogenous force) and then compare equilibrium quantities and prices. The model adds imperfect competition among firms to a framework similar to Caballero, Hoshi, and Kashyap (2008).

Time is discrete and the economy is populated by a large, but finite, number of firms that produce a single good. Firms are identical in size and can be incumbent or potential entrants. At each date t, there are m_t incumbent firms and e potential entrant firms.

The problem of firms at each date t is as follows. First, firms (incumbents and potential entrants) pay a fixed cost I. Second, incumbent firms simultaneously set prices. Third, firms draw their production y_{it} from a uniform distribution $y_{it} \sim U[0, 1]$. Firms' profits are $(p_t - c)y_{it} - I$, where c is the (exogenous) marginal cost. Depending on the realization of their production, potential entrant firms might enter the market and incumbent firms might default. A firm that makes negative profits is forced to default.

There is an exogenous demand $D_t(p_t) = \alpha_t - p_t$, where p_t is the average price set by incumbent firms. This aggregate demand is satiated starting with the production of the firm that sets the lowest price.[1]

Lemma 1: *Firms choose $p_{it} = p_t$, where*

$$p_t = \alpha_t - \frac{m_t}{2}. \tag{IA.1}$$

Proof. Suppose m_t identical firms set prices simultaneously at t before the realization of the production parameter in a single shot game. The marginal cost of production is c. There is only one good and the demand is $D(p_t) = \alpha_t - p_t$, where $\alpha_t \geq \frac{1}{2}(m_t + 1) + c$. The expected production is $\mathbb{E}(y_{it}) = \frac{1}{2}$. This problem is similar to a Bertrand price-setting model with an exogenous capacity constraint equal to the expected production. We claim

[1] Given $p_t = \sum_i p_{it}/m_{it}$, this allocation rule resembles limit order books used in stock exchanges. If multiple firms set the same lowest price, the demand is split evenly among them.

that $p_{it} = p_t^* = \alpha_t - \frac{m_t}{2}$. Given the one shot nature of the game, we can ignore the time subscripts. Firm i optimally deviates from $p_i = p_{-i} < p^*$ because it can get a higher price on the residual demand given that other firms cannot produce more than $\frac{1}{2}$ in expectation. Firm i optimally deviates from $p_i = p_{-i} > p^*$ because it can undercut slightly the price and expect to sell its entire expected production. Firm i optimally deviates from $p_i < p_{-i}$ because it can get a higher price on the residual demand. □

Firms set prices knowing that their expected production is 1/2. In the unique equilibrium, the price p_t set by incumbent firms is such that the total expected production equals demand at the price p_t. It is not optimal for firm i to lower its price as it will end up selling at a lower price its entire expected production. It is also not optimal for firm i to increase its price as it can increase profits by increasing the expected quantity sold.[2] Because of the production constraint, firms charge a positive markup $(p_t - c)/c$.[3]

After the price is set, firms learn the realization of their production. Incumbent firms that generate negative profits are forced to default. Invoking the law of large numbers, the mass of defaulting firms X_t and the mass of surviving incumbent firms S_t are:

$$X_t = m_t \int_0^{\frac{I}{p_t - c}} di = \frac{m_t I}{p_t - c} \qquad S_t = m_t \int_{\frac{I}{p_t - c}}^1 di = m_t \left(1 - \frac{I}{p_t - c}\right). \quad \text{(IA.2)}$$

Potential entrant firms that generate profits enter the market. The mass of

[2]If α_t is large enough, the marginal revenue is greater than the marginal cost, that is, the firm can increase profits by lowering the price and, in turn, increasing the quantity produced.

[3]The price p_t is determined in terms of cost as the numeraire. In our environment, we implicitly assume a form of rigidity on the cost side.

entrants is:

$$E_t = e \int_{\frac{I}{p_t - c}}^{1} di = e \left(1 - \frac{I}{p_t - c} \right). \tag{IA.3}$$

Total production N_t is the sum of the production of entrants and surviving incumbents:

$$N_t = (e + m_t) \frac{1}{2} \left(1 - \left(\frac{I}{p_t - c} \right)^2 \right). \tag{IA.4}$$

Equilibrium. We now define an equilibrium without zombie credit (EqN) and an equilibrium with zombie lending (EqZ).

DEFINITION 1: *Given the demand parameter α, fixed cost I, marginal cost c, an equilibrium without zombie credit (EqN) is price p_t, incumbents m_t, production N_t such that the product price is given by* (IA.1)*, total production is given by* (IA.4)*, and the number of incumbent firms follows $m_{t+1} = m_t + E_t - X_t$.*

The equilibrium without zombie credit (EqN) is governed by three conditions. First, the price of the good follows Lemma 1. Second, total production is the sum of the production of firms that enter the market and production of incumbent firms that survive. Third, the incumbent firms at $t + 1$ are the sum of incumbent firms at time t plus entrant firms at time t minus defaulting firms at time t. Formally:

$$p_t = \alpha_t - \frac{m_t}{2}$$

$$m_{t+1} = m_t + \overbrace{e\left(1 - \frac{I}{p_t - c}\right)}^{E_t} - \overbrace{\frac{m_t I}{p_t - c}}^{X_t}$$

$$N_t = (e + m_t)\frac{1}{2}\left(1 - \left(\frac{I}{p_t - c}\right)^2\right)$$

In steady state, $m_{t+1} = m$ and defaults are exactly offset by entry. Formally:

$$p^* = \alpha - \frac{m^*}{2} \quad \text{and} \quad \underbrace{\frac{m^* I}{p^* - c}}_{X^*} = \underbrace{e\left(1 - \frac{I}{p^* - c}\right)}_{E^*}$$

$$\Rightarrow \quad m^* = \frac{e(\alpha - c - I)}{I + \frac{e}{2}} \qquad p^* = \frac{2\alpha I + e(c + I)}{2I + e} \qquad N^* = \frac{e + m^*}{2}\left(1 - \left(\frac{I}{p^* - c}\right)^2\right)$$

where $\frac{\partial m^*}{\partial \alpha} > 0$, $\frac{\partial p^*}{\partial \alpha} > 0$, $\frac{\partial p^*}{\partial I} > 0$, and $\frac{\partial^2 p^*}{\partial \alpha \partial I} > 0$.

The equilibrium with zombie credit is characterized by four conditions. First, the price of the good follows Lemma 1. Second, total production is the sum of the production of firms that enter the market plus the production of surviving firms, including the production of zombie firms. Third, defaults are such that zombie firms are $\overline{Z}$. Specifically, we assume that, in the productivity distribution, banks with zombie lending incentives keep firms from zero to $\overline{Z}/m$ alive, leading to a number of "saved" firms equal to $\overline{Z}$. Fourth, the incumbent firms at $t + 1$ are the sum of incumbent firms at time t plus entrant firms at time t minus defaulting firms at time t. Formally:

$$p_t = \alpha_t - \frac{m_t}{2} \tag{IA.5}$$

$$m_{t+1} = m_t + \overbrace{e\left(1 - \frac{I}{p_t - c}\right)}^{E_t} - \overbrace{\left(\frac{m_t I}{p_t - c} - \overline{Z}\right)}^{X_t} \tag{IA.6}$$

$$N_t = (e + m_t)\frac{1}{2}\left(1 - \left(\frac{I}{p_t - c}\right)^2\right) + \frac{\overline{Z}^2}{2m_t} \quad \text{where} \quad \frac{\overline{Z}^2}{2m_t} = m_t \int_0^{\frac{\overline{Z}}{m_t}} idi \tag{IA.7}$$

DEFINITION 2: *Given the demand parameter α, fixed cost I, marginal cost c, and zombie firms $\overline{Z}$, an equilibrium with zombie credit (EqZ) is price p_t, incumbents m_t, production N_t such that the product price is given by* (IA.1)*, total production is given by* (IA.7)*, $\overline{Z}$ firms are prevented from defaulting, and the number of incumbent firms follows $m_{t+1} = m_t + E_t - X_t$.*

In steady state, $m_{t+1} = m$ (and defaults are exactly offset by entry).

$$p^{**} = \alpha - \frac{m^{**}}{2} \quad \text{and} \quad \frac{m^{**}I}{p^{**} - c} - \overline{Z} = e\left(1 - \frac{I}{p^{**} - c}\right)$$

$$\Rightarrow \quad m^{**} = \frac{e(\alpha - c - I) + \overline{Z}(\alpha - c)}{I + \frac{e}{2} + \frac{\overline{Z}}{2}} \qquad p^{**} = \frac{2\alpha I + e(c + I) + \overline{Z}c}{2I + e + \overline{Z}}$$

$$N^{**} = (e + m^{**})\frac{1}{2}\left(1 - \left(\frac{I}{p^{**} - c}\right)^2\right) + \frac{\overline{Z}^2}{2m^{**}}$$

Insights. The main insight is that the equilibrium with zombie lending is characterized by lower prices and higher aggregate production compared with an equilibrium without zombie lending. Formally, we have the following

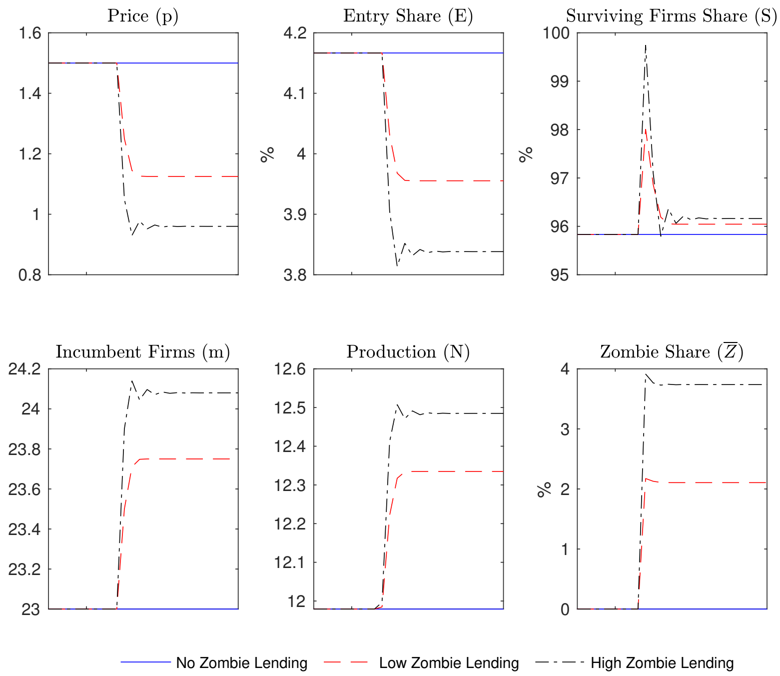

Figure IA.1. Responses to positive zombie credit shock. This figure shows how equilibrium quantities and prices respond to a permanent increase in $\overline{Z}$. The dashed lines indicate an equilibrium with low zombie credit. The dash-dot lines indicate an equilibrium with high zombie credit. The parameters are $I = 0.05$, $e = 1$, $c = 0.3$, $\alpha = 13$, $\overline{Z}^L = 0.5$, and $\overline{Z}^H = 0.9$.

proposition.

Proposition 1: *In the equilibrium with zombie credit, in steady state, fewer firms default, there are more incumbent firms, the price and markup are lower, and fewer firms enter compared with the steady state in an equilibrium without zombie credit.*

Proof. Note that if $\overline{Z} = 0$, $p^{**} = p^*$ and $m^{**} = m^*$. We also have that:

$$m^{**} - m^* = \frac{I(\alpha - c + \frac{e}{2})}{(I + \frac{e}{2} + \frac{\overline{Z}}{2})(I + \frac{e}{2})}\overline{Z} \geq 0 \quad \text{and} \quad p^{**} - p^* = -\frac{I(\alpha - c + \frac{e}{2})}{(I + \frac{e}{2} + \frac{\overline{Z}}{2})(2I + e)}\overline{Z} \leq 0$$

Given the equilibrium conditions for EqN and EqZ, it then follows that markups, defaults,

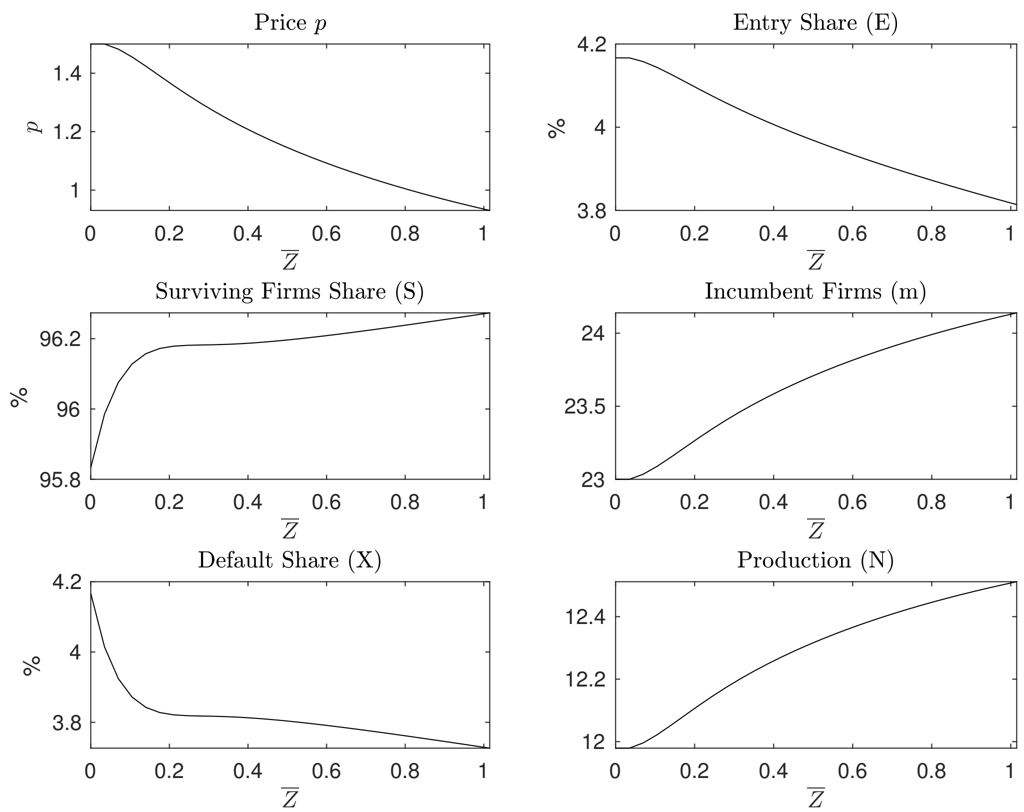

Figure IA.2. Steady state equilibrium prices as zombie credit changes – Extensive margin model. This figure shows how equilibrium steady state quantities and prices respond to changes in $\overline{Z}$. The parameters are $I = 0.05$, $e = 1$, $c = 0.3$, $\alpha = 13$, and $\overline{Z}^L \in$[0,1].

and entry are lower in EqZ compared with EqN. □

These results can be shown graphically using simple numerical exercises, which qualitatively illustrate the dynamics generated by the framework described above. Figure IA.1 shows how an economy in a steady state with no zombie lending adjusts to a sudden and permanent increase in zombie lending—to an economy with low zombie lending (dashed line) and an economy with high zombie lending (dash-dot line). Comparing EqN and EqZ steady states, we observe that (i) prices and entry are lower and (ii) survivors, incumbents, and production are higher as zombie lending increases.

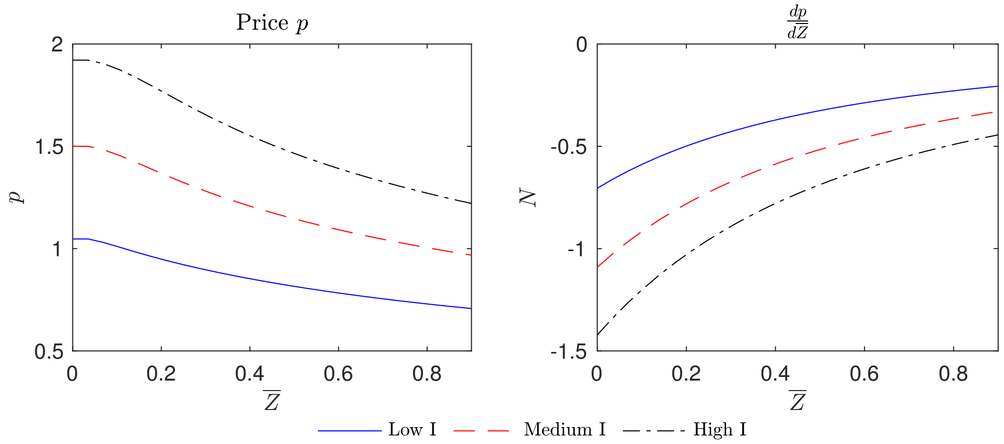

Figure IA.3. Sensitivity with respect to I – Extensive margin model. This figure shows how equilibrium steady state prices respond to changes in $\overline{Z}$. The parameters are $e = 1$, $c = 0.3$, $\alpha = 13$, and $\overline{Z} \in [0, 1]$. The figure shows the collection of equilibria for $I = \{0.03, 0.05, 0.07\}$.

Figure IA.2 shows how steady state equilibrium quantities and prices change as we increase $\overline{Z}$. This collection of steady state equilibria confirms the insights discussed above.

Figure IA.3 shows how the relationship between zombie lending and prices changes as we vary the fixed cost I. The figure shows that, for a high zombie prevalence, the decline in price associated with an increase in zombie lending is more pronounced for high fixed costs. Analytically, $\frac{\partial^2 p^{**}}{\partial \overline{Z} \partial I} < 0$ if $\overline{Z} > 2I - e$.

Input costs. The framework described above can be adapted to analyze the effect of zombie lending on input costs. Specifically, consider an environment where the product price is exogenous, there is an exogenous supply of input $L_t = c_t - \mu_t$ (where c_t is the price of input and marginal cost for each firm i), and—after paying the fixed cost I—firms set the price c_t of the input, knowing that their expected production is 1/2. In this environment, the two equilibrium definitions take the product price as given and display the equilibrium condition for the input cost: $c_t = \frac{m_t}{2} + \mu_t$. The intuition for this expression follows the intuition from Lemma 1. Firms set the marginal cost of input c_t such that the total demand for the input equals its supply at the price c_t. It is easy to show that, in this environment, an increase in zombie lending leads to a decrease in the (now exogenous) product price on the (now endogenous) marginal cost.

I.2. Intensive Margin Model

In this section, we extend the extensive margin framework from Section I.1 and allow firms to decide how much they produce, thereby adding an intensive margin effect to our model framework.

Setup. Consider the framework discussed in Section I.1. To keep the intensive margin extension tractable, we assume that firms consider the market price as given, the exogenous demand is given by $D_t(p_t) = \alpha_t - \beta p_t$, and, in equilibrium, the price p_t is such that the aggregate production equals demand at this price. Consider also exogenous variation in I, which can be interpreted as operating and/or financial leverage. We assume that for both incumbent and entrant firms I is distributed over the interval $[0, \bar{I}]$ and according to a distribution $G(I)$.

Let y_{it} be the (now endogenously chosen) production scale of firm i at time t, where we assume that firms' maximum output quantity is equal to 1. In an intermediate period (i.e., between the production decision and production outcome), with probability $1 - q(y)$, a large additional production expenditure, $\overline{\delta}$, needs to be incurred to continue production, where $q' < 0$,

$q'' \leq 0$, $q(0) \leq 1$, and $q(1) \geq 0$. That is, the likelihood that the additional production costs arise increases with the chosen production scale. If these additional production costs arise, the NPV of continuing the production process turns negative, irrespective of I (i.e., for all firms). In the following, we refer to this state as the "bad state."

However, with probability z, firms with $I > \widehat{I}$ (i.e., highly levered firms) receive zombie credit in the bad state. That is, they are "bailed out" by their bank through an injection of a sufficiently large subsidy that lets the firm break even (i.e., having zero profits) when paying the additional production expenditure and continuing production. Without a bailout by its bank in the bad state, a firm stops producing. Consequently, the firm's output is zero, it defaults, and incurs the bankruptcy cost δ. The fact that zombie credit potentially saves firms with $I > \widehat{I}$ from incurring the bankruptcy cost creates an incentive to take higher risks for these firms (see, e.g., Allen and Gale (2004) for a similar risk-taking model setup).

The maximization problem for a firm with $I \in (\widehat{I}, \bar{I}]$ is given by:

$$max_{y_{it} \in [0,1]} (M_t y_{it} - I) q(y_{it}) - (1 - q(y_{it}))(1 - z)\delta, \tag{IA.8}$$

where $M_t = p_t - c$ is the markup. With probability $q(y_{it})$, the firm's production works seamlessly, in which case the firm receives the output times the margin net of I. With probability $1 - q(y_{it})$, the additional production expenditures arise. When the firm is bailed out by its bank, which happens with probability z, it receives zero profit. With probability $1 - z$, the firm is not rescued, fails, and incurs the bankruptcy cost δ.

Taking the first-order condition (FOC) of Eq. (IA.8) with respect to the production scale yields:

$$M_t q(y_{it}) + (M_t y_{it} - I + \delta(1-z))q'(y_{it}) = 0. \tag{IA.9}$$

Hence, the optimal production scale for a firm with $I \in (\widehat{I}, \bar{I}]$ is a function of I and the probability of being rescued by zombie credit in the bad state, z. The implicit differentiation of the production scale from Eq. (IA.9) with respect to z yields:

$$\frac{\partial y_{it}}{\partial z} = \frac{\delta q'(y_{it})}{2M_t q'(y_{it}) + (M_t y_{it} - I + \delta(1-z))q''(y_{it})} > 0, \tag{IA.10}$$

which shows that a higher likelihood of receiving zombie credit in the bad state pushes the production scale choice of a firm with $I \in (\widehat{I}, \bar{I}]$ upwards. Moreover, the implicit differentiation of the production scale of firm i (with $I \in (\widehat{I}, \bar{I}]$) with respect to I yields:

$$\frac{\partial y_{it}}{\partial I} = \frac{q'(y_{it})}{2M_t q'(y_{it}) + (M_t y_{it} - I + \delta(1-z))q''(y_{it})} > 0. \tag{IA.11}$$

Similarly, for a firm with $I \in [0, \hat{I}]$, the maximization problem becomes:

$$max_{y_{it} \in [0,1]}(M_t y_{it} - I)q(y_{it}) - (1 - q(y_{it}))\delta, \tag{IA.12}$$

where the FOC with respect to y_{it} is given by:

$$M_t q(y_{it}) + (M_t y_{it} - I + \delta)q'(y_{it}) = 0. \tag{IA.13}$$

Note that, in this case, z does not affect the firms' production choices. The implicit differentiation of the production scale from Eq. (IA.13) with respect to I yields:

$$\frac{\partial y_{it}}{\partial I} = \frac{q'(y_{it})}{2M_t q'(y_{it}) + (M_t y_{it} - I + \delta)q''(y_{it})} > 0. \tag{IA.14}$$

The intuition underlying Eqs. (IA.11) and (IA.14) is as follows. A higher I gives firms an incentive to increase their output quantity since this raises their expected profits: while it lowers the likelihood of the good state occurring, it increases the profits $(M_t y_{it} - I)$ in the good state. This benefit of choosing a higher output quantity when I is high is equal for both types of firms (i.e., for firms with I below and above $\widehat{I}$). The cost of a higher production scale is that it increases the likelihood of the bad state occurring. However, this cost is less severe for firms with $I > \widehat{I}$ as they potentially benefit from zombie credit, which lowers their expected bankruptcy costs. Hence, increasing the output quantity is less "costly" for these firms in the bad state. Consequently, it holds that:

$$\frac{\partial y_{it}^2}{\partial I \partial z} = \frac{\delta q'(y_{it})q''(y_{it})}{\left(2M_t q'(y_{it}) + (M_t y_{it} - I + \delta(1-z))q''(y_{it})\right)^2} > 0. \tag{IA.15}$$

Hence, an increase in I pushes the production scale more strongly upwards when the zombie credit level, z, is higher, which also directly follows from comparing Eqs. (IA.11) and (IA.14). Similarly, an increase in z pushes the output quantity more strongly upwards when I is larger.

As in the extensive margin model, suppose that in each period t there is a mass m_t of incumbent firms and a mass e of potential entrants. The problem of entrant firms is similar to the one of the incumbents, with two differences. First, firms that have just entered the market are never bailed out in the bad state, even if $I \in (\widehat{I}, \bar{I}]$. This assumption captures the fact that banks only provide zombie credit to firms to which they have pre-existing lending relationships and which are thus somewhat mature and already in the market. Second, potential entrants have to sustain a setup cost K to enter the market. Hence, these firms enter only if they expect to make positive profits net of this entry cost. Given the optimal production choice $y^*(I)$ of a potential entrant firm with leverage I, this firm enters the market if and only if:

$$(M_t y_{it}^*(I) - I)q(y_{it}^*(I)) - (1 - y_{it}^*(I))\delta > K. \tag{IA.16}$$

Condition (IA.16) implies that a potential entrant firm enters the market if and only if its leverage belongs to a set which we denote $\mathcal{I}_{\mathcal{E}}$.

Equilibrium. Let F_t be the total number of firms in the economy in period t (i.e., incumbents and new entrants). Given that a firm defaults with probability $(1 - q(y_{it}))(1 - z)$ if $I \in (\hat{I}, \bar{I}]$ and with probability $1 - q(y_{it})$ if $I \in [0, \hat{I}]$, the law of large numbers implies that the fraction of incumbent firms that default in each period is:

$$X_t = m_t \left[\int_0^{\hat{I}} [1 - q(y_{it}^*(I))] dG(I) + (1 - z) \int_{\hat{I}}^{\bar{I}} [1 - q(y_{it}^{**}(I))] dG(I) \right] \Big/ F_t, \tag{IA.17}$$

where y_{it}^* denotes the optimal production choice of entrant firms and incumbents with $I \in [0, \hat{I}]$, and y_{it}^{**} the optimal production choice of incumbents firms with $I \in (\hat{I}, \bar{I}]$. Moreover, the fraction of surviving incumbents is:

$$S_t = m_t\Big[\int_0^{\hat{I}} q(y_{it}^*(I))dG(I) + \int_{\hat{I}}^{\bar{I}} q(y_{it}^{**}(I))dG(I) + z\int_{\hat{I}}^{\bar{I}} [1 - q(y_{it}^{**}(I))]dG(I)\Big]\Big/F_t. \tag{IA.18}$$

Finally, the total fraction of surviving entrants is:

$$E_t = e\int_{\mathcal{I}_\mathcal{E}} q(y_{it}^*(I))dG(I)\Big/F_t. \tag{IA.19}$$

Hence, aggregate production is given by:

$$N_t = m_t\Big(\int_0^{\hat{I}} q(y_{it}^*(I))y_{it}^*(I)dG(I) + \int_{\hat{I}}^{\bar{I}} q(y_{it}^{**}(I))y_{it}^{**}(I)dG(I) + z\int_{\hat{I}}^{\bar{I}} [1 - q(y_{it}^{**}(I))]y_{it}^{**}(I)dG(I)\Big) + e\int_0^{\mathcal{I}_\mathcal{E}} q(y^*(I))y^*(I)dG(I). \tag{IA.20}$$

Accordingly, the steady state equilibrium is characterized by the following two conditions:

$$\alpha - \beta p^{**} = m^{**}\Big(\int_0^{\hat{I}} q(y^*(I))y^*(I)dG(I) + \int_{\hat{I}}^{\bar{I}} q(y^{**}(I))y^{**}(I)dG(I) + z\int_{\hat{I}}^{\bar{I}} [1 - q(y^{**}(I))]y^{**}(I)dG(I)\Big) + e\int_{\mathcal{I}_\mathcal{E}} q(y^*(I))y^*(I)dG(I), \tag{IA.21}$$

$$m^{**}\Big(\int_0^{\hat{I}} [1 - q(y^*(I))]dG(I) + (1-z)\int_{\hat{I}}^{\bar{I}} [1 - q(y^{**}(I))]dG(I)\Big) = e\int_{\mathcal{I}_\mathcal{E}} q(y^*(I))dG(I), \tag{IA.22}$$

where p^{**} and m^{**} denote the equilibrium values for the case where we have an economy with $z > 0$. The first condition comes from the fact that, in equilibrium, the price p_t is such that the aggregate production equals demand at this price. The second condition states that in steady state, $m_{t+1} = m_t = m$ and defaults are exactly offset by entry.

To obtain closed-form solutions for the equilibrium quantities, we assume in the following that I is uniformly distributed over $[0, \overline{I}]$ and that $q(y) = 1 - \theta y$ with $\theta \in (0, 1]$. From the firms' FOCs, we then get:

$$y^{**} = \min\left\{\frac{1}{2}\left(\frac{1}{\theta} + \frac{I-(1-z)\delta}{p-c}\right), 1\right\} \text{ and}$$
$$q(y^{**}) = \begin{cases} \frac{1}{2}\left(1 - \frac{\theta(I-(1-z)\delta)}{p-c}\right) & \text{if } y^{**} = \frac{1}{2}\left(\frac{1}{\theta} + \frac{I-(1-z)\delta}{p-c}\right) \\ 1-\theta & \text{if } y^{**} = 1 \end{cases}$$

if $I \in (\hat{I}, \bar{I}]$, and

$$y^{*} = \min\left\{\frac{1}{2}\left(\frac{1}{\theta} + \frac{I-\delta}{p-c}\right), 1\right\} \quad \text{and} \quad q(y^{*}) = \begin{cases} \frac{1}{2}\left(1 - \frac{\theta(I-\delta)}{p-c}\right) & \text{if } y^{*} = \frac{1}{2}\left(\frac{1}{\theta} + \frac{I-\delta}{p-c}\right) \\ 1-\theta & \text{if } y^{*} = 1 \end{cases}$$

if $I \in [0, \hat{I}]$ or the firm is a potential entrant. Note that, for a firm with $I \in (\hat{I}, \bar{I}]$, the production constraint is binding if:

$$I \geq I_z := (2 - 1/\theta)(p-c) + (1-z)\delta, \tag{IA.23}$$

and for a firm with $I \in [0, \hat{I}]$ if:

$$I \geq I_{nz} := (2 - 1/\theta)(p-c) + \delta. \tag{IA.24}$$

Given the optimal production choice of a potential entrant, and with the assumed functional form for $q(y)$, Condition (IA.16) becomes

$$\left[\frac{p-c}{2}\left(\frac{1}{\theta}+\frac{I-\delta}{p-c}\right)-I\right]\frac{1}{2}\left(1-\frac{\theta(I-\delta)}{p-c}\right)-\frac{1}{2}\left(1+\frac{\theta(I-\delta)}{p-c}\right)\delta>K, \tag{IA.25}$$

assuming a nonbinding production constraint. Hence, a potential entrant firm will only enter if and only if Condition (IA.25) is satisfied. Condition (IA.25) has two roots:

$$I_{1,2}=p-c+\theta\delta\pm 2\sqrt{(p-c)\theta(\delta+K)}. \tag{IA.26}$$

For reasonable parameter ranges, the first root of Condition (IA.25) is always greater than $\bar{I}$. Hence, Condition (IA.25) translates into:

$$I<\mathcal{I}_{\mathcal{E}}:=p-c+\theta\delta-2\sqrt{(p-c)\theta(\delta+K)}. \tag{IA.27}$$

An analogous condition can be obtained in case of a binding production constraint.

Insights. Figure IA.4 qualitatively illustrates, using simple numerical exercises, how the equilibrium quantities in the intensive margin model change as the probability of being rescued by zombie credit in case of a failure increases. All results from the extensive margin model continue to hold in the intensive margin framework.

Interestingly, adding the intensive margin effects reveals a shift in the quantity supplied from non-zombie to zombie firms as a result from the

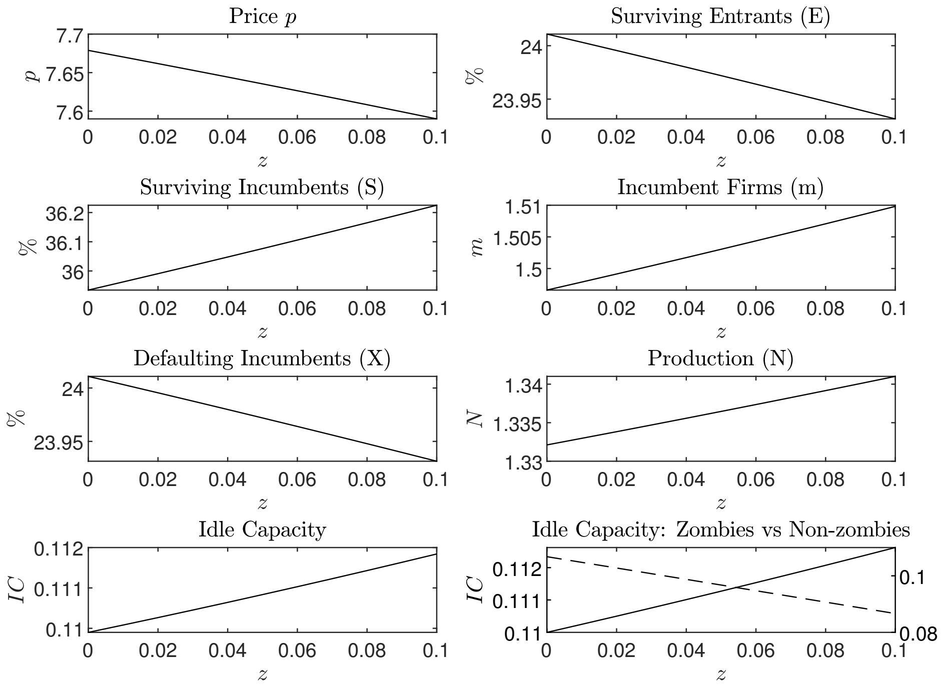

Figure IA.4. Steady state equilibrium prices as zombie credit changes – Intensive margin model. This figure shows how equilibrium steady state quantities and prices respond to changes in z. In the last panel, zombies (right axis) are the dashed line, non-zombies (left axis) are the solid line. The parameters are $e = 1$, $c = 0.1$, $\alpha = 2.1$, $\beta = 0.1$, $\delta = 3.4$, $K = 0.5$, $\theta = 0.45$, $\hat{I} = 0.095$, and $I \in [0, 0.1]$.

prevalence of zombie credit. By lowering the expected costs associated with choosing a higher output quantity (i.e., higher expected bankruptcy costs), zombie credit incentivizes the affected firms to "overproduce"—lifting aggregate supply through the intensive margin.

At the same time, through the previously described extensive margin effect, zombie credit induces both, zombies and non-zombie firms, to produce less because of the elevated aggregate supply (which is caused by the survival of zombie firms and their overproduction) and the resulting lower equilibrium price. Overall, zombie credit thus increases aggregate supply, but with asymmetric effects on the individual production scale of zombie and non-zombie

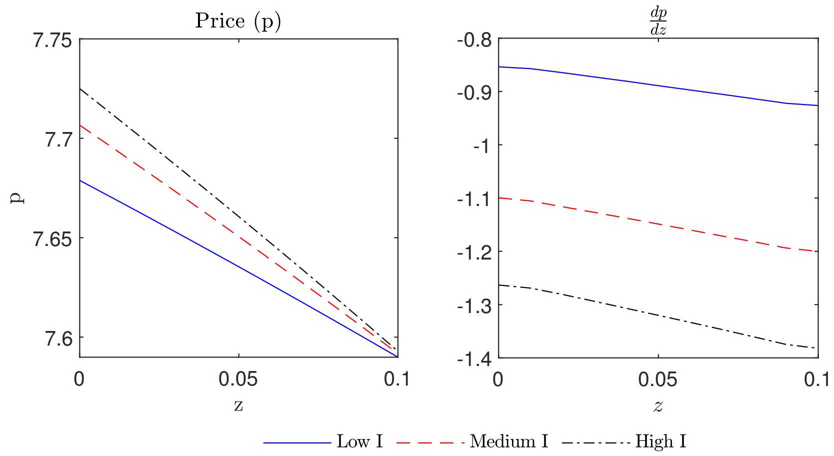

Figure IA.5. **Sensitivity of price with respect to I – Intensive margin model.** This figure shows how equilibrium steady state prices respond to changes in z, for different supports of I. The parameters are $e = 1$, $c = 0.1$, $\alpha = 2.1$, $\beta = 0.1$, $\delta = 3.4$, $K = 0.5$, and $\theta = 0.45$. The figure shows the collection of equilibria for $I \in [\varepsilon, 0.1+\varepsilon]$, $\varepsilon \in \{0, 0.03, 0.05\}$. $\hat{I}$ is such that in each case 5% of firms are zombies.

firms. It has a strictly negative effect on the production scale of non-zombie firms due to the lower equilibrium price, and two opposing effects on the production scale of zombie firms: positive due to the incentive to overproduce and negative due to the lower equilibrium price.

Furthermore, as in the extensive margin model, the negative relationship between price and zombie lending is stronger in industries characterized by a higher I (see Figure IA.5). The intuition is that zombie credit lowers firms' expected bankruptcy costs associated with sustaining a high fixed costs base and the resulting high optimal production scale.

In our model, each firm can choose to produce at most an output quantity equal to 1, which can be interpreted as the production capacity. By comparing the actual production choice of each firm with the potential output of 1,

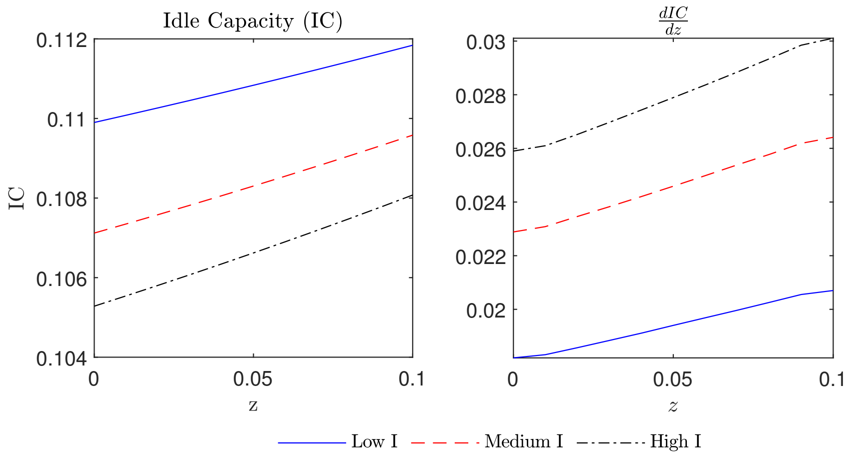

Figure IA.6. Sensitivity of idle capacity with respect to I – Intensive margin model. This figure shows how equilibrium steady state prices respond to changes in z, for different supports of I. The parameters are $e = 1$, $c = 0.1$, $\alpha = 2.1$, $\beta = 0.1$, $\delta = 3.4$, $K = 0.5$, and $\theta = 0.45$. The figure shows the collection of equilibria for $I \in [\varepsilon, 0.1 + \varepsilon]$, $\varepsilon \in \{0, 0.03, 0.05\}$. $\hat{I}$ is such that in each case 5% of firms are zombies.

we can measure the average idle capacity in the economy as:

$$Idle\ Capacity = \frac{m \int_0^{\bar{I}} (1 - y(I)) dG(I) + e \int_{I_E} (1 - y(I)) dG(I)}{m + eE}$$

The lower-left panel in Figure IA.4 shows that the average idle capacity increases with zombie credit. This result suggests that for markets with a high zombie prevalence, the lower production level for non-zombie firms as a consequence of the elevated number of active firms, and the resulting lower equilibrium price, can outweigh the incentive of zombies to overproduce in anticipation of potentially being supported with zombie credit.

The decomposition of the idle capacity result into the change for zombie and non-zombie firms in the lower-right panel of Figure IA.4 confirms this intuition: idle capacity increases with z for non-zombie firms and decreases with z for zombie firms.

Finally, Figure IA.6 shows that the positive relationship between idle capacity and zombie lending is stronger in industries characterized by a higher I.

II. Markup Estimation

To obtain firm-level markups, we follow the procedure proposed in De Loecker and Warzynski (2012), which relies on the insight that the output elasticity of a variable production factor is only equal to its expenditure share in total revenue when price equals marginal cost of production. Under any form of imperfect competition, however, the relevant markup drives a wedge between the input's revenue share and its output elasticity.

In particular, this approach relies on standard cost minimization conditions for variable input factors free of adjustment costs. To obtain output elasticities, a production function has to be estimated. A major challenge is a potential simultaneity bias since the output may be determined by productivity shocks, which might be correlated with a firm's input choice.

To correct the markup estimates for unobserved productivity shocks, De Loecker and Warzynski (2012) follows the control function or proxy approach, developed by Ackerberg, Caves, and Frazer (2015), based on Olley and Pakes (1996) and Levinsohn and Petrin (2003). This approach requires a production function with a scalar Hicks-neutral productivity term (i.e., changes in productivity do not affect the proportion of factor inputs) and that firms can be pooled together by time-invariant common production technology at the industry-country level.

Hence, we consider the case where in each period t, firm i minimizes the contemporaneous production costs given the following production function:

$$Q_{ijt} = Q_{ijt}(\Omega_{ijt}, V_{ijt}, K_{ijt}), \tag{IA.28}$$

where Q_{ijt} is the output quantity produced by technology $Q_{ijt}(\cdot)$, V_{ijt} the variable input factor, K_{ijt} the capital stock (treated as a dynamic input in production), and Ω_{ijt} the firm-specific Hicks-neutral productivity term. Following De Loecker, Eeckhout, and Unger (2019), we assume that within a year the variable input can be adjusted without frictions, while adjusting the capital stock involves frictions.

As we assume that producers are cost minimizing, we have the following Lagrangian:

$$\mathcal{L}(V_{ijt}, K_{ijt}, \lambda_{ijt}) = P_{ijt}^{V} V_{ijt} + r_{ijt} K_{ijt} + F_{ijt} - \lambda_{ijt}(Q(\cdot) - \overline{Q}_{ijt}), \qquad \text{(IA.29)}$$

where P^V is the price of the variable input, r is the user cost of capital, F_{ijt} is the fixed cost, and λ_{ijt} is the Lagrange multiplier. The first order condition with respect to the variable input V is thus given by:

$$\frac{\partial \mathcal{L}_{ijt}}{\partial V_{ijt}} = P_{ijt}^{V} - \lambda_{ijt} \frac{\partial Q(\cdot)}{\partial V_{ijt}} = 0. \qquad \text{(IA.30)}$$

Multiplying by V_{ijt}/Q_{ijt}, and rearranging terms yields an expression for input V's output elasticity:

$$\theta_{ijt}^{v} \equiv \frac{\partial Q(\cdot)}{\partial V_{ijt}} \frac{V_{ijt}}{Q_{ijt}} = \frac{1}{\lambda_{ijt}} \frac{P_{ijt}^{V} V_{ijt}}{Q_{ijt}}. \qquad \text{(IA.31)}$$

As the Lagrange multiplier λ is the value of the objective function as we relax the output constraints, it is a direct measure of the marginal costs. We thus define the markup as $\mu = P/\lambda$, where P is the price for the output good, which depends on the extent of market power. Substituting marginal costs for the markup/price ratio, we obtain a simple expression for the markup:

$$\mu_{ijt} = \theta^{v}_{ijt} \frac{P_{ijt} Q_{ijt}}{P^{V}_{ijt} V_{ijt}}. \tag{IA.32}$$

Hence, there are two ingredients needed to estimate the markup of firm i: its expenditure share of the variable input, $P_{ijt}Q_{ijt}/P^{V}_{ijt}V_{ijt}$, which is readily observable in the date, and its output elasticity of the variable input, θ^{v}_{ijt}.

To obtain an estimate of the output elasticity of the variable input of production, we estimate a parametric production function for each industry (at the 2-digits NACE level).

For a given industry h in country j, we consider the translog production function (TLPF):[4]

$$q_{ijt} = \beta_{v1} v_{ijt} + \beta_{k1} k_{ijt} + \beta_{v2} v^{2}_{ijt} + \beta_{k2} k^{2}_{ijt} + \omega_{ijt} + \epsilon_{ijt}. \tag{IA.33}$$

where lower cases denote logs.[5] In particular, q_{ijt} is the log of the realized firm's output (i.e., deflated turnover), v_{ijt} the log of the variable input factor

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[4]The TLPF is a common technology specification that includes higher order terms that is more flexible than, e.g., a Cobb-Douglas production function. The departure from the standard Cobb-Douglas production function is important for our purpose. If we were to restrict the output elasticities to be independent of input use intensity when analyzing how markup differs across firms, we would be attributing variation in technology to variation in markups, and potentially bias our results. (e.g., when comparing zombie vs non-zombie firms).

[5]Following De Loecker, Eeckhout, and Unger (2019), we do not consider the interaction term between v and k to minimize the potential impact of measurement error in capital to contaminate the parameter of most interest, i.e., the output elasticity.

(i.e., cost of goods sold and other operational expenditures), k_{ijt} the log of the capital stock (i.e., tangible assets), $\omega_{ijt} = ln(\Omega_{ijt})$, and ϵ_{ijt} is the unanticipated shock to output.[6] Moreover, we follow best practice and deflate these variables with the relevant industry-country specific deflator.

We follow the literature and control for the simultaneity and selection bias, inherently present in the estimation of Eq. (IA.33), and rely on a control function approach, paired with a law of motion for productivity, to estimate the output elasticity of the variable input.

This method relies on a so-called two-stage approach. In the first stage, the estimates of the expected output ($\widehat{\phi}_{ijt}$) and the unanticipated shocks to output (ϵ_{ijt}) are purged using a non-parametric projection of output on the inputs and the control variable:

$$q_{ijt} = \phi_{ijt}(v_{ijt}, k_{ijt}) + \epsilon_{ijt}. \tag{IA.34}$$

The second stage provides estimates for all production function coefficients by relying on the law of motion for productivity:

$$\omega_{ijt} = g_t(\omega_{ijt-1}) + \varepsilon_{ijt}. \tag{IA.35}$$

We can compute productivity for any value of β, where $\beta = (\beta_{v1}, \beta_{k1}, \beta_{v2}, \beta_{k2})$, using $\omega_{ijt}(\beta) = \widehat{\phi}(\beta_{v1}v_{ijt} + \beta_{k1}k_{ijt} + \beta_{v2}v_{ijt}^2 + \beta_{k2}k_{ijt}^2)$. By

[6] De Loecker and Warzynski (2012) shows that when relying on revenue data (instead of physical output), only the markup level is potentially affected but not the estimate of the correlation between markups and firm-level characteristics or how markups change over time.

nonparametrically regressing $\omega_{ijt}(\beta)$ on its lag, $\omega_{ijt-1}(\beta)$, we recover the innovation to productivity given β, $\varepsilon_{ijt}(\beta)$.

This gives rise to the following moment conditions, which allow us to obtain estimates of the production function parameters:

$$E\left(\varepsilon_{ijt}(\beta)\begin{pmatrix} v_{ijt-1} \\ k_{ijt} \\ v_{ijt-1}^2 \\ k_{ijt}^2 \end{pmatrix}\right) = 0, \tag{IA.36}$$

where we use standard GMM techniques to obtain the estimates of the production function and rely on block bootstrapping for the standard errors. These moment conditions exploit the fact that the capital stock is assumed to be decided a period ahead and thus should not be correlated with the innovation in productivity. We rely on the lagged variable input to identify the coefficients on the current variable input since the current variable input is expected to react to shocks to productivity.

The output elasticities are computed using the estimated coefficients of the production function:

$$\theta_{ijt}^{v} = \widehat{\beta}_{v1} + 2\widehat{\beta}_{v2}v_{ijt}, \tag{IA.37}$$

which allows us to calculate the markup of firm i.

For the misallocation tests from Table XII, we slightly deviate from the procedure outlined in this section. Specifically, for these tests, we include the intermediate inputs (measured as material costs in Amadeus) and labor inputs as separate factors in the markup and output elasticity estimation (instead of considering them as a single variable input factor, i.e., the sum of COGS and other OPEX). We then estimate the markups based on the intermediate inputs, which allows us to also determine the marginal revenue product of labor in addition to the MRPK.

III. Additional Tables

Table IA.I. CPI growth – Without extreme markets. In this table, we redo the analysis from Panel B of Table II, but drop extreme markets with less than -50% or more than +50% annual CPI growth. The dependent variable is the annual CPI growth rate (inflation) from $t-1$ to t. *Share Zombies* measures the asset-weighted share of zombie firms in a particular market at $t-1$. A firm is classified as zombie if it is low-quality and paid advantageous interest rates (see Section II.B for more details). All regressions control for the asset-weighted share of low-quality firms. Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	ΔCPI	ΔCPI	ΔCPI	ΔCPI
Share Zombies	−0.021**	−0.018**	−0.024***	−0.021***
	(0.008)	(0.007)	(0.009)	(0.007)
Observations	3,833	3,833	3,833	3,833
R-squared	0.515	0.718	0.545	0.749
Country-Industry FE	✓	✓	✓	✓
Year FE	✓			
Industry-Year FE		✓		✓
Country-Year FE			✓	✓

Table IA.II. CPI growth – Alternative zombie classifications. This table presents estimation results from Specification (3). The dependent variable is the annual CPI growth rate (inflation) from $t-1$ to t. *Share Zombies* measures the asset-weighted share of zombie firms in a particular market at $t-1$. A firm is classified as zombie if it is low-quality and paid advantageous interest rates (see Section II.B for more details). Column (1) calculates median values for leverage and IC ratio at the industry-year-level. Column (2) considers solely the IC ratio criterion to define a firm as low-quality. Column (3) considers only the leverage criterion to define a firm as low-quality. Column (4) calculates the IC ratio using EBITDA/interest expenses. Column (5) adjusts the advantageous interest rate criterion of the zombie classification for differences in CPI growth across countries. Specifically, to calculate the adjusted interest rate for firm i in country h, we deduct the CPI growth in country h from $t-1$ to t from the firm's interest rate at t. To calculate the adjusted benchmark interest rate, we subtract the EU-level CPI growth from $t-1$ to t from the benchmark rate. All regressions control for the asset-weighted share of low-quality firms. Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	Def. #1	Def. #2	Def. #3	Def. #4	Def. #5
	ΔCPI	ΔCPI	ΔCPI	ΔCPI	ΔCPI
Share Zombies	−0.011***	−0.010***	−0.010***	−0.023**	−0.019***
	(0.004)	(0.004)	(0.004)	(0.010)	(0.005)
Observations	3,880	3,880	3,880	3,880	3,880
R-squared	0.754	0.754	0.754	0.764	.764
Country-Industry FE	✓	✓	✓	✓	✓
Industry-Year FE	✓	✓	✓	✓	✓
Country-Year FE	✓	✓	✓	✓	✓

Table IA.III. CPI growth – Alternative zombie share measures. This table presents estimation results from Specification (3). The dependent variable is the annual CPI growth rate (inflation) from $t-1$ to t. A firm is classified as zombie if it is low-quality and paid advantageous interest rates (see Section II.B for more details). In Columns (1) and (2) *Share Zombies* measures the turnover-weighted share of zombie firms in a particular market at $t-1$. In Column (1) we calculate the IC ratio using EBIT/interest expenses and in Column (2) using EBITDA/interest expenses. In Columns (3) and (4) we set the value of *Share Zombies* to zero if it is below 5% and 2%, respectively. In Columns (1) and (2) we control for the turnover-weighted share of low-quality firms and in Columns (3) and (4) for the asset-weighted share of low-quality firms. Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	Alt. #1 ΔCPI	Alt. #2 ΔCPI	Alt. #3 ΔCPI	Alt. #4 ΔCPI
Share Zombies	−0.019***	−0.023**	−0.025***	−0.026***
	(0.007)	(0.010)	(0.007)	(0.007)
Observations	3,880	3,880	3,880	3,880
R-squared	0.764	0.764	0.764	0.764
Country-Industry FE	✓	✓	✓	✓
Industry-Year FE	✓	✓	✓	✓
Country-Year FE	✓	✓	✓	✓

Table IA.IV. CPI growth – Single and multiple bank relationships. This table presents estimation results from Specification (3). The dependent variable is the annual CPI growth rate (inflation) from $t-1$ to t. *Share Zombies* measures the asset-weighted share of zombie firms in a particular market at $t-1$. A firm is classified as zombie if it is low-quality and paid advantageous interest rates (see Section II.B for more details). For this analysis, we additionally require for the zombie classification that the firm has only a single (Panel A) or multiple (Panel B) bank lending relationships, respectively. All regressions control for the asset-weighted share of low-quality firms. Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Panel A: Single Bank	ΔCPI	ΔCPI	ΔCPI	ΔCPI
Share Zombies	−0.019**	−0.020**	−0.023***	−0.024***
	(0.008)	(0.008)	(0.007)	(0.008)
Observations	2,080	2,080	2,080	2,080
R-squared	0.501	0.774	0.524	0.798
Panel B: Multiple Banks	ΔCPI	ΔCPI	ΔCPI	ΔCPI
Share Zombies	−0.006	−0.009	−0.006	−0.009
	(0.007)	(0.007)	(0.007)	(0.007)
Observations	2,080	2,080	2,080	2,080
R-squared	0.500	0.774	0.523	0.797
Country-Industry FE	✓	✓	✓	✓
Year FE	✓			
Industry-Year FE		✓		✓
Country-Year FE			✓	✓

Table IA.V. Instrumental variable estimation with NPL growth. This table presents the estimation results from the IV specification, where the first stage results are shown in Panel B and the second stage results in Panel A. The dependent variable in the second stage is the annual CPI growth rate (inflation). *Share Zombies* measures the asset-weighted share of zombie firms at $t-1$. *Tier-1 2009* measures the Tier-1 ratio of the banks linked to the firms in the particular market in 2009. *NPL Growth* measures the annual growth rate in non-performing loans to total loans at the country-level of the bank's country of incorporation. Bank relationships are determined using Amadeus and DealScan in Column (1), solely Amadeus in Column (2), as well as Amadeus plus DealScan for Italian firms in Column (3). Standard errors clustered at the industry-country level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Panel A: Second Stage	ΔCPI	ΔCPI	ΔCPI
$\widehat{\textit{Share Zombies}}$	−0.108**	−0.084*	−0.107**
	(0.052)	(0.045)	(0.051)
Observations	2,080	1,839	2,080
Panel B: First Stage	**Share Zombies**	**Share Zombies**	**Share Zombies**
Tier-1 2009 x (−NPL Growth)	−0.551***	−0.727***	−0.555***
	(0.168)	(0.216)	(0.168)
F-Test	26.6	32.4	27.0
Observations	2,080	1,839	2,080
R-squared	0.706	0.710	0.706
Sample	Amadeus + DealScan	Amadeus Only	Amadeus + DealScan Italy
Country-Industry FE	✓	✓	✓
Industry-Year FE	✓	✓	✓
Country-Year FE	✓	✓	✓

Table IA.VI. Summary statistics – Equilibrium predictions. This table presents summary statistics for the dependent variables in Section IV.A to Section IV.C.

	ΔActive Firms	Default	Entry	Sales Growth	Idle Capacity	ΔMarkup	Material Cost	Labor Cost
Mean	0.012	0.092	0.079	0.071	17.69	0.01	0.413	0.022
SD	0.053	0.047	0.036	0.188	8.41	0.052	0.217	0.032

Table IA.VII. Firm defaults – Evidence based on Amadeus data. This table presents estimation results from Specification (5). The dependent variable is the share of firm defaults at time t. We follow Acharya et al. (2019) to identify firm defaults based on the legal status variable in Amadeus. *Share Zombies* measures the asset-weighted share of zombie firms in a particular market at $t-1$. A firm is classified as zombie if it is low-quality and paid advantageous interest rates (see Section II.B for more details). All regressions control for the asset-weighted share of low-quality firms. Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

	Default	Default	Default	Default
Share Zombies	−0.013*	−0.015**	−0.016**	−0.018**
	(0.008)	(0.007)	(0.008)	(0.007)
Observations	2,708	2,708	2,708	2,708
R-squared	0.843	0.862	0.886	0.906
Country-Industry FE	✓	✓	✓	✓
Year FE	✓			
Industry-Year FE		✓		✓
Country-Year FE			✓	✓

Table IA.VIII. Firm-level evidence – Robustness. This table presents estimation results from Specification (5). The dependent variables are a firm's markup, EBIT/Sales, material cost (material input cost/turnover), sales growth, employment growth, or net investment. *Non-Zombie* is an indicator variable equal to one if a firm is classified as non-zombie in year t. *Share Low-Quality* measures the asset weighted share of low-quality firms in a particular market at $t-1$. Firm-level controls include net worth, leverage, ln(total assets), and the IC ratio. A firm is classified as low-quality if it has a below median IC ratio and an above median leverage. Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	Markup	EBIT/Sales	Material Cost	Sales Growth	Empl. Growth	Net Investment
Non-Zombie	0.040***	0.065***	−0.016***	0.037***	0.028***	0.006***
	(0.010)	(0.006)	(0.004)	(0.006)	(0.002)	(0.002)
Non-Zombie	0.017	0.022	−0.002	0.037	−0.008	0.001
× Share Low-Quality	(0.038)	(0.033)	(0.009)	(0.024)	(0.007)	(0.006)
Observations	4,211,633	5,910,165	4,653,410	5,922,959	3,957,765	3,817,557
R-squared	0.565	0.157	0.517	0.033	0.028	0.032
Industry-Country-Year FE	✓	✓	✓	✓	✓	✓
Firm-Level Controls	✓	✓	✓	✓	✓	✓

Table IA.IX. CPI growth – Dynamics. This table presents estimation results from Specification (3), but additionally including *Share Zombies*$_{t-2}$ (Columns 1 and 4), *Share Zombies*$_{t-2}$ and *Share Zombies*$_{t-3}$ (Columns 2 and 5) or *Share Zombies*$_{t-2}$, *Share Zombies*$_{t-3}$, and *Share Zombies*$_{t-4}$ (Columns 3 and 6). The dependent variable is the annual CPI growth rate (inflation) from $t-1$ to t. *Share Zombies*, *Share Zombies*$_{t-2}$, *Share Zombies*$_{t-3}$, and *Share Zombies*$_{t-4}$ measure the asset-weighted share of zombie firms in a particular market at $t-1$, $t-2$, $t-3$, and $t-4$, respectively. A firm is classified as zombie if it is low-quality and paid advantageous interest rates (see Section II.B for more details). All regressions control for the asset-weighted share of low-quality firms. Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	ΔCPI	ΔCPI	ΔCPI	Idle Capacity	Idle Capacity	Idle Capacity
Share Zombies$_{t-1}$	−0.029***	−0.023**	−0.020*	7.889***	7.679***	5.786**
	(0.008)	(0.010)	(0.012)	(2.421)	(2.607)	(2.715)
Share Zombies$_{t-2}$	−0.013*	−0.014**	−0.014*	4.800*	5.223**	5.235*
	(0.007)	(0.007)	(0.007)	(2.567)	(2.609)	(2.713)
Share Zombies$_{t-3}$		−0.009	−0.001		1.551	4.110
		(0.007)	(0.009)		(2.597)	(3.944)
Share Zombies$_{t-4}$			0.014*			−6.043*
			(0.008)			(3.566)
Observations	3,494	2,875	2,370	2,196	1,995	1,678
R-squared	0.779	0.797	0.781	0.833	0.838	0.850
Country-Industry FE	✓	✓	✓	✓	✓	✓
Industry-Year FE	✓	✓	✓	✓	✓	✓
Country-Year FE	✓	✓	✓	✓	✓	✓

Table IA.X. Employment growth and net investment – Firm-level evidence. This table presents estimation results from Specification (5). The dependent variables are a firm's employment growth or net investment (growth in fixed assets, set to 0 if negative). *Non-Zombie* is an indicator variable equal to one if a firm is classified as non-zombie in year t. *Productivity* is the asset productivity (sales/fixed assets) in Column (1) and labor productivity (sales/employment) in Column (2) at $t-1$. *Share Zombies* measures the asset-weighted share of zombie firms in a particular market at $t-1$. Firm-level controls include net worth, leverage, ln(total assets), and the IC ratio. A firm is classified as zombie if it is low-quality and paid advantageous interest rates (see Section II.B for more details). Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Panel A	Net Investment	Employment Growth
Non-Zombie	0.014***	0.027***
	(0.001)	(0.002)
Non-Zombie	−0.043***	−0.032***
× Share Zombies	(0.011)	(0.011)
Observations	3,028,814	3,957,765
R-squared	0.039	0.028

Panel B	Net Investment	Employment Growth
Productivity	0.035***	−0.008***
	(0.001)	(0.000)
Productivity	−0.018**	−0.008**
× Share Zombies	(0.008)	(0.003)
Observations	3,028,814	3,957,765
R-squared	0.045	0.040
Industry-Country-Year FE	✓	✓
Firm-Level Controls	✓	✓

Table IA.XI. Value added and productivity. This table presents estimation results from Specification (3). The dependent variables are *ln(Value Added)* in Panel A and asset-weighted productivity (*log(sales)–2/3*log(employment)–1/3*log(fixed assets)*) in Panel B. *Share Zombies* measures the asset-weighted share of zombie firms in a particular market at $t-1$. A firm is classified as zombie if it is low-quality and paid advantageous interest rates (see Section II.B for more details). All regressions control for the asset-weighted share of low-quality firms. Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Panel A	Value Added	Value Added	Value Added	Value Added
Share Zombie	−0.129**	−0.150***	−0.094*	−0.112**
	(0.059)	(0.054)	(0.055)	(0.051)
Observations	4,020	4,020	4,020	4,020
R-squared	0.994	0.996	0.995	0.997

Panel B	Productivity	Productivity	Productivity	Productivity
Share Zombies	−0.307***	−0.327***	−0.293***	−0.310***
	(0.099)	(0.114)	(0.100)	(0.116)
Observations	4,209	4,209	4,209	4,209
R-squared	0.905	0.916	0.909	0.920
Country-Industry FE	✓	✓	✓	✓
Year FE	✓			
Industry-Year FE		✓		✓
Country-Year FE			✓	✓

Table IA.XII. Summary statistics – Zombie share and CPI growth. This table presents summary statistics at the industry-country (NACE 1-digit) level. *Zombie Share Growth* is defined as the growth in the share of zombie firms from 2012 to 2015 in a given industry-country pair. *Average CPI Growth* is defined as the average annual inflation (CPI Growth) in a given industry-country pair.

Country	Industry	Zombie Share Growth	Average CPI Growth	Country	Industry	Zombie Share Growth	Average CPI Growth
AT	0	0	0.00610	FR	0	0.172	0.0146
AT	1	0.0577	0.0115	FR	1	0.181	0.0127
AT	2	−0.00368	0.00850	FR	2	0.0223	−0.00162
AT	3	0	0.0141	FR	3	0.0469	0.00852
AT	4	−0.00196	0.00781	FR	4	0.143	0.0105
AT	5	0.0239	0.00586	FR	5	0.0114	−0.00404
AT	6	−0.0116	0.0274	FR	6	0.150	0.00184
AT	7	0	0.0129	FR	7	0.151	0.0177
AT	8	−0.0126	0.0192	FR	8	0.0577	0.0121
AT	9	0	0.0280	FR	9	0.101	0.00898
BE	0	0.229	−0.0204	IT	0	0.185	0.00611
BE	1	0.219	−0.00113	IT	1	0.0881	0.00983
BE	2	0.0706	0.00776	IT	2	0.0324	0.00470
BE	3	0.0106	0.0116	IT	3	0.0295	0.0126
BE	4	0.0229	0.00468	IT	4	0.0575	0.0122
BE	5	0.0628	0.00963	IT	5	0.0693	0.0131
BE	6	0.0277	0.0127	IT	6	0.170	0.00434
BE	7	0.0124	0.0169	IT	7	0.0667	0.0141
BE	8	0.0154	0.0178	IT	8	0.228	0.0136
BE	9	0.0468	0.0169	IT	9	0.0809	0.00846
DE	0	0.125	0.0107	PL	0	0.0715	0.00973
DE	1	0.0227	0.0132	PL	1	0.00248	−0.00403
DE	2	−0.00368	0.00582	PL	2	0.0764	−0.00103
DE	3	−0.00782	0.0112	PL	3	0.115	−0.000842
DE	4	0.00550	0.0113	PL	4	0.139	−0.000884
DE	5	0.00838	0.0120	PL	5	0.0219	−0.00423
DE	6	−0.00196	0.00574	PL	6	0.104	0.0126
DE	7	−0.0383	0.0129	PL	7	0.0766	0.0113
DE	8	0.00122	0.0109	PL	8	0.0361	0.0275
DE	9	0.0969	0.0108	PL	9	−0.0158	−0.00230
DK	0	0.0108	−0.00174	PT	0	−0.0474	0.0133
DK	1	0.000425	0.00473	PT	1	0.163	−0.00160
DK	2	0.0136	−0.00434	PT	2	0.0416	−0.00639
DK	3	0.000374	−0.00281	PT	3	0.0313	−0.00163
DK	4	0.00474	0.00340	PT	4	0.0381	0.00653
DK	5	0.0256	0.0396	PT	5	0.130	0.00675
DK	6	−0.00226	0.00741	PT	6	0.0377	0.0105
DK	7	0.0489	0.00571	PT	7	0.0434	0.00830
DK	8	0.161	0.0135	PT	8	0.175	0.00504
DK	9	0.0301	0.0140	PT	9	0.0967	0.00323
ES	0	0.0238	0.00350	SE	0	−0.0126	0.00405
ES	1	0.0253	0.00818	SE	1	0.0155	0.0111
ES	2	0.0719	−0.000988	SE	2	0.0120	−0.00317
ES	3	0.0686	0.00929	SE	3	−0.0114	−0.00141
ES	4	0.0186	0.00190	SE	4	0.0364	0.0114
ES	5	0.0624	−0.00523	SE	5	0.0153	0.000679
ES	6	0.00718	0.0167	SE	6	0.0189	0.0222
ES	7	0.0543	0.0121	SE	7	−0.0114	0.00510
ES	8	−0.0134	0.00391	SE	8	−0.0186	0.0192
ES	9	0.0139	0.0104	SE	9	0.00614	0.00990
FI	0	−0.0538	0.00323	SK	0	−0.0458	0.00521
FI	1	−1.48e-05	0.0120	SK	1	0.0693	0.0104
FI	2	0.0286	−0.00229	SK	2	0.122	−0.00261
FI	3	0.00389	0.00463	SK	3	0.113	−0.00585
FI	4	0.00192	0.00798	SK	4	0.0512	0.00612
FI	5	0.0156	0.0103	SK	5	0.101	−0.0159
FI	6	−0.0116	−0.00309	SK	6	0.0613	0.00830
FI	7	−0.00676	0.00355	SK	7	0.0458	0.00442
FI	8	−0.00357	0.0207	SK	8	0.00593	0.0214
FI	9	0.0252	0.00679	SK	9	0.0173	0.0145

IV. Additional Figures

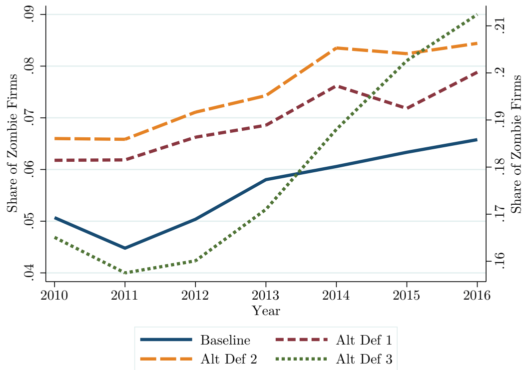


Figure IA.7. Alternative zombie classifications. This figure shows the evolution of the zombie share for alternative zombie definitions. The blue solid line replicates our main measure of the zombie share (scale on left y-axis). Alt Def 1 (red dashed line; left y-axis) calculates median values for leverage and IC ratio at the industry-year-level instead of industry-country-year level. Alt Def 2 (orange dashed line; left y-axis) considers solely the IC ratio criterion to define a firm as low-quality. Alt Def 3 (green dotted line; right y-axis) considers only the leverage criterion to define a firm as low-quality.

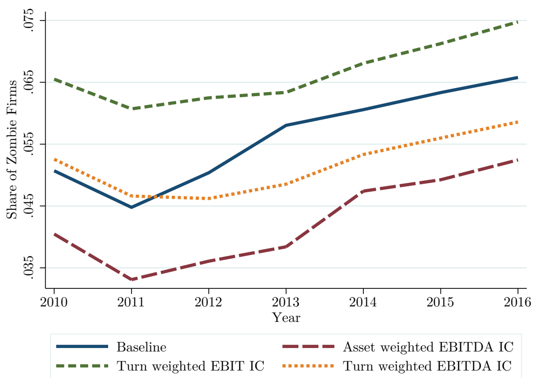


Figure IA.8. Alternative zombie share weighting. This figure shows the evolution of the zombie share for alternative zombie definitions. The blue solid line replicates our main zombie share measure (i.e., asset-weighted aggregation and IC ratio based on EBIT). The red long dashed line shows the evolution of the asset-weighted share of zombie firms using the IC ratio based on EBITDA/interest expenses. The green short dashed line shows the turnover-weighted share of zombie firms using the EBIT-based IC ratio. The yellow dotted line shows the evolution of the turnover-weighted share of zombie firms using the EBITDA-based IC ratio.

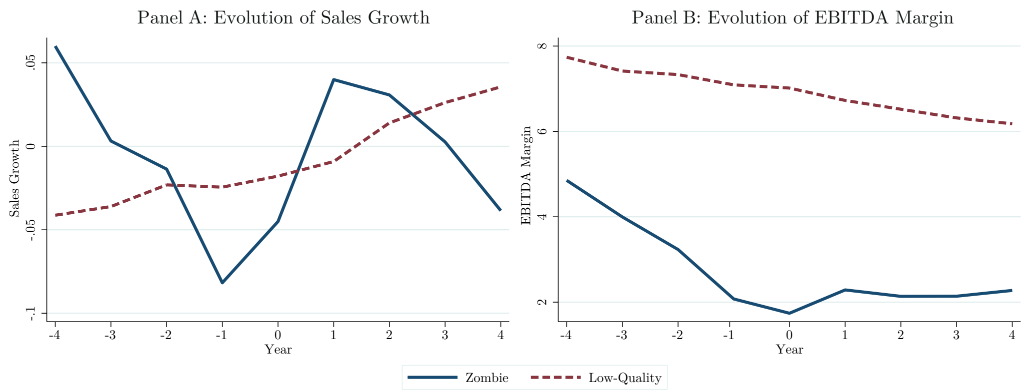


Figure IA.9. Evolution of sales growth and EBITDA margin. This figure shows the evolution of sales growth and profitability for zombie firms. Year 0 corresponds to the first sample year when a firm is classified as zombie. The zombie status can change after year 0, i.e., the zombie condition is not imposed for years 1 to 4. The firm performance of zombies is compared to a matched sample of low-quality firms. Panel A shows the evolution of the asset-weighted sales growth. Panel B shows the evolution of the asset-weighted EBITDA margin (i.e., EBITDA/sales ratio).

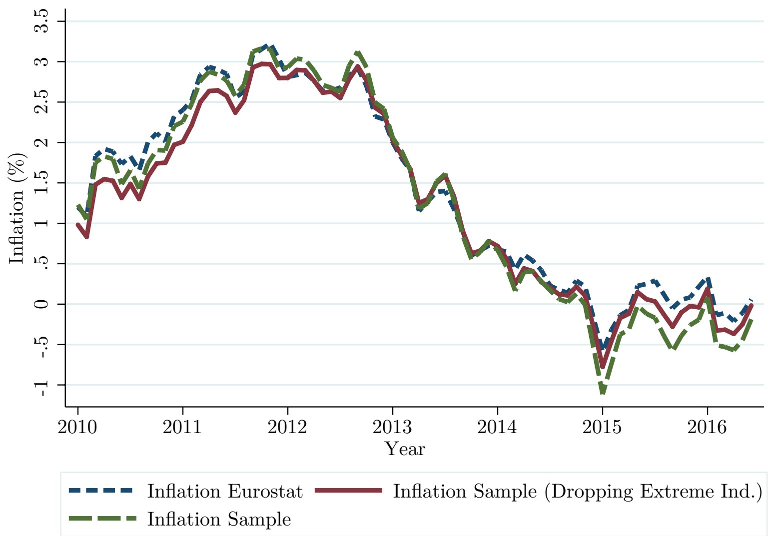


Figure IA.10. Sample vs. official inflation. This figure shows evolution of the official inflation for our 12 sample countries from Eurostat (blue short dashed line), the inflation aggregated from our industry-country data set with (red solid line) and without (green long dashed line) dropping extreme markets with less than -50% or more than +50% annual price growth.

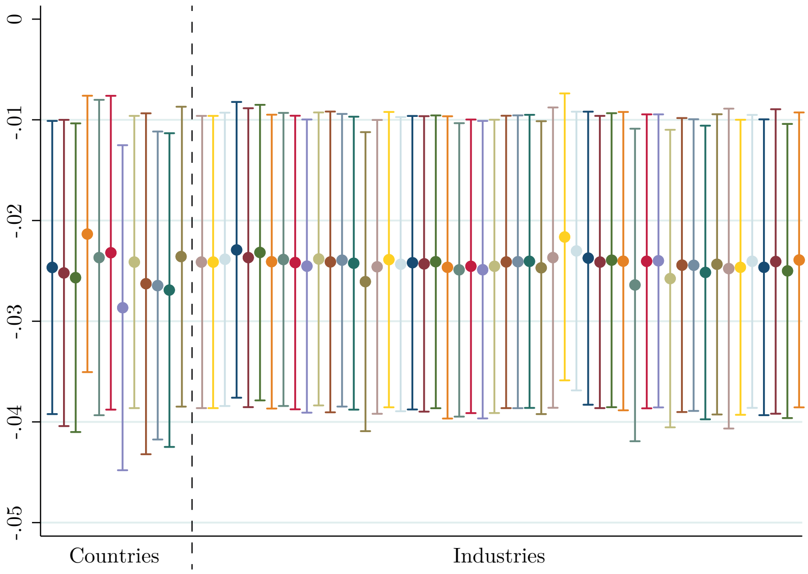


Figure IA.11. CPI growth – Exclusion of individual countries and industries. This figure presents estimation results from Specification (3). Each bar shows the coefficient for *Share Zombies* and its 95% confidence interval for the regression of CPI growth rate (inflation) from $t-1$ to t on *Share Zombies*, dropping either one country (left side) or one industry (right side) at a time. Each regression controls for the share of low-quality firms, as well as industry-country, industry-year, and country-year fixed effects. *Share Zombies* measures the asset-weighted share of zombie firms in a particular market at $t-1$. A firm is classified as zombie if it is low-quality and paid advantageous interest rates (see Section II.B for more details).

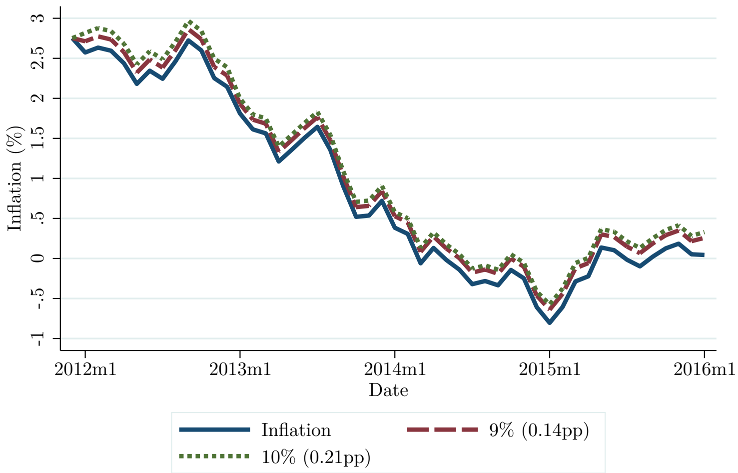


Figure IA.12. CPI growth counterfactual – Depressed markets constraint. This figure shows the actual CPI growth in our sample and two counterfactual CPI growth rates. For this exercise, we stipulate that zombies can only exist in depressed markets (markets with a below median percentage change in value added between 2007 and 2011). The counterfactual inflation rates are measured as the CPI growth that would have prevailed from 2012 to 2016 if weakly-capitalized banks entered our sample period with a higher Tier-1 ratio. Specifically, we consider the cases where banks with a Tier-1 ratio below 9% and 10% in 2009, respectively, are recapitalized to the respective threshold value. For each counterfactual, the label includes the average spread between the actual CPI growth and the counterfactual CPI growth.

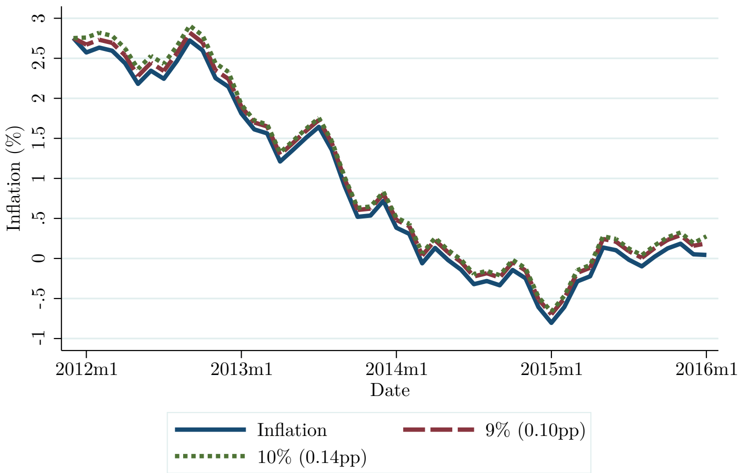


Figure IA.13. **CPI growth counterfactual – Depressed markets and lenient bank supervision constraint.** This figure shows the actual CPI growth in our sample and two counterfactual CPI growth rates. For this exercise, we stipulate that zombies can only exist in depressed markets (markets with a below median percentage change in value added between 2007 and 2011) and when banks face lenient bank supervision (measured with *Supervisory Powers*). The counterfactual inflation rates are measured as the CPI growth that would have prevailed from 2012 to 2016 if weakly-capitalized banks entered our sample period with a higher Tier-1 ratio. Specifically, we consider the cases where banks with a Tier-1 ratio below 9% and 10% in 2009, respectively, are recapitalized to the respective threshold value. For each counterfactual, the label includes the average spread between the actual CPI growth and the counterfactual CPI growth.

V. IV Diagnostic Tests

To assess the plausibility of the identification assumptions of our Bartik IV estimation, we follow the diagnostic tests outlined in Goldsmith-Pinkham, Sorkin, and Swift (2020).

In a first step, we perform a Rotemberg decomposition of our Bartik IV estimator. If any particular instrument is misspecified, the Rotemberg weight tells us how sensitive the overall estimator is to the misspecification of the individual instrument.

Panel A of Table IA.XIII splits the instruments into those with positive and negative bank-specific Rotemberg weights, denoted α_b. The results show that the share of negative and positive weights are 0.254 and 0.746, respectively, while the sum of the negative and positive weights are -0.516 and 1.516, respectively. These values are thus in a similar range as in the canonical Bartik setting (see Table 1 in Goldsmith-Pinkham, Sorkin, and Swift (2020)).

Some negative α_b raise the possibility of (but do not imply) nonconvex weights on β_{hj}, in which case the overall Bartik estimate would not have a LATE-like interpretation as a weighted average of treatment effects. A higher variation in the $\hat{\beta}_b$ increases the likelihood that the negative weights on the b generate negative weights on the β_{hj} (note that these weights cannot be directly estimated). Naturally, in our setting, there is some variation in the $\hat{\beta}_b$ across banks. Banks differ in their exposures to different markets, and, as shown in our OLS analysis, the effect of zombie credit on CPI growth is heterogeneous across markets (e.g., different for tradable vs. nontradable

Table IA.XIII. Summary of Rotemberg weights. This table reports statistics about the Rotemberg weights. Panel A reports the share and sum of negative and positive weights. Panel B reports correlations between the weights ($\hat{\alpha}_b$), the aggregate loan growth ($\textit{Loan Growth}_c$), the just-identified coefficient estimates ($\hat{\beta}_b$), the first-stage F-statistic of the bank share ($\hat{F}_b$), and the variation in the bank shares across markets ($\text{var}(Share_{hjb})$). Panel C reports variation in the weights across years. Panel D reports the average Rotemberg weights, size (measured as total assets), and Tier-1 capital ratio separately for the top ten banks ranked according to their Rotemberg weights, and the banks outside of the top ten. Panel E reports statistics about how the values of $\hat{\beta}_b$ vary with the positive and negative Rotemberg weights.

Panel A: Negative and Positive Weights

	Sum	Mean	Share
Negative	−0.516	−0.018	0.254
Positive	1.516	0.039	0.746

Panel B: Correlations

	α_b	$\textit{Loan Growth}_c$	β_b	F_b	$\text{var}(Share_{hjb})$
α_b	1				
$\textit{Loan Growth}_c$	−0.016	1			
β_b	−0.015	0.471	1		
F_b	0.113	−0.032	−0.023	1	
$\text{var}(Share_{hjb})$	0.140	−0.019	−0.092	−0.073	1

Panel C: Variation Across Years in α_b

	Sum	Mean
2009	0.158	0.002
2010	0.013	0.000
2011	0.281	0.004
2012	0.206	0.003
2013	0.077	0.001
2014	0.100	0.001
2015	0.192	0.003
2016	−0.026	−0.000

Panel D: Top Ten Rotemberg Weight Banks versus other Banks

	Av. α	Total Assets (in bn)	Tier-1 Ratio
Top Ten	0.069	756	7.32%
Other	0.0012	340	9.94%

Panel E: Estimates of β_b for Positive and Negative Weights

	α-weighted Sum	Share of overall β	Mean
Negative	0.109	−0.895	0.098
Positive	−0.231	1.895	0.079

and high vs. low fixed cost sectors). Hence, we cannot rule out that there are negative weights on the β_{hj}.

Panel B reports correlations between the weights ($\hat{\alpha}_b$), the aggregate loan growth (*Loan Growth*$_c$), the just-identified coefficient estimates ($\hat{\beta}_b$), the first-stage F-statistic of the bank share ($\hat{F}_b$), and the variation in the bank shares across markets (var($Share_{hjb}$)). The panel shows that the aggregate loan growth rates are not materially correlated with the Rotemberg weights, which implies that the loan growth rates provide an imperfect guide to understanding what variation in the data drives estimates. In contrast, the Rotemberg weights are related to the variation in the bank shares across industry-country pairs ($var(Share_{hjb})$). This evidence suggests that the variation in the lending relationships to different banks (with different capitalization levels) across markets is driving our estimates. This observation is reassuring as it provides further evidence for the zombie credit channel.

Panel D shows the average size (measured with total assets) and the Tier-1 ratio of the ten banks with the highest Rotemberg weights, as well as for the banks outside of the top ten. The panel shows that our IV estimates are driven by large banks active in multiple markets, which results from (i) their relevance for the overall credit supply and (ii) our stringent fixed effects setting. Specifically, our fixed effects setting relies on exploiting cross-country and cross-industry variation, which limits the importance of smaller banks with a limited market breadth across industries and countries in our empirical analysis.

Moreover, Panel D shows that the most important banks (in terms of their Rotemberg weights) are on average much weaker capitalized than less important banks. Overall, these findings indicate that our IV estimation captures the effect of a low capitalization on the zombie lending behavior of large multinational banks and, in turn, CPI growth.

In a second step, we analyze the relationship between bank composition and market characteristics to explore whether there is variation that may be problematic for the exclusion restriction. To this end, Table IA.XIV shows the relationship between market characteristics in 2009 and the share of the top 10 banks ranked according to their Rotemberg weights.

Specifically, each column reports results of a single regression of a 2009 bank share on market characteristics in 2009 that proxy for the performance and productivity of the respective market. The market characteristics include *output*, *intermediate consumption*, *compensation of employees*, *consumption of fixed capital*, all scaled by *total employment*. We obtain this data from Eurostat. At the top of each column, we report the country code and the within-country rank of the respective bank (ordered from left to right according to their Rotemberg weight). The results show no significant relationship between the bank shares and the market characteristics, mitigating concerns about potential violations of the exclusion restriction.

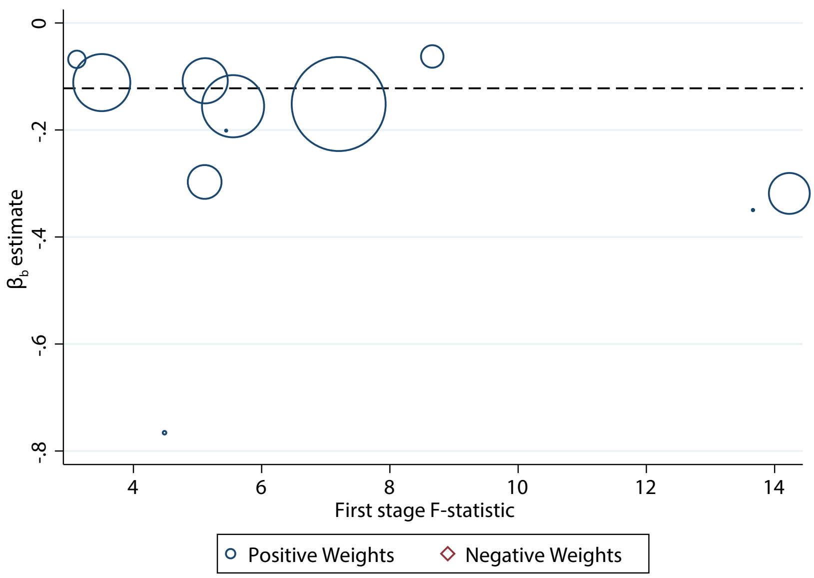
As previously described, our OLS evidence suggests that the effect of zombie credit on CPI growth is heterogeneous across markets and, in turn, each instrument will converge to a different estimate (β_b). Therefore, in a third step, we probe the patterns of this heterogeneity by exploring the distribution of the just identified IV estimates (i.e., the $\hat{\beta}_b$).

To this end, Figure IA.14 shows the relationship between the Rotemberg weights and the first-stage F-statistic. Specifically, the x-axis is the first-

Table IA.XIV. Relationship between bank shares and market characteristics. Each column of this table reports results of a single regression of a 2009 bank share on market characteristics in 2009. The market characteristics include *output*, *intermediate consumption*, *compensation of employees*, *consumption of fixed capital*, all divided by *total employment*. Standard errors are clustered at the industry-country level and reported in parentheses.

	IT1	GB1	PT1	FR1	DE1	PT2	IT2	ES1	GB2	IT3
Output	0.035	−0.017	−0.012	−0.038	0.003	−0.004	−0.003	−0.001	0.000	−0.015
	(0.045)	(0.021)	(0.008)	(0.032)	(0.004)	(0.013)	(0.005)	(0.010)	(0.006)	(0.034)
Interm. cons.	−0.035	0.013	0.013	0.045	−0.003	0.001	0.003	0.001	0.001	0.015
	(0.045)	(0.020)	(0.008)	(0.032)	(0.004)	(0.014)	(0.005)	(0.010)	(0.007)	(0.033)
Compensation	−0.076	0.050	0.028	0.014	−0.027	0.028	−0.009	−0.030	0.010	−0.014
	(0.080)	(0.028)	(0.021)	(0.056)	(0.022)	(0.024)	(0.012)	(0.014)	(0.015)	(0.085)
Cons. of FC	−0.035	0.016	0.016	0.036	−0.004	−0.007	0.002	0.000	0.003	0.013
	(0.039)	(0.019)	(0.009)	(0.035)	(0.006)	(0.017)	(0.005)	(0.010)	(0.008)	(0.032)
Observations	183	183	183	183	183	183	183	183	183	183
R-squared	0.41	0.39	0.59	0.80	0.08	0.96	0.09	0.93	0.66	0.65
Country FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Figure IA.14. Heterogeneity of β_b. This figure plots the relationship between each instruments' $\hat{\beta}_b$, first-stage F-statistics, and the Rotemberg weights. Each point is a separate instrument estimate. The figure plots the estimated $\hat{\beta}_b$ for each instrument on the y-axis and the estimated first-stage F-statistic on the x-axis. The size of the points is scaled by the magnitude of the Rotemberg weights, with the circles denoting positive Rotemberg weights and the diamonds denoting negative weights. The horizontal dashed line is plotted at the value of the overall $\hat{\beta}$ reported in the Column (1) of Table IV. The figure excludes instruments with first-stage F-statistics below 3.



stage F-statistic and the y-axis is the $\hat{\beta}_b$ associated with each instrument. The individual points of $\hat{\beta}_b$ are weighted by the absolute size of the α_b from the Bartik Rotemberg weights. The dashed horizontal line reflects the overall Bartik estimate.

The figure shows that there is some dispersion around the Bartik $\hat{\beta}$, but the banks with larger Rotemberg weights tend to be relatively close to the overall point estimate. Moreover, none of the high-powered banks have negative Rotemberg weights, which mitigates concerns that there are negative weights on particular market-specific parameters (i.e., β_{hj}).

In sum, these diagnostic tests suggest that our Bartik IV results are driven by zombie lending behavior of low-capitalized large banks. Since these banks are exposed to different markets with different characteristics, the effect of zombie credit on CPI growth is heterogeneous across these markets and the coefficient estimates ($\hat{\beta}_b$) have some variation. Given this variation and the fact that some Rotemberg weights are negative, we cannot rule out the general possibility that there are nonconvex weights on the β_{hj}. However, the visual tests alleviate this concern. Finally, the diagnostic tests do not raise concerns about potential violations of the exclusion restriction.

VI. Data on Bank Supervision Strictness

To rank countries according to the strictness of their bank supervision, we employ data from the Bank Regulation and Supervision Survey conducted by the World Bank (see Čihák et al., 2012 for a thorough explanation of the survey and the data). The database provides information on bank regulation and supervision for 143 jurisdictions, including all our sample countries. The survey questions are grouped into different topics. The two topics most relevant for zombie lending incentives are (i) "Asset classification mechanisms" and (ii) "Supervisory powers in cases of bank losses."

The category "Asset classification mechanisms" includes questions like: (i) Do you have an asset classification system under which banks have to report the quality of their loans and advances using a common regulatory scale? (ii) Do you require banks to write off non-performing loans after a specific time period? (iii) Are there minimum levels of specific provisions for loans and advances that are set by the regulator? (iv) Is there a regulatory requirement for general provisions on loans and advances?

The category "Supervisory powers in cases of bank losses" includes statements about supervisory powers like: (i) Require commitment/action from controlling shareholder(s) to support the bank with new equity (e.g. capital restoration plan); (ii) Require banks to constitute provisions to cover actual or potential losses; (iii) Require banks to reduce or suspend bonuses and other remuneration to bank directors and managers.

We use this survey data to construct two bank supervisory measures, the first based on the "Asset classification mechanisms" survey questions category and the second based on "Supervisory powers in cases of bank losses" category. Specifically, for each category we code the yes/no responses for each survey question as 1/0, respectively, and then take the mean per category of the binary responses for each of our sample countries.

VII. Supply Chain Evidence

In this section, we broaden our analysis to the whole supply chain (by including intermediate good prices) and investigate the effects of the zombie credit mechanism employing producer price index (PPI) data from Eurostat and input-output tables from the World Input-Output Database (WIOD). Table IA.XV presents the estimation results. In Column (1), we regress the change in the producer price index (PPI) on the share of zombie firms. The results confirm a negative relation between the prevalence of zombie firms and price levels.

In Columns (2) and (3), we investigate the zombie credit channel along the supply chain employing input-output information between industries. Consider as an example the case where industries A and B sell goods to industry C, and—for the sake of simplicity—no further industry sells goods to industry C. The zombie credit mechanism predicts that an increase in the zombie share in industries A and B puts downward pressure on prices for goods that these industries sell to industry C. Moreover, the mechanism suggests that an increases in zombie prevalence in industry C leads to higher prices for goods sold to industry C because relatively more firms demand the same inputs, sustaining their prices. Column (2) tests the first prediction. We investigate the second prediction in Column (3).

Accordingly, in Column (2), we regress the weighted PPI growth of the goods delivered to industry C on the weighted share of zombie firms in sectors A and B, using the trade flow information from the input-output tables as weights. The result suggests that industries that buy more goods from

Table IA.XV. PPI growth and input-output flows. This table presents estimation results from Specification (3). The dependent variable is the annual PPI growth rate from $t-1$ to t (Column 1) and the weighted PPI growth from $t-1$ to t, using trade flows as weights (Columns 2 and 3). *Share Zombies* measures the asset-weighted share of zombie firms in a particular industry-country pair at $t-1$. *Weighted Share Zombies* is the weighted share of zombie firms in the supplying sectors at $t-1$, using trade flows as weights. A firm is classified as zombie if it is low-quality and paid advantageous interest rates (see Section II.B for more details). All regressions control for the asset-weighted share of low-quality firms. Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	ΔPPI	Δweighted PPI	Δweighted PPI
Share Zombies	−0.033**		0.005**
	(0.014)		(0.003)
Weighted Share Zombies		−0.027*	
		(0.015)	
Observations	1,513	2,026	2,026
R-squared	0.735	0.751	0.760
Country-Industry FE	✓	✓	✓
Industry-Year FE	✓	✓	✓
Country-Year FE	✓	✓	✓

zombified sectors obtain these goods at lower prices. In Column (3), we regress the weighted PPI growth of the goods delivered to industry C (again using the trade flows as weights) on the share of zombie firms in industry C. The results show that, consistent with the zombie credit mechanism, an increase in the share of zombie firms in industry C is associated with relatively higher prices for the goods delivered to this industry.

VIII. Alternative Supply-Side Channels

While our empirical evidence is consistent with the zombie credit channel, the literature has suggested other (financial frictions-induced) supply-side effects that could also have affected the European inflation dynamics during our sample period. The cost channel (see, e.g., Barth III and Ramey (2001)) suggests that access to cheap debt decreases zombie firms' marginal production costs because it lowers the costs associated with financing their working capital. This cost reduction might give zombie firms more wiggle room to cut output prices. The liquidity squeeze channel (see, e.g., Chevalier and Scharfstein (1996) and Gilchrist et al. (2017)) suggests that low-quality non-zombie firms have an incentive to raise prices to increase their current cash flows (assuming they are liquidity constrained), while zombie firms do not have the necessity to react this way due to their access to cheap credit. Hence, the observed negative correlation between zombie share and CPI growth is also consistent with the cost channel and the liquidity squeeze channel.

Table IA.XVI rules out that our results are materially driven by one or a combination of these alternative channels. In this table, we add additional controls to our baseline specification to capture the cost channel and the liquidity squeeze channel. In the spirit of Barth III and Ramey (2001), we proxy for the cost channel by including firms' average marginal financing costs associated with their net working capital (*Working Capital Costs*). Following Gilchrist et al. (2017), we proxy for the liquidity squeeze channel using firms' average liquidity ratio (*Liquidity Ratio*), defined as the ratio of cash and short-term investments to total assets. As an alternative measure for

Table IA.XVI. Alternative supply-side channels. This table presents estimation results from Specification (3). The dependent variable is the annual CPI growth rate (inflation) from $t-1$ to t. *Share Zombies* measures the asset-weighted share of zombie firms in a particular market at $t-1$. *Liquidity Ratio* is defined as the firms' average asset-weighted ratio of cash and short-term investments to total assets. *Share Low-Quality NZ* measures the asset-weighted share of low-quality non-zombie firms. *Working Capital Costs* is defined as the firms' average asset-weighted (net working capital/total assets)*(interest expenses/sales). A firm is classified as zombie if it is low-quality and paid advantageous interest rates (see Section II.B for more details). Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	ΔCPI	ΔCPI	ΔCPI	ΔCPI
Share Zombies	−0.022***	−0.021***	−0.023***	−0.022***
	(0.007)	(0.007)	(0.007)	(0.007)
Liquidity Ratio	−0.044*			−0.042*
	(0.026)			(0.026)
Share Low-Quality NZ		0.005**		
		(0.003)		
Working Capital Cost			0.528**	0.537**
			(0.235)	(0.231)
Observations	3,880	3,880	3,880	3,880
R-squared	0.759	0.770	0.753	0.757
Country-Industry FE	✓	✓	✓	✓
Industry-Year FE	✓	✓	✓	✓
Country-Year FE	✓	✓	✓	✓

this channel, we employ a refined low-quality firm measure that aims at capturing only firms that are of low-quality but not zombie (*Share Low-Quality NZ*).

The inclusion of proxies for these alternative channels does not change the point estimate of the zombie share nor does it significantly alter the explanatory power of the zombie credit channel for CPI growth.[7] These results suggest that, while the other supply-side channels likely contributed to the European disinflationary trend, the zombie credit channel is a distinctive driver for the observed low inflation level in Europe during our sample period.

[7]Note that we cannot include the variable *Share Low-Quality NZ* in Column (4) since it is a linear combination of the other variables in this regression.

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