# Zombie Credit and (Dis-)Inflation: Evidence from Europe*


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**Abstract**

We show that "zombie credit"—subsidized credit to non-viable firms—has a disinflationary effect. By keeping these firms afloat, zombie credit creates excess aggregate supply, thereby putting downward pressure on prices. Granular European data on inflation, firms, and banks confirm this mechanism. Markets affected by a rise in zombie credit experience lower firm entry and exit, capacity utilization, markups, and inflation, as well as a misallocation of capital and labor, which results in lower productivity, investment, and value added. If weakly-capitalized banks were recapitalized in 2009, inflation in Europe would have been up to 0.45pp higher post-2012.



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# 1 Introduction

In response to the global financial crisis and the European sovereign debt crisis, the European Central Bank (ECB) and other European central banks provided substantial monetary stimulus, including longer-term refinancing operations, negative deposit rates, and large-scale asset purchase programs. However, even post-stimulus, Europe's economic growth and inflation have remained depressed and consistently undershot projections (see Figure 1). In the words of former ECB President Mario Draghi, *"although we have seen the successful transmission of monetary policy to financing conditions, and from financing conditions to GDP and employment, the final legs of the transmission process to wages and inflation have been slower than we expected. Wage growth is now strengthening as slack in the labor market diminishes. But the pass-through from wages to prices remains weak."*[1]

Europe's "missing inflation puzzle" in the years between its sovereign debt crisis and the Covid-19 pandemic bears a striking resemblance to Japan's "lost decade." Besides a deflationary pressure, both economies have been characterized by highly accommodative and lenient central bank policies and "zombie lending" by weakly-capitalized banks.[2] In this paper, we propose and test a *zombie credit channel* that can explain the concurrence of the rise of zombie firms and the disinflationary pressure shown in Figure 1. While the share of zombie firms in Europe increased from 4.5% to 6.7% between 2012 and 2016, inflation dropped from roughly 3% to zero. During the same time, inflation forecasts started to significantly overshoot the actual inflation rate.

Political constraints led to a hesitant introduction of recapitalization measures in Europe in the aftermath of the 2008 global financial crisis (see Acharya et al., 2018b), leaving many

[1] See Mario Draghi's speech "Twenty Years of the ECB's monetary policy" at the ECB Forum on Central Banking in Sintra on June 18, 2019. The speech is available at `www.ecb.europa.eu`.

[2] See, e.g., Caballero et al. (2008), Giannetti and Simonov (2013), Acharya et al. (2019), Blattner et al. (2020), Bonfim et al. (2020), and Schivardi et al. (2022).

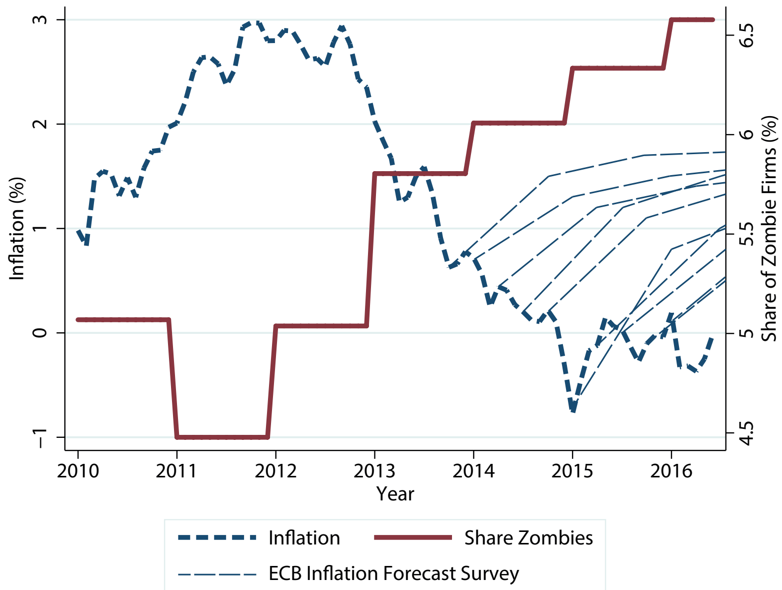


**Figure 1: Zombie Credit and Inflation.** This figure shows the year-over-year (yoy) growth of the CPI on the left axis and the asset-weighted share of zombie firms on the right axis in our sample. A firm is classified as zombie if it is low-quality (i.e., above median leverage and below median interest coverage ratio) and receives subsidized credit (interest expenses/debt lower than that of AAA-rated industry peers in a given year). See Section 3.2 for a detailed explanation of how we identify zombie firms in the data. The inflation forecasts are from the ECB Survey of Professional Forecasters (one, two, and five year ahead). Sources: Eurostat, ECB, and Amadeus.

banks weakly-capitalized and, in turn, creating zombie lending incentives. By extending subsidized loans, weakly-capitalized banks can provide their non-viable borrowers with the liquidity needed to meet debt payments and to continue operations. Thereby, these banks can avoid, or at least defer, realizing loan losses and the resulting regulatory repercussions.

Building on Caballero et al. (2008), we illustrate in a simple model that by keeping non-viable firms artificially alive, zombie credit creates excess supply, which puts downward pressure on prices. In equilibrium, zombie credit causes a decrease in firm entry and exit rates, markups, capacity utilization, and CPI growth, as well as a misallocation of capital and labor, which results in lower productivity, investment, and value added.[3]

Our empirical results support the zombie credit channel. In our analysis, we combine product-country level Consumer Price Index (CPI) data with industry-country-level information from Eurostat and detailed firm-level information from Bureau van Dijk's Amadeus for 1.1 million firms from 12 European countries across 65 industries. Using linking tables, we calculate changes in consumer prices at the industry-country level from the CPI data. Using Amadeus data, we identify zombies as firms that meet two criteria: (i) they are of low-quality, that is, their interest coverage (IC) ratio is below the median and their leverage ratio is above the median, and (ii) their borrowing costs are lower than the costs paid by their most creditworthy industry peers. Post-zombification, the (low) profitability of the firms classified as zombies does not improve, their leverage increases, and they are more likely to default in the long-term—suggesting that their access to cheap credit is not due to a positive outlook and/or relationship lending.

In the cross-section of countries and industries, we find that industry-country pairs (henceforth called "markets") that experience a 10 percentage point (pp) increase in the share of zombie firms subsequently have a 24 basis point (bp) lower CPI growth. In our most stringent specification, we include industry-country, country-year, and industry-year fixed effects, which absorb time-invariant industry-country characteristics as well as industry- and country-specific shocks (most importantly demand shocks). Moreover, we control for the share of low-quality firms to capture industry-country-year specific demand factors that

[3]The Italian concrete and cement industry offers a textbook example of this mechanism at work. Following the 2008 crisis, many firms in this sector relied on their banks to remain alive. The CEO of Cementir, one of the industry leaders in Italy, stated in 2017 that "*in Italy, in the cement industry, we have zombies kept alive by banks. [...] Banks do everything they can to keep these zombies alive to avoid realizing losses on their balance sheets.*" In a 2017 Senate hearing, industry representatives stated that "*the excessive production capacity caused an unprecedented price competition that, in turn, caused firms to realize large losses*" (audizione di AITEC, 2017). In 2015, the price of cement in Italy was 22% below the EU average.

affect firm quality. We also show that our main results are robust to employing an array of alternative zombie classifications and to measuring price changes with the producer price index (PPI) instead of the CPI.

To mitigate concerns that the negative correlation between the zombie share and CPI growth could be driven by demand shocks, we conduct a robustness check where we consider two additional criteria to identify zombies that are unrelated to demand effects. First, we exclude firms from our zombie measure that already enjoyed low interest rates and then turned into a zombie because their quality deteriorated. Second, we further restrict the zombie share measure to instances where firms are connected to weakly-capitalized banks. The estimated effects of zombie credit on CPI growth are larger for these more stringent zombie measures than in our baseline OLS specification, suggesting that our estimates are not materially driven by demand-side effects.

To further address potential omitted variable biases, we instrument a market's zombie share exploiting that weaker banks have stronger zombie lending incentives. In particular, we employ a Bartik-style shift-share instrument (see Bartik, 1991) based on the ex-ante capitalization of the banks connected to the firms in the respective market and aggregate loan growth, where loan growth is a proxy for time-varying country-level bank shocks (we also use non-performing loan growth as a robustness test).

The idea is that the average bank health differs across markets at the beginning of the sample period and markets linked to ex-ante weaker banks are more likely to see an increase in zombie lending when the banking system experiences a negative shock. Our instrument thus gets all of the cross-sectional variation in exposure to weak banks from *pre-existing* lending shares, and all of its time-series variation from country-level loan growth. Our instrumental variable (IV) regression estimates confirm the negative effect of zombie credit on CPI growth. Our calculations suggest that in the hypothetical case where weakly-capitalized banks were recapitalized in 2009, the annual CPI growth in Europe would have been on average between 0.21pp (for a recapitalization to 9% Tier-1 capital ratio) to 0.45pp (for a recapitalization to

12%) higher between 2012 and 2016.

Consistent with the insights of our theoretical framework about the inner workings of the zombie credit mechanism, we also find that, in the cross-section of countries and industries, markets that experience a stronger increase in the share of zombie firms subsequently have: (i) more active firms and aggregate sales growth, (ii) lower firm default and entry rates, (iii) higher average idle capacity, (iv) lower average markups, and (v) higher average material and labor costs. The positive correlation between zombie credit and sales growth provides further evidence that the negative correlation between zombie credit and CPI growth is not demand driven (as lower demand would *lower* sales). The positive correlation between zombie credit and firm input costs is consistent with relatively more firms demanding the same inputs sustaining their prices. In line with this finding, we confirm, using PPI data and input-output tables from the World Input-Output database, that the zombie credit mechanism also affects prices along the supply chain.

At the firm-level, we show that the market-level outcomes are at least partly caused by negative spillover effects to non-zombie firms. In particular, healthy firms that face competition from a growing number of zombie firms have lower markups, profitability, and sales growth, as well as higher input costs.

We present a set of tests that provide further evidence for the zombie credit channel. Specifically, we show that the effect of an increase in the zombie prevalence on CPI growth is driven by (i) high fixed cost industries, (ii) countries with lenient bank supervision, (iii) national markets for nontradable goods and supranational markets for tradable goods, and (iv) borrowers with a single banking relationship. We also show that the zombie credit mechanism appears to be a short- to medium-term phenomenon.

Finally, our results show that the zombie credit channel affects investment and employment. Markets with a stronger increase in the zombie share subsequently experience a higher misallocation of capital and labor—measured as the dispersion of the marginal revenue product of capital and labor, respectively. The lower allocative efficiency in these markets results in lower average net investment, productivity, and value added.

Our findings show that a central bank that implements policy measures that contribute to a persistent zombification of the economy with the objective of restoring inflation and growth might end up working against its own objectives. Conversely, accommodative monetary policy might be more effective in times of a weakening financial sector, if accompanied by a targeted bank recapitalization program.

**Literature Review.** We contribute to three strands of literature. First, we contribute to the literature on zombie credit, starting with the evidence from Japan in the 90s (see Peek and Rosengren, 2005, Caballero et al., 2008, and Giannetti and Simonov, 2013).[4] More recent evidence suggests that zombie credit has increased globally (Banerjee and Hofmann, 2018; McGowan et al., 2018) and, in particular, in Europe. In the European context, Blattner et al. (2020) shows that zombie lending in Portugal increased input misallocation across firms reducing firm productivity; Schivardi et al. (2022) shows that non-viable Italian firms obtained favorable bank credit; and Acharya et al. (2019) links zombie lending to the ECB's OMT program.[5] We build on this literature and show that, by allowing non-viable firms to stay afloat, zombie lending elevates aggregate production, affecting product prices.

Second, we contribute to the literature on the effects of financial frictions on inflation. Chevalier and Scharfstein (1996) suggests that liquidity-constrained firms might raise prices to increase cash flows—the "liquidity squeeze channel." Gilchrist et al. (2017) and de Almeida (2015) show that this mechanism helps to explain the pricing behavior of U.S. and European firms following the financial crisis. Barth III and Ramey (2001) proposes the "cost channel,"

[4] Peek and Rosengren (2005) documents that weakly-capitalized banks extended credit to their weak borrowers to avoid realizing losses on outstanding loans; Caballero et al. (2008) shows that this zombie lending behavior affected healthy firms, reducing their investment and employment; and Giannetti and Simonov (2013) shows that large capital injections can prevent zombie lending.

[5] Angelini et al. (2021), Kulkarni et al. (2021), and Bonfim et al. (2020) find that banks became less likely to engage in zombie lending after regulatory bank inspections and in presence of stricter supervision.

arguing that firms' marginal costs depend on their funding costs, which implies an increase (decrease) in inflation after a monetary tightening (loosening). Christiano et al. (2015) shows that the cost channel helps to explain the modest disinflation in the U.S. during the Great Recession. Our results draw further attention to the impact of supply-side financial frictions on inflation, showing that the zombie credit channel, by hampering supply adjustments, contributed to the disinflationary trend in Europe after its sovereign debt crisis.

Third, we contribute to the literature on resource misallocation.[6] Most related to our work, Bertrand et al. (2007) analyzes a French banking deregulation in the 80s, which curbed subsidized lending that created implicit entry and exit barriers. They find that, once banks cut back on "(cheap) credit to poorly performing firms" entry and exit rates rose, improving the allocative efficiency across firms and raising employment. Peters (2020) shows that when entry and exit is hampered, incumbents have time to gain market power, which increases markups and misallocation, reducing productivity. Relatedly, Liu et al. (2022) shows that low interest rates can trigger a relatively stronger investment response by market leaders, which can create entry barriers and lower productivity growth. Gopinath et al. (2017) shows that an interest rate reduction led to capital misallocation in Southern Europe in the 90s.

# 2 Mechanism of the Zombie Credit Channel

In this section, we define the zombie credit concept and lay out the intuition of the zombie credit mechanism and its testable predictions. In Appendix A, we present two formal models. First, an extensive margin model in which firms' production scales are exogenously set, and where we focus on the impact of zombie credit on prices through its effect on the number of

[6] Hsieh and Klenow (2009) shows that resource misallocation reduces productivity. Extending this work, Whited and Zhao (2021) analyzes the misallocation of debt and equity in the U.S. and China. Midrigan and Xu (2014) shows that financial frictions distort entry and technology adoption, causing productivity losses.

active firms, and, in turn, aggregate supply. Second, an intensive margin extension where, in addition, we consider the effect on firms' individual production scale choices.

**Zombie Definition.** We consider a firm to be a zombie if (i) the net present value (NPV) of its operating profits is negative and (ii) it is kept alive by a bank with zombie lending incentives—such as a weakly-capitalized bank avoiding the regulatory costs associated with realizing losses on its outstanding loans. While providing more debt to a zombie firm has a negative NPV on a standalone basis (i.e., just considering the debt interest and debt principal payments) and from a welfare perspective, such incentives might make it privately optimal for weakly-capitalized banks to extend zombie credit. In sum, zombie credit is a subsidy, provided by a bank to a non-viable firm, that turns the NPV of continuing the business for the equity holders of the zombie firm positive.

**Extensive Margin Model.** Since our focus is the analysis of the effect of zombie credit on CPI growth, we include zombie credit in our model as an exogenous force that prevents some (zombie) firms from defaulting, and compare changes in product prices in an economy with zombie credit versus an economy without zombie credit.

We consider an environment with imperfect competition among firms that produce a single good, with fixed and marginal costs. The firms' production scales are drawn from a random distribution, and firms simultaneously set prices. Incumbent firms that draw a low production scale might be forced to exit and entrant firms that draw a high scale might enter the market. The demand for the good is exogenous and its aggregate supply is the sum of the production by incumbent and entrant firms.

Suppose the economy is in a steady state, namely the number of firms that default each period is exactly offset by the number of entrants. The equilibrium is illustrated by point $A$ in Figure 2, where the exogenous demand is equal to the production by the constant number of incumbent firms. To illustrate the effect of zombie credit, we analyze how the economy transitions to a new equilibrium following a demand shock that reduces the demand to $D'$.

In the case without zombie credit, the demand shock causes the price and quantity to

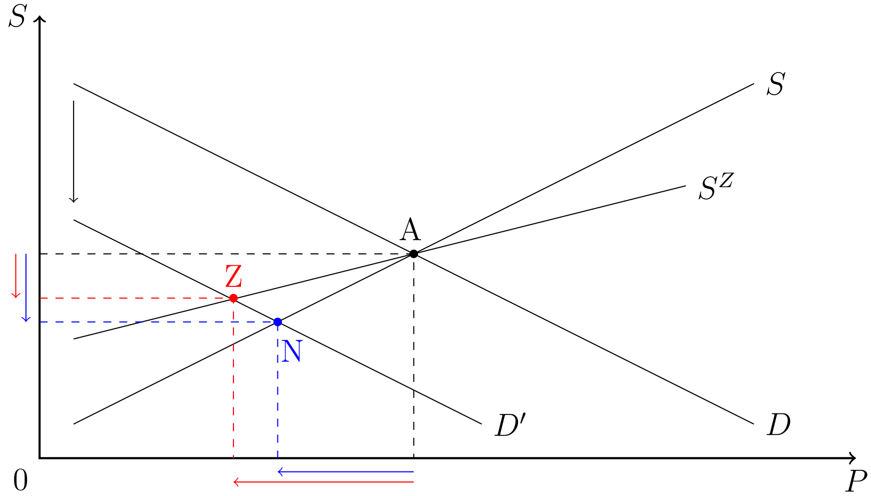


**Figure 2: Intuition.** This figure shows how zombie credit affects the equilibrium quantity and price.

decrease along the supply curve $S$ to the new equilibrium $N$. The shock causes a drop in price, making the economy less attractive for both entrant and incumbent firms. More incumbent firms default and fewer potential entrant firms enter. The lower number of active firms has a positive effect on price, but not enough to offset its initial decline.

In the case with zombie credit, the adjustment in aggregate supply through firm exits is hampered as zombie credit keeps some incumbent firms afloat that would otherwise default, which results in a higher number of active firms (each with an exogenously set production scale) and, in turn, a higher aggregate supply. The result is a flatter supply curve $S^Z$: aggregate supply is elevated compared with the case without zombie credit, leading to a relatively lower equilibrium price level ($Z$).

**Intensive Margin Model.** In our intensive margin model, we extend our extensive margin framework by allowing firms to choose their individual production scales.

Now, firms face a negative production shock with some probability. When this shock occurs, the NPV of continuing the production turns negative. The likelihood of this negative shock increases with the chosen production scale. Distressed firms (i.e., firms with a high operating and/or financial leverage), however, have a positive likelihood of being "bailed out" by their lenders when they experience the negative production shock. When being bailed out, these (zombie) firms receive subsidized zombie credit that makes continuing the production economically viable for them, allowing them to avoid defaulting, which would involve bankruptcy costs. By lowering the expected costs associated with choosing a higher output quantity, zombie credit incentivizes these firms to "overproduce"—lifting aggregate supply also through the intensive margin, in addition to the extensive margin effect (i.e., by keeping non-viable firms afloat).

The elevated aggregate supply, in turn, reduces the equilibrium price, inducing both, zombie and non-zombie firms, to produce less. Overall, zombie credit thus increases aggregate supply, but with asymmetric effects on the individual production scale of zombie and non-zombie 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 zombies: positive due to the incentive to overproduce and negative due to the lower equilibrium price.

**Insights from the Model.** Our empirical analysis is in the spirit of Figure 2 and compares equilibrium product prices in markets that—because of the heterogeneity in the prevalence of zombie firms—have a different supply curve. We present this analysis in Section 4.

The inner workings of the zombie credit mechanism generate insights beyond the effect on product prices, which provide the basis for our empirical analysis in Section 5 and Section 6. First, zombie credit reduces firm default rates, thereby increasing the number of active firms. The resulting elevated aggregate production reduces product prices, making the market less attractive to potential entrant firms. Moreover, while the elevated number of active firms reduces sales for individual non-zombie firms, the depressed output prices slightly increase aggregate demand, which leads to relatively higher aggregate sales. As a result, markets with a higher zombie prevalence experience a relatively lower drop in sales growth in response to a negative demand shock. We test these predictions in Section 5.1.

Second, our numerical exercises in Appendix A.2 suggests that, for markets with a high zombie prevalence, the elevated number of active firms and the resulting lower equilibrium price can lead to a higher average idle capacity for individual firms, outweighing the incentive of zombies to overproduce in anticipation of potentially being supported with zombie credit. We test the effect of zombie credit on idle capacity in Section 5.2.

Third, the mirror image in our model of product prices and zombie credit is the congestion of input markets due to zombie credit. By sustaining the number of active firms and their production, zombie credit increases the aggregate demand for labor and intermediate inputs, thereby raising input costs. We test these predictions in Section 5.3.[7]

Fourth, zombie credit creates negative spillover effects for non-zombie firms; these firms experience lower markups, sales, and profitability as they are forced to share the market demand with zombie firms. We test these spillover effects in Section 5.4.

Finally, the effect of zombie credit on prices should be more pronounced (i) when the zombie share measure comprises the precise scope of the respective market (i.e., national for nontradable goods and supranational for tradable goods) and (ii) in industries characterized by high fixed costs. The intuition for the latter effect is that zombie credit lowers firms' expected bankruptcy costs associated with sustaining a high fixed costs base and the resulting high optimal production scale. Moreover, zombie lending should be more prevalent in countries with lenient bank supervision. We test these predictions in Section 6.

# 3 Data and Empirical Work

In this section, we describe our data and our strategy to identify zombie firms. We test the zombie credit mechanism in the context of the European economy during the 2009-2016

[7]Note that in our theoretical framework, we develop predictions on how zombie credit affects product prices normalized by costs. Our baseline framework assumes a form of rigidity on the cost side but can be adapted to a setting where firms set prices for their inputs (i.e., labor and materials). Our framework implies a positive effect of zombie credit on input prices as "too many" firms demand the same input factors. In our empirical work, we test the effect of zombie credit on both, CPI growth and firm markups; we also test the effect on input prices directly.

period, which is well-suited to analyze the effect of zombie credit and the associated supply adjustment frictions following a negative demand shock. First, the European economy was hit by the global financial crisis and the subsequent sovereign debt crisis. Second, while the U.S. banking system was recapitalized decisively in the aftermath of the 2007-08 financial crisis by the Troubled Asset Relief Program and stress-test based capital requirements, the European banking system remained weakly-capitalized after its crises, which led to zombie lending behavior (see, e.g., Acharya et al., 2019).

## 3.1 Data

Our core data set combines detailed firm-level and industry-country-level data, as well as product-level inflation data from 2009 to 2016. The firm-level data are financial information, firm characteristics, firm default information, and information about firms' bank relationships from Bureau van Dijk's (BvD) Amadeus database.[8] BvD obtains the data, which is initially collected by local chambers of commerce, through roughly 40 information providers including business registers. Kalemli-Ozcan et al. (2019) shows for selected European countries that Amadeus covers roughly 75-80% of the economic activity reported in Eurostat. Moreover, we obtain industry-country level data on the number of active firms, firm entry and exit rates, labor costs, labor productivity, as well as value added from Eurostat.[9]

The inflation data are also from Eurostat, which provides information for various consumer price indices for all European countries. This data set is very granular as we observe consumer prices at the five-digit COICOP (product category) level. Since the firm data are

[8]The data coverage from the Amadeus 2017 version is incomplete before 2009. Regarding the firms' bank relationships, Amadeus provides information on the names of the most important relationship banks. We obtain the time-series of the "banker" variable through historic vintages of Amadeus. For some tests, we additionally include lending relationship information obtained from Refinitiv's DealScan database.

[9]In Table C.7, we show that our results are robust to calculating firm default rates using Amadeus data.

at the industry (NACE) level, we use COICOP-NACE linking tables to merge these two data sets. More precisely, we use the linking tables to obtain inflation at the industry-country level, by calculating a weighted CPI growth average of all COICOP categories that are related to a NACE (two digits) industry. Consider, for example, the textiles industry (NACE 13). This industry's CPI is a weighted average of the following COICOP categories: (i) clothing, (ii) furniture and furnishings, carpets and other floor coverings, (iii) household textiles, (iv) goods and services for routine household maintenance, and (v) other major durables for recreation and culture. Following the literature, we exclude utilities and financial and insurance industries from the sample.

Our final sample consists of 1,167,460 firms for 12 European countries and 65 industries. The twelve European countries are Austria, Belgium, Denmark, Finland, France, Germany, Italy, Poland, Portugal, Slovakia, Spain, and Sweden.[10]

## 3.2 Identifying Zombie Firms

Since our objective is to analyze the effect of zombie credit on prices, we need to identify (i) whether a firm is distressed and (ii) whether it receives subsidized debt financing. Hence, in the spirit of Caballero et al. (2008) and Acharya et al. (2019), we classify a firm as zombie if it meets the following two criteria that capture these two elements of zombie credit.[11] First, the firm is of low-quality, which we define as having an IC ratio below the median and a leverage ratio above the median, where the medians are calculated at the

[10]For the other European countries either the inflation data is not reported at a sufficiently granular level or is reported incompletely, and/or key financial firm data are missing. Table C.12 presents summary statistics by industry of the zombie share growth and the average CPI for our sample countries.

[11]Also note that, as argued by Caballero et al. (2008), defining zombies solely based on their operating characteristics would hard-wire a negative correlation between the zombie prevalence in a particular market and the market's average profitability and growth. Adding the borrowing cost criterion allows us to test for the relationship between the zombie prevalence and market-level outcomes.

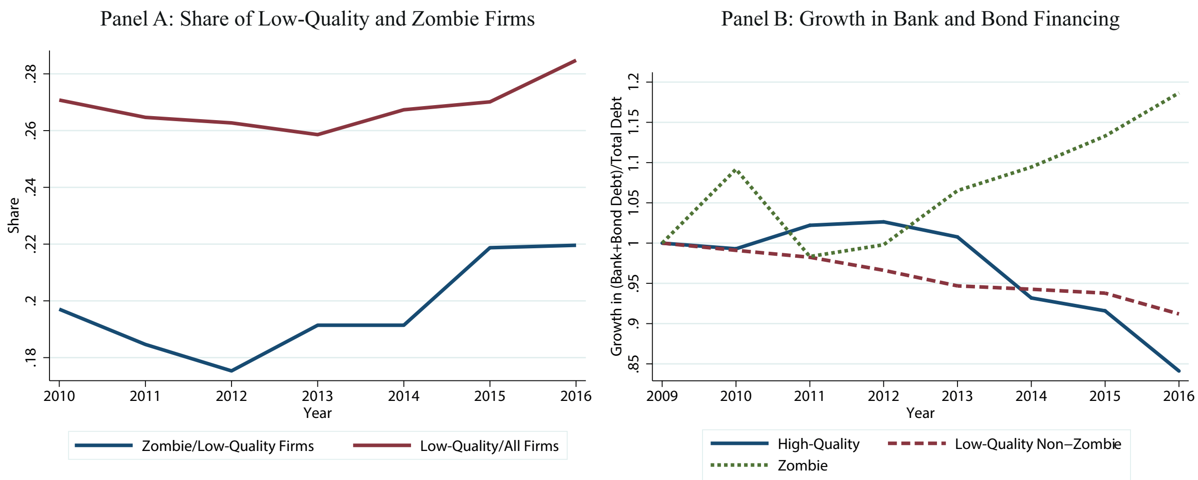


**Figure 3: Firm Shares and Firm Financing.** Panel A shows the share of zombie firms relative to all low-quality firms (blue line) and the share of low-quality firms relative to all firms (red line). Panel B shows the growth rate in bank and bond financing as a fraction of total debt relative to the beginning of our sample period for zombie firms (green dotted line), low-quality non-zombie firms (red dashed line), and high-quality firms (blue solid line).

industry-country-year level.[12] Note that we use a two-year average for the IC ratio criterion to avoid misclassification. Low-quality firms are thus impaired in the sense that they have both operational problems (captured via the IC ratio criterion) as well as a high debt level (captured via the leverage criterion). Second, the firm obtains credit at very low interest rates, i.e., the ratio of its interest expenses relative to the sum of its outstanding loans, credit, and bonds in a given year is below the interest rate paid by its most creditworthy industry peers, namely AAA-rated firms in the same industry and year in our sample.[13] In Section 4, we conduct several robustness checks with regard to the zombie firm definition.

Figure 1 shows that the share of zombie firms in our sample increased from roughly 4.5% to 6.7% between 2012 and 2016 (with a large cross-sectional variation across countries and

[12]The firms' IC ratio is defined as EBIT/interest expense and the firms' leverage ratio is defined as (loans + short-term credit + long-term debt)/total assets.

[13]We infer ratings of firms from their IC ratio as in Acharya et al. (2019).

industries).[14] In Figure 3, we document that this rise of zombie firms is mainly driven by more low-quality firms obtaining credit at very low interest rates and not by firms that already enjoy access to cheap credit deteriorating in quality. Panel A shows that, while the share of low-quality firms remains at roughly 27% during our sample period, the share of zombie firms relative to low-quality firms increased from 17.5% to 22% between 2012 and 2016. Panel B shows that bank loans and bonds play an increasingly important role in the debt funding mix of zombie firms.

Table 1 presents descriptive statistics for our sample firms separately for high-quality firms, low-quality non-zombie firms, and zombie firms. Zombie firms are weaker than low-quality non-zombie firms along several observable dimensions. Zombies have on average a lower market-to-book ratio, lower (even negative) IC ratio, lower EBITDA/assets ratio, lower net worth, and higher leverage. The market-to-book ratio of zombie firms is close to one, suggesting that these firms have limited growth prospects. Nevertheless, zombie firms pay extremely low interest rates, even compared with high-quality firms. Given their high leverage and low profitability, zombie firms would have likely had a higher default rate if they had not received subsidized debt.

Importantly, zombie firms are not younger nor more reliant on short-term credit compared with low-quality non-zombie firms, suggesting that our zombie definition does not simply capture early stage companies or companies reliant on short-term debt. The lower debt costs of zombie firms also does not seem to be due to differences in collateral availability as zombies have less tangible assets. Finally, based on syndicated loan data, Acharya et al. (2019) show that there are also no significant differences between zombie and low-quality non-zombie firms in other loan characteristics like loan size, maturity, or loan type.

[14]The standard deviation in the annual growth rate of the share of zombie firms is 7.5%. In Figure D.1 and Figure D.2, we show that alternative zombie definitions yield a similar time-series pattern.

| | High-Quality | Low-Quality Non-Zombie | Low-Quality Zombie | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (2)-(3) |
| Markup | 1.13 | 1.05 | 1.01 | 0.040*** |
| EBITDA/Assets | 0.090 | 0.046 | 0.014 | 0.032*** |
| Material Cost | 0.424 | 0.476 | 0.552 | −0.076*** |
| Total Assets (th EUR) | 1,617 | 1,726 | 1,607 | 119.0*** |
| Tangibility | 0.327 | 0.312 | 0.190 | 0.122*** |
| IC Ratio | 4.90 | 1.01 | −0.53 | 1.540*** |
| Net Worth | 0.224 | 0.107 | 0.069 | 0.038*** |
| Leverage | 0.161 | 0.351 | 0.437 | −0.086*** |
| ST Debt/Total Debt | 0.337 | 0.510 | 0.525 | −0.015 |
| Firm Age (years) | 17.5 | 17.3 | 17.8 | −0.500* |
| Interest Rate | 0.028 | 0.039 | 0.009 | 0.030*** |
| Market-to-Book | 2.07 | 1.88 | 1.03 | 0.85* |

**Table 1: Summary Statistics.** This table shows descriptive statistics for our sample firms. We split firms into high-quality, low-quality non-zombie, and zombie firms. A firm is classified as low-quality if it has below-median IC ratio and above-median leverage, where medians are calculated at the industry-country-year level. A low-quality firm is classified as zombie if its interest rate paid on its debt financing is lower than the rate paid by AAA-rated industry peers in the same year. The estimation of firm markups is discussed in Appendix B. Material cost is material input cost/turnover. Total assets is measured in thousand euro. Tangibility is fixed assets/total assets. IC Ratio is EBIT/interest expense. Net worth is total shareholders funds and liabilities - current and non current liabilities - cash, divided by assets. Leverage is debt/total assets. Market-to-book is the ratio of a firm's market capitalization to its book value. The last column is a test for the difference between Column (2) and Column (3).

Next, we track the performance of the firms we classify as zombies over time to confirm that these firms are not only temporarily weak, that is, firms that "look weak" based on observable characteristics but that might actually have a promising outlook that allows them to obtain cheap debt financing. In Figure 4, we plot the time-series evolution of leverage and incurred interest rate, where year zero corresponds to the first sample year where the respective firm is classified as zombie.

Panel A of Figure 4 shows that the average interest rate on outstanding debt paid by zombie firms decreased substantially in the year in which these firms became a zombie, while before their "zombification" these firms had to pay interest rates comparable to the rates incurred by low-quality non-zombie firms. Using syndicated loan data, Acharya et al. (2019) shows that this rate reduction for zombie firms is driven by both, very advantageous interest

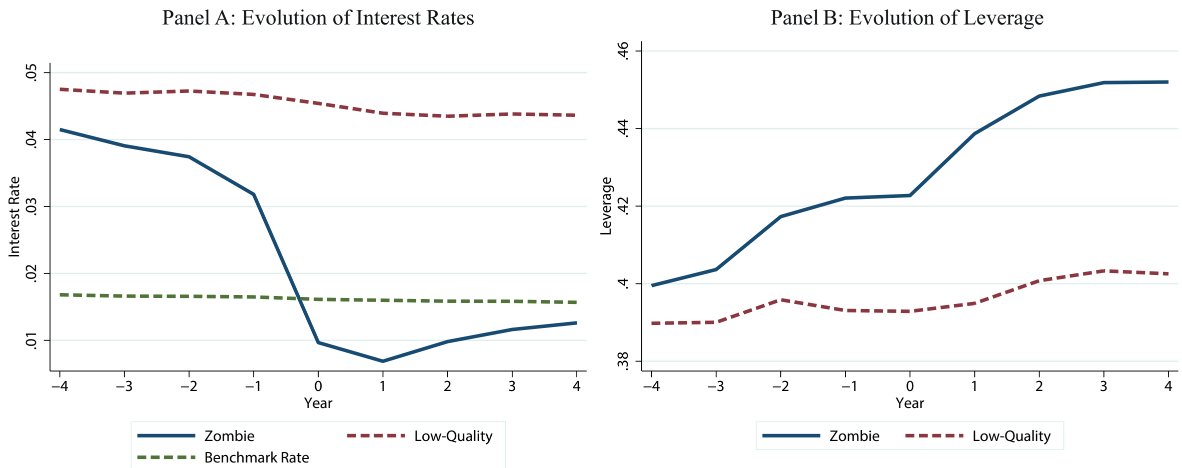


**Figure 4: Evolution of Leverage and Interest Rates.** This figure shows the evolution of interest rates and leverage for zombie firms. Year 0 corresponds to the first sample year when a firm is classified as zombie. The zombie status can change after year 0, i.e., the zombie condition is not imposed for years 1 to 4. The performance of zombies is compared to a matched sample of low-quality firms. Panel A shows the evolution of asset-weighted interest rates, while Panel B shows the evolution of asset-weighted leverage. The green dashed line in Panel A represents the benchmark interest rate below which debt is classified as subsidized.

rates on newly raised debt and renegotiations of the interest rates on pre-existing loans, which then turn the respective low-quality firms into zombies.

Panel B of Figure 4 shows that, after becoming zombies, these firms experience a leverage increase. Since zombies have on average a negative IC ratio (even though they benefit from subsidized debt), they are unable to meet their current interest payments from their earnings. To avoid default, these firms thus have to raise additional debt (which thanks to zombie credit is cheap) to obtain the liquidity necessary to meet payments on other outstanding loans.

Figure D.3 shows that zombie firms experience a sharp drop in their sales growth and profitability in the run-up to becoming a zombie firm. While these firms' sales growth temporarily increases after turning into a zombie, their (very low) profitability does not materially improve. The fact that the interest rate paid by zombie firms is not generally lower, but drops exactly at the time when their profitability deteriorates supports the notion that these firms indeed benefit from subsidized interest rates.

In Figure 5, we analyze ex-post defaults, non-parametrically in Panel A and parametri-

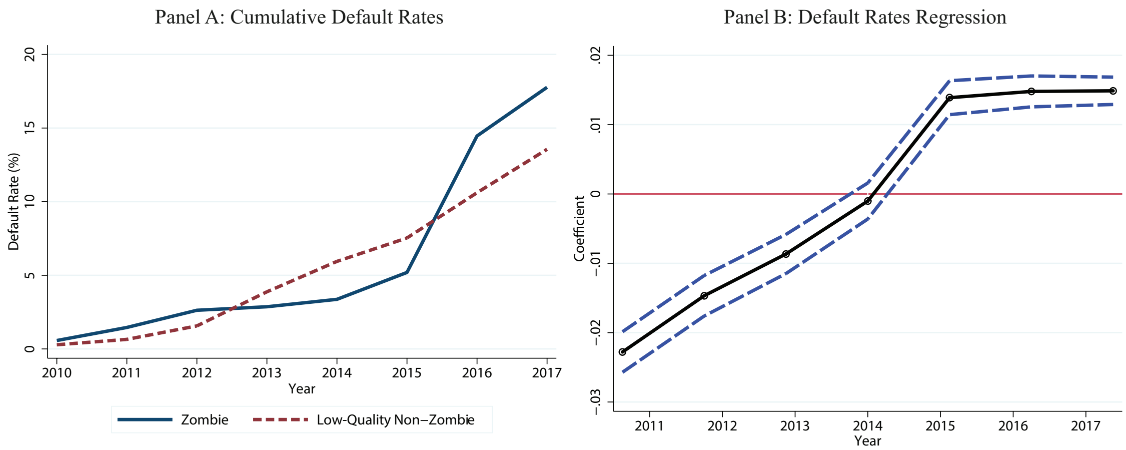


**Figure 5: Ex-Post Firm Default Rates.** Panel A shows the cumulative ex-post default rate of zombie firms (firms that have been zombies continuously since at least 2012) and low-quality non-zombie firms (low-quality non-zombie firms that were never classified as zombies). Panel B shows the coefficients from Specification (1).

cally in Panel B.[15] Panel A shows that the default rate of zombie firms increased towards the end of the sample period, suggesting that (at least some) zombies were not able to eventually avoid default despite their cheap debt financing. We test this default pattern by estimating, in the subsample of low-quality firms, the following specification separately for every year $\tau$:

$$Default_{ihjt} = \alpha + \beta_\tau \times \mathcal{I}_{t\tau} \times Zombie_{ihjt} + \gamma \times X_{ihjt} + \eta_{hjt} + \epsilon_{ihjt}, \qquad (1)$$

where $i$ is a firm, $h$ the country, $j$ the industry, and $t$ the year. $\mathcal{I}_{t\tau}$ is a yearly indicator variable equal to 1 if $t = \tau$ and 0 otherwise and $\eta_{hjt}$ are industry-country-year fixed effects. The vector $X_{ihjt}$ includes the uninteracted *Zombie* variable as well as other firm characteristics. The coefficient $\beta_\tau$ plotted in Panel B of Figure 5 confirms that zombie firms default more often than non-zombie firms towards the end of our sample period.

These figures suggest that zombie firms, even with their subsidized debt financing, still

[15]For this analysis, we employ the legal status variable from Amadeus, which allows us to determine whether a particular firm defaulted during our sample period (see also Acharya et al., 2019).


**Figure 6: Inflation Dynamics – Non-Parametric Evidence.** This figure shows inflation (year-over-year CPI growth) at monthly frequency for markets that experienced an above median (High Zombie) and below median (Low Zombie) increase in the asset-weighted share of zombie firms between 2009 and 2014.

underperformed other firms, including low-quality non-zombie firms. This ex-post evidence validates our zombie measure, suggesting that our measure does not capture only temporarily weak firms that are actually positive NPV projects for the lender. This evidence also rules out that cheap credit is provided due to relationship lending and superior information.

# 4 Zombie Firms and CPI Growth

In this section, we provide evidence consistent with a negative effect of the presence of zombie firms on inflation. In Section 4.1, we presents OLS estimates documenting a robust negative correlation between the presence of zombie firms and CPI growth. In Section 4.2, we conduct an IV estimation to further address potential endogeneity concerns.

We start by providing non-parametric evidence on the correlation, across markets, between the zombie share and CPI growth, our main variable of interest. Figure 6 shows the year-over-year CPI growth for markets with a high (above median) and low (below median) growth of zombie firms. Consistent with the rise of zombies starting in 2012, we see that, beginning in mid-2012, markets with a higher increase in the zombie share experience a stronger decline in CPI growth.[16]

## 4.1 OLS Estimation

We test the effect of zombie credit on CPI growth by estimating the following specification:

$$Y_{hjt} = \beta \times Share\ Zombies_{hjt-1} + \gamma_{ht} + \nu_{jt} + \mu_{jh} + \epsilon_{hjt}, \tag{2}$$

where the unit of observation is country $h$, industry $j$, and year $t$. $Y_{hjt}$ is the annual CPI growth rate. Our key explanatory variable is the lagged (asset-weighted) share of zombie firms in a particular market: $Share\ Zombies_{hjt-1}$. In the most conservative specification, we control for industry-country, country-year, and industry-year fixed effects.

Our fixed effects allow us to isolate the effect of zombie credit on our outcome variables of interest, holding constant the time-varying demand at the industry- and country-level. The country-year fixed effects absorb all shocks at the national level that could affect firms (e.g., country-level demand shocks, changes in tax rates and national regulations). The industry-year fixed effects absorb all shocks at the industry level (e.g., industry-level demand shocks). Country-industry fixed effects control for time-invariant industry-country characteristics.

The estimation results in Panel A of Table 2 confirm that markets that experience an increase in the share of zombie firms subsequently have lower CPI growth. The estimated coefficient is stable as we add different layers of fixed effects. Based on the estimates in Column (4), a 10pp higher *Share Zombies* is associated with a 23bp lower CPI growth.

A potential concern is that the negative correlation between zombie share and CPI growth

[16] In Figure D.4, we show that our aggregate CPI growth measure, calculated from our disaggregated market-level CPI data, closely tracks the official CPI growth for our sample countries. The difference becomes even smaller when we exclude "extreme markets," that is, markets that have an absolute value of annual CPI growth of more than 50% (five markets). All regression results are insensitive to whether we include or exclude these five markets, as shown in Table C.1.

| Panel A: Without Quality Control | ΔCPI | ΔCPI | ΔCPI | ΔCPI |
|---|---|---|---|---|
| Share Zombies | −0.021** | −0.018*** | −0.025*** | −0.023*** |
| | (0.008) | (0.007) | (0.009) | (0.007) |
| Observations | 3,880 | 3,880 | 3,880 | 3,880 |
| R-squared | 0.496 | 0.732 | 0.526 | 0.764 |
| | | | | |
| Panel B: Baseline | ΔCPI | ΔCPI | ΔCPI | ΔCPI |
| Share Zombies | −0.025*** | −0.021*** | −0.028*** | −0.024*** |
| | (0.009) | (0.007) | (0.009) | (0.007) |
| Share Low-Quality | 0.005 | 0.004 | 0.004 | 0.002 |
| | (0.004) | (0.003) | (0.004) | (0.003) |
| Observations | 3,880 | 3,880 | 3,880 | 3,880 |
| R-squared | 0.496 | 0.733 | 0.526 | 0.764 |
| | | | | |
| Panel C: Placebo | ΔCPI | ΔCPI | ΔCPI | ΔCPI |
| Share Low-Quality | 0.001 | 0.000 | −0.000 | −0.002 |
| | (0.004) | (0.003) | (0.004) | (0.003) |
| Observations | 3,880 | 3,880 | 3,880 | 3,880 |
| R-squared | 0.495 | 0.731 | 0.524 | 0.763 |
| Country-Industry FE | ✓ | ✓ | ✓ | ✓ |
| Year FE | ✓ | | | |
| Industry-Year FE | | ✓ | | ✓ |
| Country-Year FE | | | ✓ | ✓ |

**Table 2: Prevalence of Zombie Firms and CPI Growth.** This table presents estimation results from Specifications (2) and (3). The dependent variable is the annual CPI growth rate (inflation) from $t-1$ to $t$. *Share Zombies* and *Share Low-Quality* measure the asset-weighted share of zombie firms and low-quality firms in a particular market at $t-1$, respectively. A firm is classified as zombie if it is low-quality and paid advantageous interest rates (see Section 3.2 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.

could be driven by negative demand shocks, which might simultaneously reduce price levels and increase the number of low-quality firms (and, in turn, zombie firms). We address this concern with two sets of tests. First, we additionally control for the average firm quality in each market. Second, we construct more stringent zombie share measures by considering additional criteria to identify zombie firms that are unrelated to demand effects.

Specifically, for our first test, we add a control for the share of low-quality firms in a particular market to Specification (2):

$$Y_{hjt} = \beta_1 \times \textit{Share Zombies}_{hjt-1} + \beta_2 \times \textit{Share Low-Quality}_{hjt-1} + \gamma_{ht} + \nu_{jt} + \mu_{jh} + \epsilon_{hjt}, \quad (3)$$

where $Y_{hjt}$ is again the annual CPI growth rate. This additional control captures industry-country-year specific factors that affect average firm quality. The results in Panel B of Table 2 show that the coefficient of *Share Low-Quality* is insignificant and that adding this control has almost no effect on the coefficient of *Share Zombies*.

As a further robustness test, in Table H.1, we employ an alternative low-quality firm measure that includes only firms that are of low-quality but non-zombie (*Share Low-Quality NZ*). While there is a positive correlation between *Share Low-Quality NZ* and CPI growth, including this alternative measure does not materially affect the statistical significance nor the economic magnitude of *Share Zombies*.

Finally, in Panel C of Table 2, we conduct a placebo test and substitute *Share Zombies* in Specification (2) with *Share Low-Quality*. Its coefficient remains insignificant.

For our second test, we employ two more stringent zombie classifications where we include additional criteria based on the zombie lending mechanism (i.e., subsidized credit from weakly-capitalized banks to non-viable borrowers) that are unlikely affected by demand-side factors. In Table 3, Column (1) we only consider changes to the zombie status that occurred due to a *switch* in the advantageous interest rates criterion. Specifically, we do not classify firms as zombies that first received debt at low interest rates (maybe for reasons other than zombie lending), and then turned into a zombie because their quality deteriorated.

In Column (2), we further restrict the zombie share measure of Column (1) to instances where firms are connected to banks that have, on average, a Tier-1 capital ratio below 9%

| | ΔCPI | ΔCPI | ΔCPI |
|---|---|---|---|
| Stringent Share Zombies | −0.031** | | |
| | (0.014) | | |
| Stringent Share Zombies - Weak Banks | | −0.061** | |
| | | (0.027) | |
| Stringent Share Zombies - Healthy Banks | | | −0.011* |
| | | | (0.006) |
| Observations | 3,880 | 2,080 | 2,080 |
| R-squared | 0.765 | 0.807 | 0.813 |
| Country-Industry FE | ✓ | ✓ | ✓ |
| Industry-Year FE | ✓ | ✓ | ✓ |
| Country-Year FE | ✓ | ✓ | ✓ |

**Table 3: CPI Growth – Stringent 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 3.2 for more details). *Stringent Share Zombies* measures the asset-weighted share of zombie firms in a particular market at $t-1$ where we only consider zombie status changes that occurred due to a switch in the advantageous interest rates criterion. In Columns (2) and (3), we additionally require for the zombie classification that the firm's banks have on average a Tier-1 capital ratio below 9% (Weak Banks; Column 2) or above 9% (Healthy Banks; Column 3), 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.

in 2009.[17] In Column (3), we re-run this test, but only considering firms that are connected to banks that have, on average, an above 9% Tier-1 ratio in 2009.

The magnitudes in the first two columns in Table 3 are larger than our baseline results in Table 2. This difference provides further evidence in support of the zombie credit channel and suggests that our estimates are not materially biased by demand-side effects. Moreover, the fact that including more stringent criteria based on the zombie credit mechanism increases the magnitude of the OLS estimate hints towards a reduction in the number of cases where we misclassify "true" non-zombie firms as zombies relative to our baseline OLS regression.

[17] We set the Tier-1 capital ratio threshold to 9% since the European Banking Authority required banks to reach this ratio by 2012. Measuring bank capitalization in the year 2009 rules out that banks are weakly-capitalized because of negative demand shocks during our sample period. Overall, 21% of the banks in our sample have a Tier-1 capital ratio below 9% in 2009.

These misclassifications can lead to an underestimation of the true zombie credit effect on CPI growth in our baseline specification since they inflate the zombie share measure, while the misclassified firms do not contribute to the downward pressure on product prices. This evidence thus suggests that our baseline OLS estimate constitutes a lower bound for the effect of zombie credit on CPI growth.

Finally, we conduct several robustness checks. First, we show that our results are robust to using alternative zombie classifications (see Table C.2). In particular, we (i) calculate median values for leverage and IC ratio at the industry-year level instead of the industry-country-year level, (ii) consider solely the IC ratio criterion and solely the leverage criterion instead of both criteria, and (iii) calculate the IC ratio using EBITDA/interest expenses instead of EBIT/interest expenses. Moreover, to mitigate concerns that our zombie classification is influenced by inflation-induced differences in loan rates across countries, we employ an alternative zombie definition that includes a debt cost adjustment for the differential between the inflation of the respective firm's home country and EU-wide inflation.[18]

Second, our results are robust to employing alternative zombie share measures (see Table C.3). Specifically, we (i) use a weighting by turnover instead of assets for the zombie share calculation and (ii) account for the potential non-linear effect of zombies on inflation by setting the value of *Share Zombies* to zero if it is below 5% or 2%, respectively.

Third, our results do not materially change if we drop one country or industry at a time (Figure D.5). Fourth, we show that the zombie credit mechanism can also be observed when we measure price changes with the PPI instead of the CPI (Table G.1, Column 1). Fifth, we find that the effect of a higher zombie presence on CPI growth is driven by borrowers with a single bank relationship (Table C.4), which is consistent with zombie lending being the

[18]The cost of providing credit is positively linked to inflation. Hence, when inflation in a country decreases, loan rates might follow, which can mechanically increase the zombie share in that country since its firms have a higher likelihood of paying interest rates below the benchmark rate relative to firms in other countries.

driver for our results.[19] Sixth, in Appendix H, we show that our results are not explained by alternative supply-side channels.

## 4.2 IV Estimation

To address potential omitted variable biases and, in particular, to further rule out that the negative correlation between the presence of zombie firms and CPI growth is driven by demand effects, we run an IV regression. To this end, we focus on the zombie lending incentives of weakly-capitalized banks as a predictor for the increase in zombie prevalence. In particular, by extending loans at subsidized interest rates, weakly-capitalized banks can provide their impaired borrowers with the liquidity needed to meet payments on other outstanding loans (see Peek and Rosengren, 2005). Hence, these banks can avoid, or at least defer, realizing loan losses and the resulting regulatory repercussions. Acharya et al. (2019), Blattner et al. (2020), Bonfim et al. (2020), and Schivardi et al. (2022) provide evidence for this zombie lending behavior in Europe in the aftermath of the sovereign debt crisis.

Section 4.2.1 explains our Bartik-style shift-share instrument. Section 4.2.2 presents the estimation results. Section 4.2.3 presents the diagnostic tests outlined in Goldsmith-Pinkham et al. (2020). Section 4.2.4 presents a counterfactual exercise to assess the economic magnitude of the zombie credit channel.

### 4.2.1 Setup

We use a Bartik-style shift-share instrumental variable approach (Bartik, 1991), where we instrument a market's zombie share with the product between the weighted Tier-1 capital

[19] For firms with a single bank relationship, zombie lending incentives should be stronger as the respective bank does not need to worry that the subsidized loan is used to repay another bank. Of the zombie firms in our sample, 72% only report one banking relationship, whereas 28% have more than one bank relationship.

ratio in 2009 of banks connected to the firms in this market (weighted by the banks' number of firm relationships) and country-level loan growth (obtained from the ECB data warehouse). Formally, our Bartik instrument is:

$$\tilde{B}_{hjt} = \sum_{b} \left[ m_{bhj,2009} \times \text{Tier-1 ratio}_{b,2009} \times \text{Loan Growth}_{ct} \right], \tag{4}$$

where $m_{bhj,2009}$ denotes the number of bank relationships of firms in market $hj$ (industry $j$ in country $h$) to bank $b$ in 2009 divided by the total number of bank relationships in 2009 of market $hj$. Tier-1 ratio$_{b,2009}$ is bank $b$'s Tier-1 ratio in 2009, while Loan Growth$_{ct}$ is the aggregate loan growth in bank $b$'s country of incorporation $c$ at time $t$.

The logic behind our shift-share instrument is that the average health of banks connected to firms in the respective markets differs across markets at the beginning of the sample period, and markets linked to weakly-capitalized banks are more likely to see an increase in zombie lending when the macroeconomic conditions decline.[20]

Our instrument gets all of the cross-sectional variation in the exposure to weak banks from pre-existing lending shares, and all of its time-series variation from country-level bank health shocks. The instrument thus brings additional information even with the inclusion of country-industry, industry-year, and country-year fixed effects because it has both variation across markets and over time. Although the weights could reflect unobserved differences across industry-country pairs, this heterogeneity does not vary with time and is thus controlled for by the industry-country fixed effects.

A key identification assumption is that the variation in initial bank capital is unrelated to variation in the prevalence of zombie firms. We believe this assumption is met in our empirical context for three reasons. First, the share of zombie firms was rather low in 2009

[20] Acharya et al. (2019) shows that banks' Tier-1 capital ratio is a good predictor for zombie lending.

for most European countries (see, e.g., McGowan et al., 2018, Banerjee and Hofmann, 2020, and Helmersson et al., 2021) and zombie firms were thus not a major factor in 2009. The European economy experienced a significant increase in zombie firms only after 2009 (see Figure 1). Second, the variation in equity capitalization across European banks in 2009 was largely driven by their exposure to the U.S. housing market and the associated losses incurred, for example, on mortgage-backed securities and due to off-balance sheet vehicles. Hence, banks' capitalization in 2009 was mainly determined by factors unrelated to their corporate lending. This observation is also reflected in the relatively low non-performing loan levels of European banks in 2009 (see, e.g., Huljak et al., 2020). Third, Table E.2 shows that there is no significant relationship between bank composition in 2009 (i.e., bank shares across different markets) and market characteristics.

We use the country-level loan growth as proxy for time-varying shocks to the banking sector health since there is ample evidence that a drop in loan supply is a strong indicator for a stressed banking sector (for the European context see, e.g., Bofondi et al., 2018, Balduzzi et al., 2018, Acharya et al., 2018a, De Marco, 2019, and Blattner et al., 2020).[21]

#### 4.2.2 Estimation Results

Table 4 presents the results for the IV specification. In our preferred specification, we determine bank-firm relationships using both Amadeus and DealScan (Column 1). As a robustness check, we redo our analysis using bank-firm relationships (i) solely from Amadeus (Column 2) and (ii) from DealScan for Italy (Amadeus does not have bank-firm relationships for Italy) and from Amadeus for other countries (Column 3).[22]

[21] See Ivashina and Scharfstein (2010), Cornett et al. (2011), and Chodorow-Reich (2014) for the U.S.

[22] Given that Amadeus does not report the firms' main banks for all countries, our sample size decreases when focusing on Amadeus data only. Whenever available, we can augment firm-bank links using syndicate loan data from DealScan. Still, in some industry-country pairs syndicated lending is quite rare. As a result, our overall sample size is lower for our IV estimation.

| Panel A: Second Stage | ΔCPI | ΔCPI | ΔCPI |
|---|---|---|---|
| $\widehat{Share\ Zombies}$ | −0.122** | −0.105** | −0.130** |
| | (0.051) | (0.048) | (0.053) |
| Observations | 2,080 | 1,839 | 2,080 |

| Panel B: First Stage | Share Zombies | Share Zombies | Share Zombies |
|---|---|---|---|
| Tier-1 2009 × Loan Growth | −10.05*** | −13.85*** | −9.97*** |
| | (2.37) | (3.21) | (2.37) |
| F-Test | 30.8 | 37.4 | 30.7 |
| Observations | 2,080 | 1,839 | 2,080 |
| R-squared | 0.687 | 0.691 | 0.687 |
| Sample | Amadeus + DealScan | Amadeus Only | Amadeus + DealScan Italy |
| Country-Industry FE | ✓ | ✓ | ✓ |
| Industry-Year FE | ✓ | ✓ | ✓ |
| Country-Year FE | ✓ | ✓ | ✓ |

**Table 4: Instrumental Variable Estimation.** This table presents the estimation results from the IV specification. 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. *Loan Growth* measures the annual loan growth rate 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 are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The first stage, shown in Panel B, explains the share of zombie firms at time $t-1$ in a particular market (*Share Zombies*) using its weighted *Tier-1 2009* × *Loan Growth* from Eq. (4), where the loan growth is measured from $t-2$ to $t-1$, controlling for a stringent set of fixed effects. The instrument always has a negative and significant effect on *Share Zombies*. The F-statistic ranges between 30.7 and 37.4, while the p-value is always below 0.01, confirming the strength of the instrument. In the second-stage estimation, shown in Panel A, we replace the *Share Zombies* with the predicted $\widehat{Share\ Zombies}$ from the first stage. The IV estimated coefficients confirm the negative effect of an increase in the prevalence of zombie firms on CPI growth, alleviating concerns that our effect might be driven by an omitted variable bias. In Table C.5, we show that our results are robust to using the country-level growth in non-performing loans (NPLs) as a proxy for country-level shocks to the health of the banking sector instead of the aggregate loan growth.[23]

Comparing the magnitudes across our OLS and IV estimations shows that, while the coefficients based on the more stringent zombie classifications are larger than the baseline OLS estimates, they are still smaller than our IV estimates. The remaining differences between the OLS and IV estimates are likely due to a deviation between the average treatment effect (ATE) from our OLS estimation and the local average treatment effect (LATE) from our IV estimation. Specifically, our diagnostic tests (see Section 4.2.3) indicate that our IV results are driven by a subset of banks, that is, weakly-capitalized large banks. While collectively these banks are exposed to 90% of all industry-country pairs in our sample, the weighting of their industry-country exposure differs from the exposure of the average bank in our sample. Moreover, the results in Section 6 show that the effect of zombie credit on CPI growth differs across industries and countries (e.g., high vs. low fixed cost sectors, countries with lenient vs. strict bank supervision, tradable vs. nontradable goods). Therefore, the LATE estimated with our IV approach does not necessarily coincide exactly with the estimate of the ATE from our OLS specification.

In sum, our evidence suggests that the coefficient is between -0.024 and -0.13, where our baseline OLS estimates mark the lower end and the IV estimates the upper end of this range.

### 4.2.3 Validity

To further assess the identification assumptions of our Bartik IV approach, we conduct a set of diagnostic tests outlined in Goldsmith-Pinkham et al. (2020). We discuss these diagnostics tests in detail in Appendix E and summarize the main conclusions in this section.

[23]Specifically, the first stage (see Panel B) explains *Share Zombies*$_{t-1}$ in a particular market with the market's weighted *Tier-1 2009* $\times$ *(-NPL Growth)*, where the *NPL Growth* is measured from $t-2$ to $t-1$. We obtain data about the NPL growth from the ECB data warehouse.

Goldsmith-Pinkham et al. (2020) shows that the Bartik IV approach is equivalent to using a weighted average of a set of instruments based on cross-sectional shares, with weights based on time-varying aggregate shocks. In our setting, the instruments are each market's "exposure" to banks (and their respective capitalization) in 2009 and the weights are the aggregate loan growth shocks in bank $b$'s country of incorporation at time $t$.

First, we perform a Rotemberg decomposition of our Bartik IV estimator. The Rotemberg weights tell us how sensitive the overall estimator is to a potential misspecification of individual instruments. Panel A of Table E.1 shows that the sum of the negative and positive Rotemberg weights are -0.516 and 1.516, respectively.

The existence of negative Rotemberg weights raises the possibility of (but does not necessarily imply) nonconvex weights on market-specific parameters ($\beta_{hj}$). In this case the overall Bartik estimate would not have a LATE-like interpretation as a weighted average of treatment effects (note that weights on $\beta_{hj}$ cannot be directly estimated). A higher variation in the $\hat{\beta}_b$ increases the likelihood of negative weights on $\beta_{hj}$. Naturally, in our setting, there is some variation in the $\hat{\beta}_b$ across banks. Banks differ with respect to their exposures to different markets, and, as shown in Section 6, the effect of zombie credit on CPI growth depends on market characteristics.

In a second step, we thus probe the patterns of this heterogeneity by visualizing the distribution of the just identified IV estimates (i.e., the $\hat{\beta}_b$). Figure E.1 shows that there is some dispersion around the Bartik $\hat{\beta}$, but banks with larger Rotemberg weights tend to be close to the overall point estimate. Moreover, none of the high-powered banks have negative Rotemberg weights, mitigating concerns about potentially negative weights on $\beta_{hj}$.

Third, we use the Rotemberg decomposition to investigate the drivers of our IV estimates. Panel B of Table E.1 shows that the Rotemberg weights ($\hat{\alpha}_b$) are correlated with the variation in the bank shares across markets ($\text{var}(Share_{hjb})$), suggesting that the variation in bank relationships is driving our estimates. Panel D presents summary statistics for the banks with the highest Rotemberg weights, showing that our IV estimates are driven by weakly-capitalized large banks. These findings are consistent with the zombie credit mechanism.

Finally, we check whether there is variation that could be a concern for the exclusion restriction. Table E.2 shows that there is no problematic relationship between bank composition in 2009 (i.e., bank shares across different markets) and market characteristics, specifically, output, intermediate consumption, wages, and consumption of fixed capital.

### 4.2.4 Counterfactual

In Europe, political constraints led to a hesitant introduction of recapitalization measures in the aftermath of the 2008 global financial crisis (see Acharya et al., 2018b), which led to zombie lending incentives (see Acharya et al., 2019, Blattner et al., 2020, and Schivardi et al., 2022). We can use our IV estimate to determine the evolution of the CPI growth in the hypothetical case where important banks in need of capital entered our sample period with a higher capital buffer.

For this counterfactual exercise, similar in spirit to the approach in Chodorow-Reich (2014), we "recapitalize" banks with a Tier-1 capital ratio below X% in 2009 to

$$\textit{Tier-1 ratio}^{C}_{b,2009} = X\%,$$

where we employ the thresholds $X = 9\%$, $10\%$, and $12\%$, respectively. Accordingly, we obtain the counterfactual value of our Bartik instrument as:

$$B^{C}_{hjt} = \sum_{b} \left[ m_{bhj,2009} \times \text{Tier-1 ratio}^{C}_{b,2009} \times \text{Loan Growth}_{ct} \right],$$

which allows us to calculate the counterfactual zombie share:

$$\begin{aligned} \textit{Share Zombies}^{C}_{hjt} = \textit{Share Zombies}^{C}_{hjt-1} + [\textit{Share Zombies}_{hjt} - \textit{Share Zombies}_{hjt-1}] \\ + \left[ \widehat{\beta}_B \times \left( B^{C}_{hjt} - B_{hjt} \right) \right]. \end{aligned}$$

Specifically, we accumulate the differences for each industry-country pair over time between the actual and the counterfactual zombie share that are induced by the higher counterfactual bank capitalization. We set the counterfactual zombie share to zero for negative values of $\textit{Share Zombies}^C_{hjt}$ since in practice the share of zombie firms cannot be negative. We then calculate the counterfactual CPI growth for each market as:

$$\textit{CPI Growth}^C_{hjt} = \textit{CPI Growth}_{hjt} + \left[\widehat{\beta}_S \times \left(\textit{Share Zombies}^C_{hjt} - \textit{Share Zombies}_{hjt}\right)\right].$$

In a final step, we calculate the weighted sum (using Eurostat CPI weights) of the market-level counterfactual CPI growth to the aggregate counterfactual CPI growth.

Figure 7 plots the results for this counterfactual exercise for the period characterized by a significant increase in the zombie share (i.e., 2012 to 2016; see Figure 1). The solid line is the observed CPI growth and the thin dashed lines are counterfactual CPI growth rates for the different recapitalization thresholds (i.e., 9%, 10%, and 12%, respectively). Depending on the size of the capital increase, the annual CPI growth would have been on average between 0.21pp (for the 9% recapitalization threshold) to 0.45pp (for the 12% threshold) higher between 2012 and 2016.

To get a better sense of the magnitude, we report the share of markets that would have become "zombie-free," as well as the average spread between actual and counterfactual CPI growth for each recapitalization threshold in the legend of Figure 7. Our calculations show that the zombie share would have dropped to zero for between 51% (for the 9% recapitalization threshold) to 88% (for the 12% threshold) of the markets in our sample.

There are two caveats to our counterfactual exercise. The first caveat relates to the fact that we use a partial equilibrium analysis with a focus on supply-side factors. However, a higher bank capitalization and, in turn, less zombie lending likely affects CPI growth also through the demand channel. At least in the medium-term, a more efficient capital allocation would likely lead to higher firm investment and household income levels (see, e.g., Jiménez

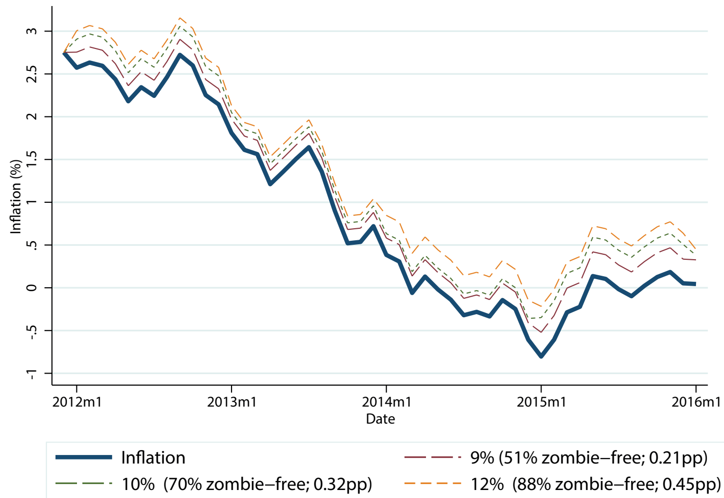


**Figure 7: CPI Growth Counterfactual.** This figure shows the actual CPI growth in our sample and several counterfactual CPI growth rates. The counterfactual inflation rates are measured as the CPI growth that would have prevailed from 2012 to 2016 if weakly-capitalized banks entered our sample period with a higher Tier-1 ratio. Specifically, we consider the cases where banks with a Tier-1 ratio below 9%, 10%, and 12% in 2009, respectively, are recapitalized to the respective threshold value. For each counterfactual, the label includes the respective share of markets that would have become zombie-free, as well as the average spread between the actual CPI growth and the counterfactual CPI growth.

et al., 2017 and Célérier et al., 2018), which would push the CPI growth further upwards. Hence, in a general equilibrium framework, raising bank capital might induce an even higher counterfactual CPI growth compared to our partial equilibrium counterfactual.

The second caveat relates to how bank capitalization is raised, that is, whether the recapitalization measure requires banks to increase their equity capital, or just their equity to risk-weighted assets ratio. Specifically, recapitalization measures that require banks to increase their risk-weighted capital ratio, like the capital exercise conducted in 2012 by the European Banking Authority, can have unintended consequences. As shown by Gropp et al. (2019), banks tend to respond to higher risk-weighted capital requirements mainly by lowering their risk-weighted assets (i.e., by decreasing their loan supply), as opposed to an increase in their equity capital. This loan volume reduction potentially affects CPI growth also through the demand channel due to the resulting decrease in investment activity and sales growth of affected borrowers. It is also not obvious whether the affected banks would dial back their loan supply more strongly for zombie or non-zombie firms.

Hence, our counterfactual exercise is more applicable to a recapitalization program that requires a capital increase in absolute terms, such that the increase in the capital ratio we consider in the counterfactual exercise is driven by an increase in the numerator of the bank's capital ratio. A good example for such a program is the Supervisory Capital Assessment Program (SCAP) in the U.S., which stated the banks' capital shortages in absolute terms.

# 5 Equilibrium Predictions

In this section, we document empirical evidence consistent with the insights of our theoretical framework about the inner workings of the zombie credit channel.

Specifically, employing our baseline Specification (3), we show that a higher zombie prevalence is associated with (i) lower default and entry rates, as well as a higher number of active firms and sales growth (Section 5.1); (ii) a higher average idle productive capacity (Section 5.2); as well as, (iii) lower firm markups and higher average input costs (Section 5.3). Moreover, in Section 5.4, we show that an increase in the share of zombie firms leads to negative spillover effects for non-zombie firms, that is, these firms have lower markups, profitability, and sales growth, as well as higher input costs. In Table C.6, we report the mean and standard deviation for our equilibrium prediction outcome variables.

## 5.1 Active Firms, Default, Entry, and Aggregate Sales Growth

In this section, we test the prediction of the zombie credit channel that more zombie credit is associated with lower default and entry rates, as well as a higher number of active firms and higher aggregate sales growth.

Table 5 shows the estimation results. Using our most conservative specification in the last column, we observe that a 10pp increase in the share of zombie firms is associated with a 75bp higher change in the number of active firms (Panel A) and a 20bp and 21bp lower

| Panel A | ΔActive Firms | ΔActive Firms | ΔActive Firms | ΔActive Firms |
|---|---|---|---|---|
| Share Zombies | 0.064*** | 0.074*** | 0.065*** | 0.075*** |
| | (0.023) | (0.025) | (0.019) | (0.020) |
| Observations | 3,844 | 3,844 | 3,844 | 3,844 |
| R-squared | 0.475 | 0.529 | 0.625 | 0.675 |
| **Panel B** | **Default** | **Default** | **Default** | **Default** |
| Share Zombies | −0.016** | −0.019** | −0.017** | −0.020** |
| | (0.007) | (0.009) | (0.007) | (0.008) |
| Observations | 3,626 | 3,626 | 3,626 | 3,626 |
| R-squared | 0.828 | 0.842 | 0.872 | 0.885 |
| **Panel C** | **Entry** | **Entry** | **Entry** | **Entry** |
| Share Zombies | −0.024** | −0.026** | −0.021** | −0.021** |
| | (0.010) | (0.012) | (0.010) | (0.011) |
| Observations | 3,824 | 3,824 | 3,824 | 3,824 |
| R-squared | 0.825 | 0.846 | 0.874 | 0.895 |
| **Panel D** | **Sales Growth** | **Sales Growth** | **Sales Growth** | **Sales Growth** |
| Share Zombies | 0.144** | 0.183*** | 0.161** | 0.193*** |
| | (0.070) | (0.070) | (0.069) | (0.067) |
| Observations | 3,894 | 3,894 | 3,894 | 3,894 |
| R-squared | 0.200 | 0.289 | 0.410 | 0.496 |
| Country-Industry FE | ✓ | ✓ | ✓ | ✓ |
| Year FE | ✓ | | | |
| Industry-Year FE | | ✓ | | ✓ |
| Country-Year FE | | | ✓ | ✓ |

**Table 5: Number of Active Firms, Firm Defaults, Firm Entry, Sales Growth.** This table presents estimation results from Specification (3). The dependent variable is the change in the number of firms (Panel A), the share of firm exits (Panel B), the share of firm entries (Panel C), and aggregate sales growth (Panel D). *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 3.2 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.

share of firm entries and exits (Panel B and C), respectively.[24] These findings are consistent

[24]Note that the entry and default variables provided by Eurostat only capture "the creation or dissemination of production factors if no other enterprises/units are involved in the event." Hence, the number of active firms can change for various additional reasons that are not captured by the entry and exit variable.

with the evidence provided by Bertrand et al. (2007), who show that inducing banks to quit zombie lending leads to an increase in firm entry and exit rates.

Moreover, Panel D shows that a 10pp higher zombie share is associated with a 1.93pp higher aggregate sales growth. This finding provides further evidence that our results are not driven by a drop in demand and a subsequent deterioration in firm quality as this demand channel would predict *lower* sales growth in markets with a high zombie prevalence.

## 5.2 Capacity Utilization

In this section, we analyze whether the zombie-induced congestion leads to a higher average idle productive capacity in the affected markets. Zombie credit elevates aggregate supply through both the survival of zombie firms and their overproduction, reducing the equilibrium price and, in turn, inducing zombie and non-zombie firms to reduce their production. Our model in Appendix A.2 shows that this effect can outweigh the higher individual production level of zombie firms (due to the incentive to overproduce induced by zombie lending), leading to a higher aggregate production and a higher average idle capacity at the same time.

We obtain information about capacity utilization by country and industry (NACE 2-digits) from the EU's "Business and consumer surveys." These harmonized EU-wide surveys are conducted using a representative firm sample at the industry-country level and published on a monthly/quarterly basis by the "Directorate General for Economic and Financial Affairs" (DG ECFIN).[25] These surveys provide data on capacity utilization (as percentage of full capacity) of European firms on a quarterly basis. We build our idle capacity variable using the following survey question: *"At what capacity is your company currently operating (as a percentage of full capacity)?"*

Table C.7 confirms that our results are robust to calculating firm default rates using Amadeus data.

[25]See https://ec.europa.eu/info/sites/default/files/bcs_user_guide.pdf for more information.

| | Idle Capacity | Idle Capacity | Idle Capacity | Idle Capacity |
|---|---|---|---|---|
| Share Zombies | 5.042** | 6.639*** | 4.924* | 6.639*** |
| | (2.469) | (2.392) | (2.536) | (2.478) |
| Observations | 2,409 | 2,409 | 2,409 | 2,409 |
| R-squared | 0.781 | 0.825 | 0.799 | 0.843 |
| Country-Industry FE | ✓ | ✓ | ✓ | ✓ |
| Year FE | ✓ | | | |
| Industry-Year FE | | ✓ | | ✓ |
| Country-Year FE | | | ✓ | ✓ |

**Table 6: Capacity Utilization.** This table presents estimation results from Specification (3). The dependent variable is the idle productive capacity as percentage of full capacity. *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 3.2 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.

Table 6 shows the estimation results, where the dependent variable, *Idle Capacity*, is calculated as 100%-(capacity utilization as % of full capacity). Across all fixed effects specifications, we find that the prevalence of zombie firms in a particular market is positively correlated with the average idle productive capacity of the firms in the same market. The estimates in Column (4) imply that a 10pp increase in the share of zombie firms is associated with a 66bp increase in the idle capacity. Recall that a zombie share increase of 10pp is associated with a 24bp lower CPI growth (see Table 2). Putting these two magnitudes into perspective shows that, per 1pp increase in idle capacity, we observe a change in CPI growth of -0.36pp (-2.4bp/6.6bp), which lines up well with the recent evidence on the Phillips curve. For example, using cross-sectional data, Hazell et al. (forthcoming) and Hooper et al. (2020) estimate for the U.S. price-Phillips curve a negative slope with a point estimate of -0.34 and between -0.301 and -0.441, respectively.

## 5.3 Markup and Input Costs

In this section, we analyze whether the zombie congestion results in lower markups and higher input costs. Lower markups are the equilibrium outcome of the higher supply of products in markets with a high zombie share. Higher input costs are the equilibrium outcome of the higher demand for labor and intermediate inputs in these markets.

Table 7 shows the estimation results. In Panel A, the dependent variable is the change in markups (price over marginal costs). We measure markups following De Loecker and Warzynski (2012) and De Loecker et al. (2019), that is, we rely on optimal input demand conditions obtained from standard cost minimization to determine markups for each firm (we explain this approach in detail in Appendix B).[26] In Panels B and C, the dependent variables are material costs and labor costs, measured as material cost/turnover and with the Eurostat's labor cost index, respectively.[27]

The estimation results confirm that a higher zombie prevalence is associated with lower markups and higher material costs. Interestingly, the positive correlation between the presence of zombie firms and labor costs only exists for markets with a high job vacancy rate, where *High Vacancy* is a dummy equal to one for industries with an above median job vacancy rate.[28] The insignificant coefficient for *Share Zombies* suggests that the relatively higher average labor cost for (some) zombie markets is indeed induced by a larger number of active firms and the resulting higher labor scarcity.

The estimates in the last column of Table 7 imply that a 10pp zombie share increase is associated with a 73bp decrease in markups, a 46bp increase in material costs, and a 1.4pp increase in the labor cost index for markets with a high job vacancy rate. Our results on the effect of an increase in the zombie share on CPI and PPI growth (Table 2 and Table G.1,

[26]This approach has the advantage that it only requires firms' financial statements information and no assumptions on demand and on how firms compete. Following De Loecker et al. (2019), we aggregate firm markups in the respective market using firms' turnover as weight.

[27]The Eurostat's labor cost index is designed to capture the labor cost pressure. It is calculated dividing the labor cost by the number of hours worked. Importantly, the labor cost index is provided at less granular industry classifications, which leads to a significant reduction in the number of observations.

[28]The job vacancy rate is calculated from Eurostat's job vacancy statistics and is defined as the number of job vacancies as a percentage of the sum of the number of occupied posts and job vacancies.

| Panel A | ΔMarkup | ΔMarkup | ΔMarkup | ΔMarkup |
|---|---|---|---|---|
| Share Zombies | −0.077*** | −0.071*** | −0.076*** | −0.073*** |
| | (0.023) | (0.025) | (0.023) | (0.026) |
| Observations | 3,261 | 3,261 | 3,261 | 3,261 |
| R-squared | 0.133 | 0.272 | 0.157 | 0.296 |
| **Panel B** | **Material Cost** | **Material Cost** | **Material Cost** | **Material Cost** |
| Share Zombies | 0.053** | 0.051** | 0.048** | 0.046** |
| | (0.022) | (0.023) | (0.023) | (0.023) |
| Observations | 3,701 | 3,701 | 3,701 | 3,701 |
| R-squared | 0.943 | 0.951 | 0.945 | 0.953 |
| **Panel C** | **Labor Cost** | **Labor Cost** | **Labor Cost** | **Labor Cost** |
| Share Zombies | 0.015 | 0.006 | 0.004 | −0.008 |
| | (0.022) | (0.024) | (0.024) | (0.027) |
| High Vacancy | −0.002 | 0.003 | −0.007* | −0.003 |
| | (0.004) | (0.004) | (0.004) | (0.004) |
| Share Zombies | 0.095*** | 0.124*** | 0.110** | 0.138*** |
| × High Vacancy | (0.036) | (0.043) | (0.043) | (0.052) |
| Observations | 922 | 922 | 922 | 922 |
| R-squared | 0.259 | 0.360 | 0.397 | 0.500 |
| Country-Industry FE | ✓ | ✓ | ✓ | ✓ |
| Year FE | ✓ | | | |
| Industry-Year FE | | ✓ | | ✓ |
| Country-Year FE | | | ✓ | ✓ |

**Table 7: Markups and Input Costs.** This table presents estimation results from Specification (3). The dependent variables are the turnover-weighted change in markups from $t-1$ to $t$ (Panel A), the industry material cost (material input cost/turnover, Panel B), and the industry labor cost (Eurostat's labor cost index, Panel C), respectively. *High Vacancy* is a dummy equal to one for industries with above median job vacancy rate. *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 3.2 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.

respectively) suggest that the negative effect of the zombie credit mechanism on markups dominates its positive effect on input costs, overall pushing product prices downwards.

Consistent with these findings, we confirm in Appendix G, using PPI data from Eurostat and input-output tables from the World Input-Output Database (WIOD), that the zombie credit mechanism affects prices along the supply chain. First, we show that a zombie share increase in supplier industries decreases prices for goods that these industries sell to customer industries. Second, we show that a higher zombie prevalence in a particular customer industry leads to higher prices for goods sold to this industry by supplier industries.

Given its positive effect on input costs and its negative effect on markups, the zombie credit channel thus helps to explain the recent weakening of the relationship between cost and product price inflation documented in the macro literature (see, e.g., Taylor, 2000, Bobeica et al., 2019, Del Negro et al., 2020).

### 5.4 Spillovers

In this section, we present evidence consistent with negative spillover effects from zombie to non-zombie firms, another prediction of the zombie credit channel. In our model, a rise of zombie credit leads to more active firms and an elevated aggregate production, resulting in a negative price pressure for *all* firms, zombie and non-zombie. Our empirical analysis confirms that non-zombie firms in markets with a high zombie prevalence face lower markups, profitability, and sales growth, and higher input costs.

Taking advantage of our firm-level data, we follow Caballero et al. (2008) and test for these spillover effects by estimating the following regression at the firm-year level:

$$\begin{aligned} Y_{ihjt} = {} & \beta_1 \times \text{Non-Zombie}_{ihjt} \\ & + \beta_2 \times \text{Non-Zombie}_{ihjt} \times \text{Share Zombies}_{hjt-1} + \eta_{hjt} + \epsilon_{ihjt}, \end{aligned} \tag{5}$$

where $i$ is a firm, $h$ a country, $j$ an industry, and $t$ a year. Our dependent variables are firm markup, EBIT/sales, material cost, and sales growth. We include industry-country-year fixed effects to absorb industry-country specific shocks. Our coefficient of interest is $\beta_2$, that is, whether non-zombie firms that operate in markets with a high share of zombie firms perform differently than non-zombie firms in markets with a lower share of zombie firms.

The first column of Table 8 shows that non-zombie firms in markets with a low zombie prevalence have higher markups than zombie firms in the same market. However, consistent

| | Markup | EBIT/Sales | Material Cost | Sales Growth |
|---|---|---|---|---|
| Non-Zombie | 0.063*** | 0.086*** | −0.023*** | 0.060*** |
| | (0.007) | (0.008) | (0.002) | (0.007) |
| Non-Zombie | −0.235*** | −0.198*** | 0.074*** | −0.153*** |
| × Share Zombies | (0.044) | (0.033) | (0.019) | (0.032) |
| Observations | 4,211,633 | 5,910,165 | 4,653,410 | 5,922,959 |
| R-squared | 0.565 | 0.157 | 0.517 | 0.033 |
| Industry-Country-Year FE | ✓ | ✓ | ✓ | ✓ |
| Firm-Level Controls | ✓ | ✓ | ✓ | ✓ |

**Table 8: Markups, EBIT/Sales, Material Costs, and Sales Growth – Firm-Level Evidence.** This table presents estimation results from Specification (5). The dependent variables are a firm's markup, EBIT/sales, material cost (material input cost/turnover), or sales growth. *Non-Zombie* is an indicator variable equal to one if a firm is classified as non-zombie in year $t$. *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 3.2 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.

with our results at the industry-country level, markups of non-zombie firms tend to be lower when the share of zombie firms active in the same market is high. Results are very similar for the EBIT margin (Column 2). The results in Column (3) confirm that non-zombie firms that face an increase in the zombie share in their respective markets have to pay higher material costs relative to non-zombie firms in non-zombie markets (we only observe a very noisy measure of labor costs at the firm-level). Finally, Column (4) confirms that a rise of zombie credit is associated with lower sales growth for individual non-zombie firms as more firms have to share a given demand level.

These results confirm that there is a zombie contagion from zombie to non-zombie firms in markets with a strong rise in zombie credit. That is, healthy firms in zombie markets suffer a decrease in their profitability due to higher price pressures and higher input costs. As a result, initially healthy non-zombie firms might turn into zombies over time due to a high prevalence of other zombies in their markets.

Moreover, this evidence suggests that the observed aggregate effects at the market-level associated with an increase in the zombie share can at least partly be explained by negative spillover effects to non-zombie firms (as predicted by the zombie credit channel), and are not solely caused by compositional effects (i.e., due to more zombies relative to non-zombies in markets that experience an increase in the zombie prevalence).

As a placebo test for the firm-level results presented in Table 8, we employ the share of low-quality firms as independent variable (instead of the share of zombie firms); thus, muting the advantageous interest rate criterion. The results presented in Table C.8 show that the spillover effects on non-zombie firms do not occur *per se* when the share of low-quality firms increases in a market. This evidence suggests that the contagion to non-zombie firms is indeed caused by an increase in the share of actual zombie firms, that is, low-quality firms receiving subsidized credit. Moreover, these results provide further evidence that the negative correlation between the rise of zombie credit and CPI growth is not linked *per se* to a deteriorating average firm performance in a specific market (e.g., due to a drop in demand).

# 6 Testing the Mechanism

In this section, we provide further evidence in support of the zombie credit channel. Section 6.1 shows that its effects are more pronounced in high compared to low fixed cost industries. Section 6.2 shows that zombie lending is more prevalent in countries with lenient bank supervision. Section 6.3 shows that the effect of zombie credit on prices is driven by national markets for nontradable goods and by supranational markets for tradable goods. Section 6.4 analyzes the time dynamics of the zombie credit mechanism.

## 6.1 High vs. Low Fixed Cost Industries

Our model suggests that the effect of zombie lending on CPI growth is more pronounced in markets characterized by high fixed costs. 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.

For this analysis, we use the ratio of the firms' labor expenses to total costs to proxy for

| | High Fixed Costs | | Low Fixed Costs | |
|---|---|---|---|---|
| | ΔCPI | Idle Capacity | ΔCPI | Idle Capacity |
| Share Zombies | −0.026*** | 6.629** | −0.007 | 2.989 |
| | (0.008) | (3.111) | (0.008) | (3.748) |
| Observations | 1,855 | 875 | 2,025 | 1,534 |
| R-squared | 0.768 | 0.797 | 0.838 | 0.802 |
| Country-Industry FE | ✓ | ✓ | ✓ | ✓ |
| Industry-Year FE | ✓ | ✓ | ✓ | ✓ |
| Country-Year FE | ✓ | ✓ | ✓ | ✓ |

**Table 9: CPI Growth – Cost Structure Split.** 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 3.2 for more details). We use the ratio of labor expenses to total costs to proxy for their degree of fixed costs exposure. The first two columns report the results for firms in markets that have an above median average fixed costs ratio, while the last two columns report the results for the markets below the median. 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.

the industries' fixed costs exposure. The idea is that it is more difficult to reduce labor costs than to adjust material costs and other operating costs, which is especially true in Europe given the relatively high firing costs (see, e.g., Holden, 2004).

Table 9 confirms this model prediction. Specifically, the results show that the effects of an increase in the zombie prevalence on idle capacity and CPI growth are only significant for industries with an above median average ratio of fixed costs to total costs.

## 6.2 Lenient vs. Strict Bank Supervision

Effective bank supervision is an efficient way to tackle zombie lending. Banks are less likely to extend credit to zombie firms if they face a strict supervisor, for example one that requires them to write-off NPLs. In this section, we confirm that, holding everything else constant, there is a lower presence of zombie firms in markets with stricter bank supervision.

For this analysis, we employ data from the World Bank Bank Regulation and Supervision Survey. This database provides information on bank regulation and supervision for 143 jurisdictions, including all our sample countries. We use data from the following two survey

| | Supervisory Powers | | Asset Classification | |
|---|---|---|---|---|
| | (high) | (low) | (high) | (low) |
| | Share Zombie | Share Zombie | Share Zombie | Share Zombie |
| Tier-1 2009 × Loan Growth | −4.816** | −15.692*** | −5.403** | −14.570*** |
| | (2.005) | (5.020) | (2.568) | (3.594) |
| Observations | 1,216 | 864 | 1,061 | 1,019 |
| R-squared | 0.689 | 0.789 | 0.569 | 0.741 |
| Country-Industry FE | ✓ | ✓ | ✓ | ✓ |
| Industry-Year FE | ✓ | ✓ | ✓ | ✓ |
| Country-Year FE | ✓ | ✓ | ✓ | ✓ |

**Table 10: Supervisory Intensity and Zombie Lending.** This table presents the estimation results from the first stage of the IV specification, split into countries with a high and low bank supervisory power. *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. *Loan Growth* measures the annual loan growth rate at the country-level of the country where the bank is incorporated. Bank relationships are determined using Amadeus and DealScan. Columns (1) and (2) present results separately for countries above (high) and below (low) the median of the measure *Supervisory Powers*, while Columns (3) and (4) present the respective results for the measure *Asset Classification*. Standard errors clustered at the industry-country level reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

topics: "Asset classification mechanisms" (which includes questions such as "*Do you require banks to write off non-performing loans after a specific time period?*") and (ii) "Supervisory powers in cases of bank losses" (which includes questions such as "*Please indicate whether the supervisory agency can require banks to constitute provisions to cover actual or potential losses*"). For each topic, we code the yes/no responses as 1/0 and compute the mean per category for each country. We explain the variable construction in detail in Appendix F.

We then rerun the first stage of the IV specification (i.e., regressing the zombie share on our Bartik instrument) separately for countries with above and below median value of our two bank supervisory intensity measures. Table 10 shows that zombie lending is indeed more prevalent in markets with more lenient bank supervision.[29]

[29]This result confirms the evidence from existing studies on the relationship between supervisory intensity and zombie lending behavior, such as Kulkarni et al. (2021) for India, Angelini et al. (2021) for Italy, and Bonfim et al. (2020) for Portugal.

## 6.3 Tradable vs. Nontradable Goods

In this section, we exploit differences in the markets' geographic scope to further pin down the zombie credit mechanism. Specifically, its measured effect on CPI growth should be more pronounced when the zombie share measure comprises the precise scope of the respective market. To this end, we take advantage of the fact that, while the relevant market for nontradable goods is likely national, it goes beyond national borders for tradable goods.

To test this prediction, we follow Mian and Sufi (2014) to distinguish between tradable and nontradable sectors.[30] Table 11 shows the estimation results of our baseline specification. Column (1) shows the results for industries producing nontradable goods, Column (2) for industries producing tradable goods, and Column (3) covers the full sample. Moreover, in Panel A, we employ our standard *Share Zombies* measure that captures the zombie prevalence at the industry-country level, while in Panel B we employ *Industry Share Zombies*, which measures the share of zombie firms at the industry-level (i.e., all firms in the same industry are considered to be in the same market, without a further country breakdown).

The results in Panel A show that the negative correlation between the zombie prevalence and the CPI growth is significant for both tradable and nontradable sectors when we measure the zombie share at the industry-country level. The effect, however, is stronger for nontradable than for tradable sectors. Panel B shows that, when measured at the industry-level, an increase in the zombie share only significantly affects the CPI growth in tradable sectors.

This evidence confirms the zombie credit mechanism and reinforces the notion that our baseline OLS results, where we measure the zombie share at the industry-country level for all sectors, constitute a lower bound for the effect size of zombie credit on CPI growth.

[30] Mian and Sufi (2014) defines a four-digit NAICS industry as tradable if its imports plus exports are at least \$10,000 per worker, or if total exports plus imports for the NAICS four-digit industry exceed \$500M. Nontradable industries are defined as the retail sector and restaurants.

| | Nontradable | Tradable | Full Sample |
|---|---|---|---|
| Panel A: Industry-Country Measure | ΔCPI | ΔCPI | ΔCPI |
| Share Zombies | −0.035*** | −0.018** | −0.024*** |
| | (0.009) | (0.008) | (0.007) |
| Observations | 1,454 | 2,181 | 3,880 |
| R-squared | 0.747 | 0.807 | 0.764 |
| Country-Industry FE | ✓ | ✓ | ✓ |
| Industry-Year FE | ✓ | ✓ | ✓ |
| Country-Year FE | ✓ | ✓ | ✓ |
| | | | |
| Panel B: Industry Measure | ΔCPI | ΔCPI | ΔCPI |
| Industry Share Zombies | 0.036 | −0.161*** | 0.028 |
| | (0.030) | (0.052) | (0.061) |
| Observations | 1,454 | 2,181 | 3,880 |
| R-squared | 0.502 | 0.558 | 0.532 |
| Country-Industry FE | ✓ | ✓ | ✓ |
| Country-Year FE | ✓ | ✓ | ✓ |

**Table 11: CPI Growth – Tradable and Nontradable Goods.** 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* and *Industry Share Zombies* measure the asset-weighted share of zombie firms in a particular industry-country pair and industry at $t-1$, respectively. A firm is classified as zombie if it is low-quality and paid advantageous interest rates (see Section 3.2 for more details). Column (1) reports the results for nontradable sectors, Column (2) for tradable sectors, and Column (3) for the full sample. We follow Mian and Sufi (2014) to identify tradable and nontradable sectors. All regressions control for the asset-weighted share of low-quality firms. Standard errors are clustered at the industry-country level in Panel A and at the industry level in Panel B. We report the standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

## 6.4 Time Dynamics

To analyze the dynamics of the zombie credit mechanism, we add additional lags of *Share Zombies* relative to the respective dependent variable (i.e., CPI growth and idle capacity) to our baseline specification. The results in Table C.9 indicate that the zombie credit channel appears to be a short- to medium-term phenomenon, which partially reverses after four years. This timing lines up with our evidence on default rates of zombie firms, which pick up four years after the initial zombie share increase (see Figure 5).

There are two potential reasons for the effects of the zombie credit mechanism taking some time to reverse, one at the extensive and one at the intensive margin.

First, a downward adjustment of the zombie-credit-induced elevated aggregate supply through firm exits (i.e., at the extensive margin) can be a long drawn-out process when policies that enable zombie lending become entrenched (see, e.g., McGowan et al., 2017, Banerjee and Hofmann, 2018, Andrews, 2019, Gropp et al., 2020, Acharya et al., 2021, and Becker and Ivashina, 2022). A high zombie prevalence creates negative spillover effects on healthy firms (see Table 8 and Table C.10), causing an economic slowdown. In response, policy makers have an incentive to stabilize the economy by loosening policies, e.g., by practicing regulatory forbearance towards banks. This can create a doom-loop, making it increasingly difficult to push the resulting large number of zombies through bankruptcy.

Second, when facing zombies in their industry, firms need to trade off the costs associated with maintaining their current production during the time their industry is congested, against the adjustment costs associated with down-scaling during the congestion phase and up-scaling again afterwards. Given the high likelihood that non-viable firms eventually have to exit, viable firms might thus decide against immediately down-scaling. This conjecture is supported by the literature that studies firms' labor adjustments in response to negative shocks, which shows that (i) given adjustment costs, firms respond sluggishly to shocks due to the option value of waiting and gathering more information on the shock (see, e.g., van Wijnbergen and Willems, 2013), and (ii) firms are less likely to adjust if the shock is perceived as temporary rather than permanent (see, e.g., Guiso et al., 2005).

# 7 Real Effects

In this section, we discuss the real effects of the zombie credit channel. While formalizing these predictions requires a general equilibrium model (beyond this paper's scope), we provide empirical evidence suggesting that zombie credit increases capital and labor misallocation, and reduces investment, value added, and productivity.

First, we analyze investment and capital misallocation using, again, Specification (3). In Panel A in Table 12, we find that an increase in the zombie share is associated with

| Panel A | Net Investment | Capital Misallocation | ΔValue Added |
|---|---|---|---|
| Share Zombies | −0.068** | 0.142** | −0.109*** |
| | (0.028) | (0.063) | (0.040) |
| Observations | 3,464 | 2,976 | 4,020 |
| R-squared | 0.397 | 0.920 | 0.488 |

| Panel B | Employment Growth | Labor Misallocation | Labor Productivity |
|---|---|---|---|
| Share Zombies | 0.002 | 0.113** | −0.019** |
| | (0.018) | (0.056) | (0.009) |
| Observations | 3,896 | 2,976 | 3,892 |
| R-squared | 0.497 | 0.905 | 0.948 |
| Country-Industry FE | ✓ | ✓ | ✓ |
| Industry-Year FE | ✓ | ✓ | ✓ |
| Country-Year FE | ✓ | ✓ | ✓ |

**Table 12: Investment, Employment, and Factor Misallocation.** This table presents estimation results from Specification (3). In Panel A, the dependent variables are net investment (measured as the growth in fixed assets and set to zero if negative), capital misallocation (measured as the standard deviation of log(MRPK)), and the value added growth. The dependent variables in Panel B are employment growth, labor misallocation (measured as the standard deviation of log(MRPL)), and labor productivity (valued added/number of employees). *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 3.2 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.

lower average net investment (Column 1).[31] In particular, a 10pp increase in the share of zombie firms in a given market implies a 68bp lower net investment ratio.[32] This reduction of investments in zombie markets can be a result of (i) the excess aggregate supply in these markets and thus a lack of profitable investment opportunities, which prevents both, zombie as well as non-zombie firms, to increase their capital expenditures, and (ii) a lower allocative efficiency of capital that hampers investment activity.

Employing the firm-level test from Specification (5), we confirm that a high zombie

[31] We measure net investment using Amadeus firm-level data and aggregate firms' non-negative change in fixed assets (i.e., the change is set to zero if negative) to the market-level with the firms' assets as weights.

[32] The net investment ratio ranged on average between 0% and 2% in the last decade in Europe.

prevalence indeed subdues the investment activity of non-zombie firms (Panel A of Table C.10, Column 1).[33] We also find evidence supporting a lower allocative efficiency of capital. For this test, we follow Hsieh and Klenow (2009) and Gopinath et al. (2017) and track the dispersion of the marginal revenue product of capital (MRPK) across markets. The underlying idea is that, given the MRPK is diminishing (i.e., decreasing returns to scale with respect to capital), firms should optimally equate it with their borrowing rate. In the absence of any borrowing distortions, the MRPK should thus be equated across otherwise equal firms. Hence, the dispersion of the MRPK across firms in a particular market is a measure of the degree of capital misallocation—since aggregate output could be increased by reallocating capital from firms with a low MRPK to firms with a higher MRPK.[34]

To calculate firms' MRPK, we decompose MPRK into the value of the marginal product ($VMPK_{ijt}$) and the inverse-markup ($\mu_{ijt}^{-1}$):

$$MRPK_{ijt} \equiv \frac{\partial(P_{ijt}(Q_{ijt})Q_{ijt})}{\partial K_{ijt}} = \underbrace{P_{ijt}\frac{\partial Q_{ijt}}{\partial K_{ijt}}}_{VMPK_{ijt}} \underbrace{\left(1 + \frac{Q_{ijt}}{P_{ijt}}\frac{\partial P_{ijt}}{\partial Q_{ijt}}\right)}_{\mu_{ijt}^{-1}} = \theta_{ijt}^{K}\frac{P_{ijt}Q_{ijt}}{K_{ijt}}\frac{1}{\mu_{ijt}},$$

where $P_{ijt}Q_{ijt}$ is total sales (price times quantity), $K_{ijt}$ is capital, and $\theta_{ijt}^{K}$ is the output elasticity of capital. To estimate firms' markup and output elasticity of capital, we rely on the procedure outlined in Appendix B.

The results in Column (2) of Table 12, Panel A show that, across markets, a rise in the zombie share is associated with an increase in the MRPK dispersion, measured as the standard deviation of log(MRPK). This evidence suggests that the weak investment dynamic

[33] Similarly, Column (1) of Table C.10, Panel B shows that more productive firms active in markets with a high zombie prevalence invest less compared with productive firms in non-zombie markets.

[34] An example for a distortion due to zombie lending is that zombies benefit from subsidized loans, while non-zombies can only borrow at regular rates. As a result, the MRPK of zombies is lower than that of non-zombies and reallocating capital from zombies to non-zombies would thus increase the allocative efficiency.

in markets affected by zombie credit is caused by a combination of excess aggregate supply and misallocation of capital. Column (3) in Panel A further shows that a higher zombie prevalence is associated with a lower growth in value added (obtained from Eurostat).[35] Hence, while zombie credit attenuates the aggregate sales reduction that usually follows a negative demand shock, the concurrent reduction in prices and increase in input costs associated with a higher zombie prevalence reduces the GDP contribution of these markets. Hence, our results suggest that the global rise in zombie firms (see Banerjee and Hofmann, 2018) might be a contributing factor to the observed secular slowdown in GDP growth.

Second, we analyze the impact of zombie credit on employment. Column (1) of Table 12, Panel B shows that an increase in a market's zombie prevalence does not affect its aggregate employment growth. There are two opposing effects of zombie credit on employment growth. One the one hand, by its very nature, zombie credit prevents layoffs at zombie firms by keeping these firms afloat.[36] On the other hand, zombie credit hampers an efficient reallocation of labor from zombie to non-zombie firms and reduces the available labor supply for non-zombie firms, potentially lowering the allocative efficiency of labor across firms. Through these spillovers, zombie credit negatively affects the employment growth of non-zombie firms that are active in markets with a high zombie prevalence. Employing Specification (5), we confirm these negative spillovers in Panels A and B of Table C.10, Column (2).[37]

The insignificant result of an increase in the zombie share on aggregate employment can thus be explained by these two opposing effects on employment growth in markets affected by

[35]Table C.11, Panel A provides a robustness check for this test where we use *ln(Value Added)* instead of the value added growth. The results are qualitatively similar. Panel B of Table C.11 shows a similar negative effect of a rise in zombie credit on productivity, where we follow Caballero et al. (2008) and measure productivity as *log(sales)–2/3*log(employment)–1/3*log(fixed assets)*.

[36]Descriptively, our data confirms that indeed employment growth is slightly less negative for zombie firms compared to low-quality non-zombie firms.

[37]This result is consistent with the results of Caballero et al. (2008), who find negative spillover effects of zombie lending on employment at non-zombie firms in the context of the Japanese crisis in the 1990s.

zombie credit, which seem to offset each other. While zombie credit prevents restructuring in zombie firms, thereby keeping employment up in these firms, it impedes employment growth in non-zombie firms by hampering the labor reallocation from zombie to non-zombie firms. In this way, zombie credit can potentially lower the allocative efficiency of labor across firms.

In the same vein as the capital misallocation test, we formally analyze to what extent a rise in the zombie share is associated with a larger labor misallocation by determining the markets' dispersion of the marginal revenue product of labor (MRPL), measured as the standard deviation of log(MRPL), where

$$MRPL_{ijt} \equiv \frac{\partial(P_{ijt}(Q_{ijt})Q_{ijt})}{\partial L_{ijt}} = \underbrace{P_{ijt}\frac{\partial Q_{ijt}}{\partial L_{ijt}}}_{VMPL_{ijt}} \underbrace{\left(1 + \frac{Q_{ijt}}{P_{ijt}}\frac{\partial P_{ijt}}{\partial Q_{ijt}}\right)}_{\mu_{ijt}^{-1}} = \theta_{ijt}^{L}\frac{P_{ijt}Q_{ijt}}{L_{ijt}}\frac{1}{\mu_{ijt}}.$$

Following Gopinath et al. (2017), we measure the labor input, $L_{ijt}$, with the firm's deflated wage bill.[38] Column (2) of Table 12, Panel B confirms that a higher zombie prevalence is associated with a higher MRPL dispersion, that is, a lower labor allocative efficiency.

Finally, the results in Column (3) of Table 12, Panel B highlight that the factor misallocation due to zombie credit drags down labor productivity, calculated by dividing value added by the number of employees (see Andrews et al., 2016). In particular, zombie credit and the resulting factor misallocation simultaneously lead to lower value added and labor allocative efficiency. Both effects reduce labor productivity.

Overall, the evidence in this section suggests that, while zombie credit likely has a stabilizing effect in the short-term, it has an adverse impact on the factor allocation and thus economic growth in the medium- to long-term. The resulting sluggish economic growth, in turn, feeds back into lasting disinflation. Therefore, scaling down the provision of zombie

[38]Using the wage bill instead of employment accounts for differences in the workforce quality across firms.

credit can raise productivity and labor productivity by improving the allocative efficiency across firms and thereby spur economic growth and inflation.[39]

# 8 Conclusion

The low-growth low-inflation environment that prevailed in Europe between its sovereign debt crisis and the Covid-19 pandemic bears a striking resemblance to Japan's "lost decade" in the aftermath of its crisis in the early 1990s. Similar to the Bank of Japan's crisis response, in an environment characterized by weakly-capitalized banks, the European central banks followed canonical demand-side theory and lowered interest rates, as well as, implemented massive quantitative easing programs to encourage more investment and consumption, hoping that this would lead to a surge in inflation. However, despite a significant drop in firm funding costs, inflation did not pick up as expected, which became known as Europe's "missing inflation puzzle" (see, e.g., Constâncio, 2015).

In this paper, we propose and test a novel supply-side channel that shows that zombie lending—subsidized credit to non-viable firms—has a disinflationary effect, thereby providing an explanation for the persistent low inflation rates in Europe. In Europe, political constraints led to a hesitant introduction of recapitalization measures in the aftermath of the 2008 global financial crisis, which led to zombie lending incentives. We show that, by fueling the survival of non-viable firms, zombie lending creates excess supply, which puts downward pressure on prices and inflation.

We test this zombie credit channel using a new inflation and firm-level data set that covers 1.1 million firms in 12 European countries across 65 industries. We show that industries

[39]Relatedly, Bertrand et al. (2007) shows that net employment and value added per worker increased in bank-dependent sectors following a French deregulation that reduced subsidized zombie lending.

that experienced an increase in the prevalence of zombie firms subsequently have lower firm defaults and entries, capacity utilization, markups, and inflation, higher input costs as well as a misallocation of capital and labor, which results in lower productivity, investment, and value added.

Our findings show that a central bank that implements policy measures that contribute to a persistent zombification of the economy with the objective of restoring inflation and growth might end up working against its own objectives. Conversely, accommodative monetary policy might be more effective in times of a weakening financial sector, if accompanied by a targeted bank recapitalization program.

Finally, our results draw attention to the often-neglected impact of supply-side financial frictions on inflation. The inclusion of these frictions in general equilibrium models is, in our view, an important area of future research.

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# Internet Appendix

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

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# Structure

This online appendix is structured as follows. Appendix A presents a model of the zombie lending channel. Appendix B shows how we obtain firm-level markups following De Loecker and Warzynski (2012). Appendix C presents additional tables. Appendix D presents additional figures. Appendix E presents the IV diagnostic tests outlined in Goldsmith-Pinkham et al. (2020). Appendix F discusses the survey data collected for the bank supervision intensity analysis. Appendix G presents the supply chain results. Appendix H shows that our results are not explained by alternative supply-side channels.

# Appendix A Model

In this appendix, we present our framework to analyze the relationship between zombie lending and inflation. Section A.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 A.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.

## A.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.[40]

[40] To this end, we rely on an extensive theoretical literature (see, e.g., Bruche and Llobet, 2014) that shows that weakly-capitalized banks have an incentive to roll over existing loans to non-viable firms to avoid realizing losses.

Specifically, we define an equilibrium with and without zombie credit and then compare equilibrium quantities and prices. The model adds imperfect competition among firms to a framework similar to Caballero et al. (2008).

**Setup.** 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.[41]

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

$$p_t = \alpha_t - \frac{m_t}{2}. \tag{A1}$$

***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

[41] 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.

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 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.[42] Because of the production constraint, firms charge a positive markup $(p_t - c)/c$.[43]

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:

$$X_t = m_t \int_0^{\frac{I}{p_t - c}} di = \frac{m_t I}{p_t - c} \qquad S_t = m_t \int_{\frac{I}{p_t - c}}^1 di = m_t \left(1 - \frac{I}{p_t - c}\right). \tag{A2}$$

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

$$E_t = e \int_{\frac{I}{p_t - c}}^1 di = e \left(1 - \frac{I}{p_t - c}\right). \tag{A3}$$

[42]If $\alpha_t$ 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.

[43]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.

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

$$N_t = (e + m_t)\frac{1}{2}\left(1 - \left(\frac{I}{p_t - c}\right)^2\right). \tag{A4}$$

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

**Definition 1.** *Given the demand parameter $\alpha$, 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 (A1), total production is given by (A4), 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:

$$\begin{aligned}
p_t &= \alpha_t - \frac{m_t}{2} \\
m_{t+1} &= m_t + \overbrace{e\left(1 - \frac{I}{p_t - c}\right)}^{E_t} - \overbrace{\frac{m_t I}{p_t - c}}^{X_t} \\
N_t &= (e + m_t)\frac{1}{2}\left(1 - \left(\frac{I}{p_t - c}\right)^2\right)
\end{aligned}$$

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:

$$p_t = \alpha_t - \frac{m_t}{2} \tag{A5}$$

$$m_{t+1} = m_t + \overbrace{e\left(1 - \frac{I}{p_t - c}\right)}^{E_t} - \overbrace{\left(\frac{m_t I}{p_t - c} - \overline{Z}\right)}^{X_t} \tag{A6}$$

$$N_t = (e + m_t)\frac{1}{2}\left(1 - \left(\frac{I}{p_t - c}\right)^2\right) + \frac{\overline{Z}^2}{2m_t} \quad \text{where} \quad \frac{\overline{Z}^2}{2m_t} = m_t \int_0^{\frac{\overline{Z}}{m_t}} i di \tag{A7}$$

**Definition 2.** *Given the demand parameter $\alpha$, 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 (A1), total production is given by (A7), $\overline{Z}$ 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 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, 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 A.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 (red dashed line) and an economy with high zombie lending (black 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 A.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.

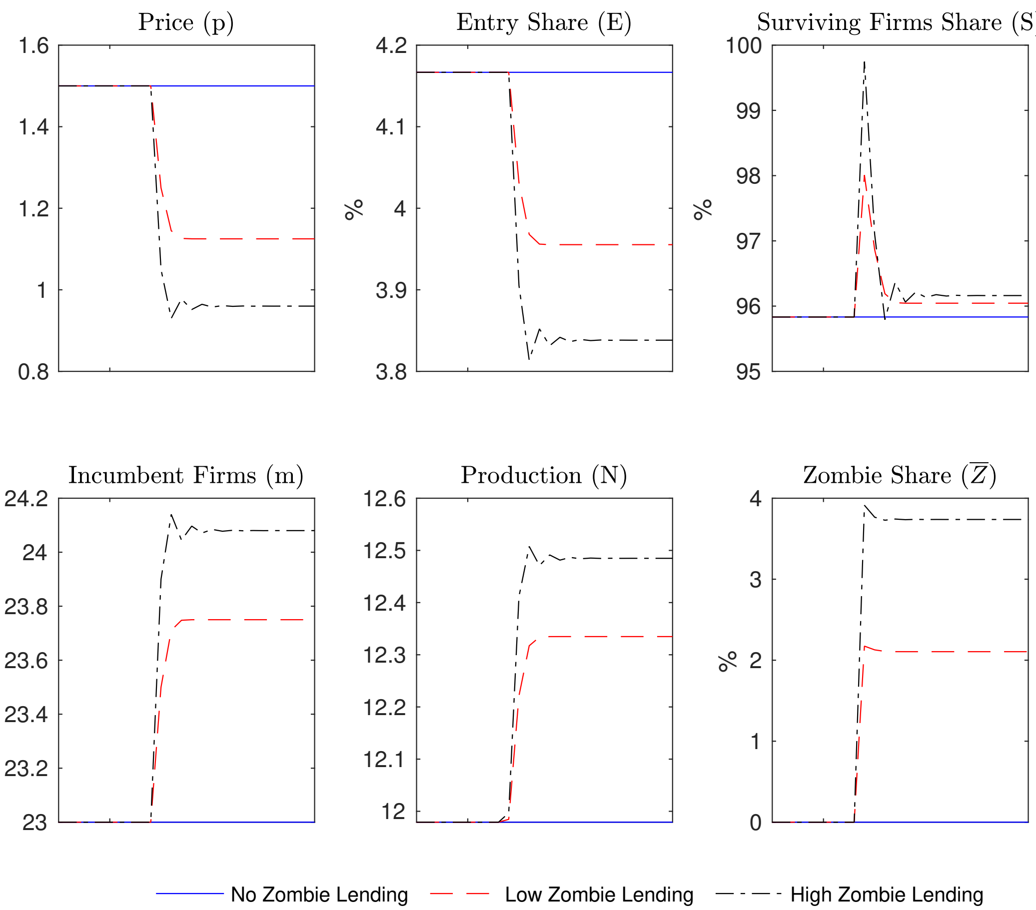


**Figure A.1: Responses to Positive Zombie Credit Shock.** This figure shows how equilibrium quantities and prices respond to a permanent increase in $\overline{Z}$. The red dashed lines indicate an equilibrium with low zombie credit. The black dash-dot lines indicate an equilibrium with high zombie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

Figure A.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

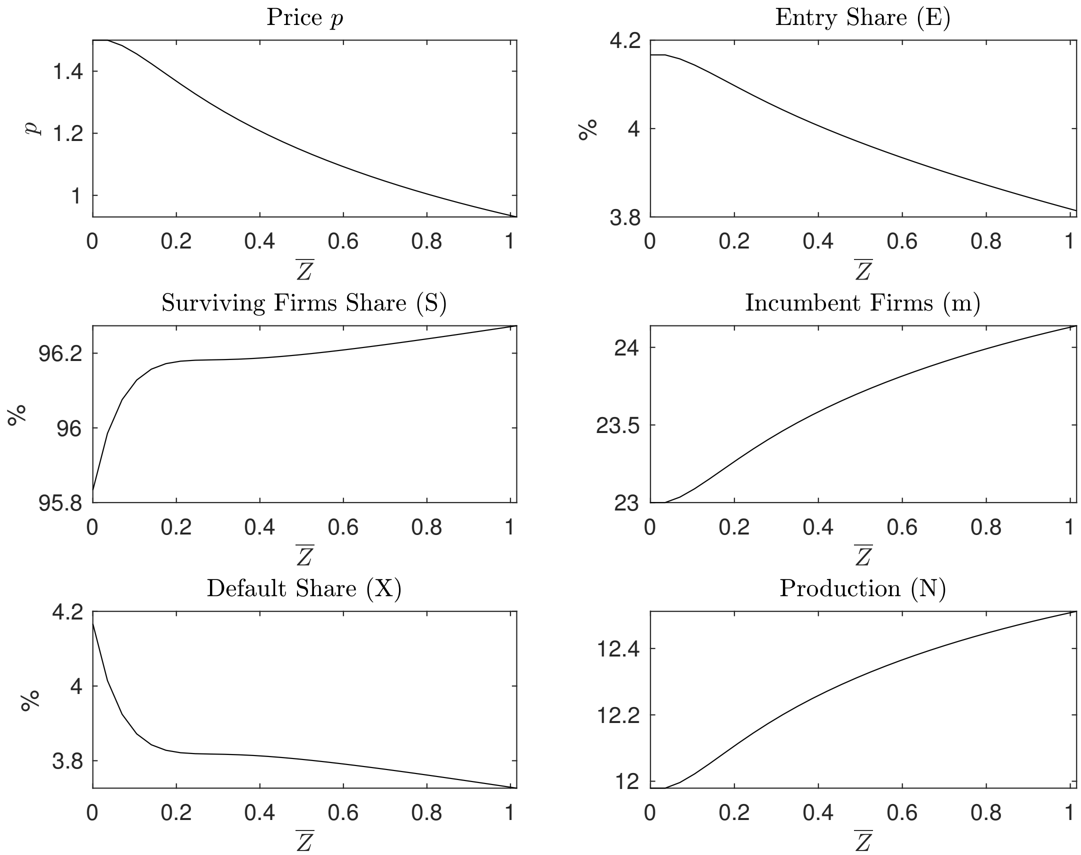


**Figure A.2: Steady State Equilibrium Prices as Zombie Credit Changes – Extensive Margin Model.** This figure shows how equilibrium steady state quantities and prices respond to changes in $\overline{Z}$. The parameters are $I = 0.05$, $e = 1$, $c = 0.3$, $\alpha = 13$, and $\overline{Z}^L \in$[0,1].

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.

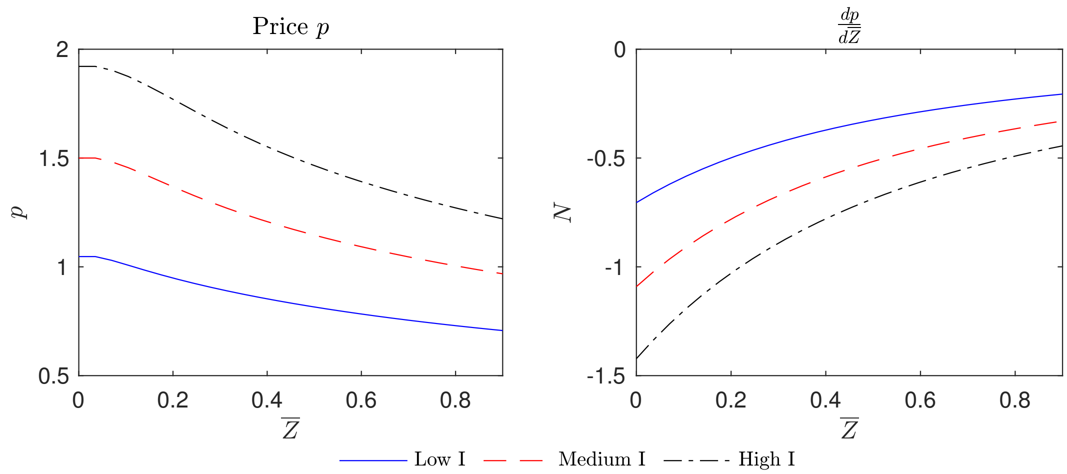


**Figure A.3: Sensitivity with respect to $I$ – Extensive Margin Model.** This figure shows how equilibrium steady state prices respond to changes in $\overline{Z}$. The parameters are $e = 1$, $c = 0.3$, $\alpha = 13$, and $\overline{Z} \in [0, 1]$. The figure shows the collection of equilibria for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

## A.2 Intensive Margin Model

In this section, we extend the extensive margin framework from Section A.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 A.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 $\delta$. 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).

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

$$max_{y_{it} \in [0,1]}(M_t y_{it} - I)q(y_{it}) - (1 - q(y_{it}))(1 - z)\delta, \tag{A8}$$

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 $\delta$.

Taking the first-order condition (FOC) of Eq. (A8) with respect to the production scale yields

$$M_t q(y_{it}) + (M_t y_{it} - I + \delta(1 - z))q'(y_{it}) = 0. \tag{A9}$$

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. (A9) with respect to $z$ yields

$$\frac{\partial y_{it}}{\partial z} = \frac{\delta q'(y_{it})}{2M_t q'(y_{it}) + (M_t y_{it} - I + \delta(1-z))q''(y_{it})} > 0, \tag{A10}$$

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

$$\frac{\partial y_{it}}{\partial I} = \frac{q'(y_{it})}{2M_t q'(y_{it}) + (M_t y_{it} - I + \delta(1-z))q''(y_{it})} > 0. \tag{A11}$$

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

$$max_{y_{it} \in [0,1]}(M_t y_{it} - I)q(y_{it}) - (1 - q(y_{it}))\delta, \tag{A12}$$

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

$$M_t q(y_{it}) + (M_t y_{it} - I + \delta)q'(y_{it}) = 0. \tag{A13}$$

Note that, in this case, $z$ does not affect the firms' production choices. The implicit differentiation of the production scale from Eq. (A13) with respect to $I$ yields

$$\frac{\partial y_{it}}{\partial I} = \frac{q'(y_{it})}{2M_t q'(y_{it}) + (M_t y_{it} - I + \delta)q''(y_{it})} > 0. \tag{A14}$$

The intuition underlying Eqs. (A11) and (A14) 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

$$\frac{\partial y_{it}^2}{\partial I \partial z} = \frac{\delta q'(y_{it}) q''(y_{it})}{\left(2M_t q'(y_{it}) + (M_t y_{it} - I + \delta(1-z)) q''(y_{it})\right)^2} > 0. \tag{A15}$$

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. (A11) and (A14). 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

$$(M_t y_{it}^*(I) - I) q(y_{it}^*(I)) - (1 - y_{it}^*(I))\delta > K. \tag{A16}$$

Condition (A16) 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:

$$X_t = m_t\Bigg[\int_0^{\hat{I}}[1-q(y^*_{it}(I))]dG(I) + (1-z)\int_{\hat{I}}^{\bar{I}}[1-q(y^{**}_{it}(I))]dG(I)\Bigg]\Bigg/F_t, \tag{A17}$$

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:

$$S_t = m_t\Bigg[\int_0^{\hat{I}} q(y^*_{it}(I))dG(I) + \int_{\hat{I}}^{\bar{I}} q(y^{**}_{it}(I))dG(I) + z\int_{\hat{I}}^{\bar{I}}[1-q(y^{**}_{it}(I))]dG(I)\Bigg]\Bigg/F_t. \tag{A18}$$

Finally, the total fraction of surviving entrants is:

$$E_t = e\int_{\mathcal{I_E}} q(y^*_{it}(I))dG(I)\Bigg/F_t. \tag{A19}$$

Hence, aggregate production is given by:

$$\begin{aligned} N_t = m_t\Bigg(&\int_0^{\hat{I}} q(y^*_{it}(I))y^*_{it}(I)dG(I) + \int_{\hat{I}}^{\bar{I}} q(y^{**}_{it}(I))y^{**}_{it}(I)dG(I) + z\int_{\hat{I}}^{\bar{I}}[1-q(y^{**}_{it}(I))]y^{**}_{it}(I)dG(I)\Bigg) \\ &+ e\int_0^{\mathcal{I_E}} q(y^*(I))y^*(I)dG(I). \end{aligned} \tag{A20}$$

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

$$\begin{aligned} \alpha - \beta p^{**} = m^{**}\Bigg(&\int_0^{\hat{I}} q(y^*(I))y^*(I)dG(I) + \int_{\hat{I}}^{\bar{I}} q(y^{**}(I))y^{**}(I)dG(I) + z\int_{\hat{I}}^{\bar{I}}[1-q(y^{**}(I))]y^{**}(I)dG(I)\Bigg) \\ &+ e\int_{\mathcal{I_E}} q(y^*(I))y^*(I)dG(I), \end{aligned} \tag{A21}$$

$$m^{**}\Bigg(\int_0^{\hat{I}}[1-q(y^*(I))]dG(I) + (1-z)\int_{\hat{I}}^{\bar{I}}[1-q(y^{**}(I))]dG(I)\Bigg) = e\int_{\mathcal{I_E}} q(y^*(I))dG(I), \tag{A22}$$

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 $[0, \bar{I}]$ 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

$$I \geq I_z := (2 - 1/\theta)(p - c) + (1 - z)\delta, \tag{A23}$$

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

$$I \geq I_{nz} := (2 - 1/\theta)(p - c) + \delta. \tag{A24}$$

Given the optimal production choice of a potential entrant, and with the assumed functional form for $q(y)$, Condition (A16) becomes

$$\left[\frac{p-c}{2}\left(\frac{1}{\theta} + \frac{I-\delta}{p-c}\right) - I\right]\frac{1}{2}\left(1 - \frac{\theta(I-\delta)}{p-c}\right) - \frac{1}{2}\left(1 + \frac{\theta(I-\delta)}{p-c}\right)\delta > K, \tag{A25}$$

assuming a nonbinding production constraint. Hence, a potential entrant firm will only enter if and only if Condition (A25) is satisfied. Condition (A25) has two roots:

$$I_{1,2} = p - c + \theta\delta \pm 2\sqrt{(p-c)\theta(\delta + K)}. \tag{A26}$$

For reasonable parameter ranges, the first root of Condition (A25) is always greater than $\bar{I}$. Hence, Condition (A25) translates into

$$I < \mathcal{I}_{\mathcal{E}} := p - c + \theta\delta - 2\sqrt{(p-c)\theta(\delta + K)}. \tag{A27}$$

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

**Insights.** Figure A.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 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 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:

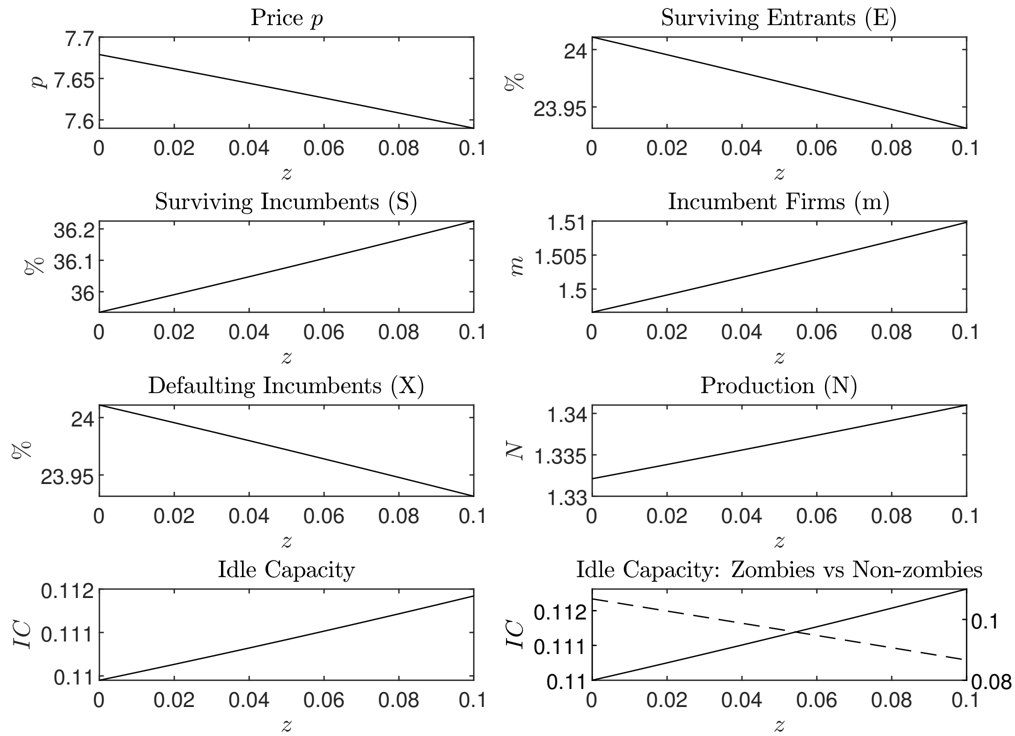


**Figure A.4: Steady State Equilibrium Prices as Zombie Credit Changes – Intensive Margin Model.** This figure shows how equilibrium steady state quantities and prices respond to changes in $z$. In the last panel, zombies (right axis) are the dashed line, non-zombies (left axis) are the solid line. The 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 $I \in [0, 0.1]$.

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 A.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, we can measure the average idle capacity

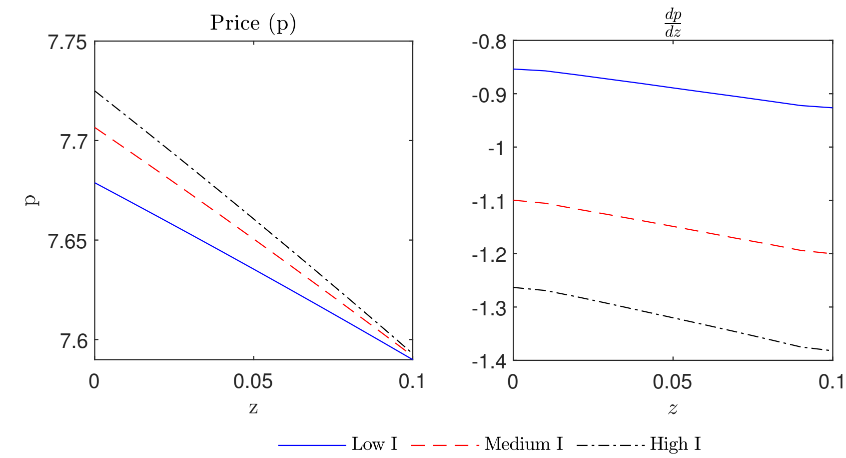


**Figure A.5: Sensitivity of price with respect to I – Intensive Margin Model.** This figure shows how equilibrium steady state prices respond to changes in $z$, for different supports of $I$. The parameters are $e = 1$, $c = 0.1$, $\alpha = 2.1$, $\beta = 0.1$, $\delta = 3.4$, $K = 0.5$, and $\theta = 0.45$. 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.

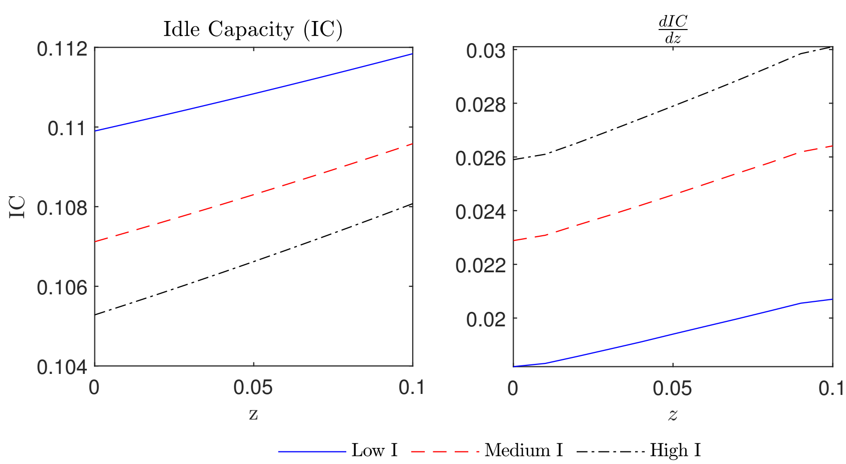


**Figure A.6: Sensitivity of idle capacity with respect to I – Intensive Margin Model.** This figure shows how equilibrium steady state prices respond to changes in $z$, for different supports of $I$. The parameters are $e = 1$, $c = 0.1$, $\alpha = 2.1$, $\beta = 0.1$, $\delta = 3.4$, $K = 0.5$, and $\theta = 0.45$. 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.

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 A.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 A.4 confirms this intuition: idle capacity increases with $z$ for non-zombie firms and decreases with $z$ for zombie firms.

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

# Appendix B Markup Estimation

To obtain firm-level markups, we follow the procedure proposed by 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 et al. (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:

$$Q_{ijt} = Q_{ijt}(\Omega_{ijt}, V_{ijt}, K_{ijt}), \tag{B1}$$

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 $\Omega_{ijt}$ the firm-specific Hicks-neutral productivity term. Following De Loecker et al. (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:

$$\mathcal{L}(V_{ijt}, K_{ijt}, \lambda_{ijt}) = P^V_{ijt} V_{ijt} + r_{ijt} K_{ijt} + F_{ijt} - \lambda_{ijt}(Q(\cdot) - \overline{Q}_{ijt}), \tag{B2}$$

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

$$\frac{\partial \mathcal{L}_{ijt}}{\partial V_{ijt}} = P^V_{ijt} - \lambda_{ijt} \frac{\partial Q(\cdot)}{\partial V_{ijt}} = 0. \tag{B3}$$

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

$$\theta^v_{ijt} \equiv \frac{\partial Q(\cdot)}{\partial V_{ijt}} \frac{V_{ijt}}{Q_{ijt}} = \frac{1}{\lambda_{ijt}} \frac{P^V_{ijt} V_{ijt}}{Q_{ijt}}. \tag{B4}$$

As the Lagrange multiplier $\lambda$ 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:

$$\mu_{ijt} = \theta^v_{ijt} \frac{P_{ijt} Q_{ijt}}{P^V_{ijt} V_{ijt}}. \tag{B5}$$

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, $\theta^v_{ijt}$.

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):[44]

$$q_{ijt} = \beta_{v1} v_{ijt} + \beta_{k1} k_{ijt} + \beta_{v2} v_{ijt}^2 + \beta_{k2} k_{ijt}^2 + \omega_{ijt} + \epsilon_{ijt}. \tag{B6}$$

where lower cases denote logs.[45] 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 (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 $\epsilon_{ijt}$ is the unanticipated shock to output.[46] 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. (B6), 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 ($\epsilon_{ijt}$) are purged using a non-parametric projection of output on the inputs and the control variable:

$$q_{ijt} = \phi_{ijt}(v_{ijt}, k_{ijt}) + \epsilon_{ijt}. \tag{B7}$$

[44]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).

[45]Following De Loecker et al. (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.

[46]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.

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

$$\omega_{ijt} = g_t(\omega_{ijt-1}) + \varepsilon_{ijt}. \tag{B8}$$

We can compute productivity for any value of $\beta$, 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 nonparametrically regressing $\omega_{ijt}(\beta)$ on its lag, $\omega_{ijt-1}(\beta)$, we recover the innovation to productivity given $\beta$, $\varepsilon_{ijt}(\beta)$.

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

$$E\left(\varepsilon_{ijt}(\beta)\begin{pmatrix} v_{ijt-1} \\ k_{ijt} \\ v_{ijt-1}^2 \\ k_{ijt}^2 \end{pmatrix}\right) = 0, \tag{B9}$$

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:

$$\theta_{ijt}^v = \widehat{\beta}_{v1} + 2\widehat{\beta}_{v2} v_{ijt}, \tag{B10}$$

which allows us to calculate the markup of firm $i$.

For the misallocation tests from Table 12, 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.

# Appendix C Additional Tables

| | 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 C.1: CPI Growth – Without Extreme Markets.** In this table, we redo the analysis from Panel B of Table 2, 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 3.2 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.

| | Def. #1 ΔCPI | Def. #2 ΔCPI | Def. #3 ΔCPI | Def. #4 ΔCPI | Def. #5 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 C.2: 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 3.2 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.

| | 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 C.3: 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 3.2 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.

| 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 C.4: 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 3.2 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: Second Stage | ΔCPI | ΔCPI | ΔCPI |
|---|---|---|---|
| $\widehat{Share\ Zombies}$ | −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 C.5: 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.

| | 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 C.6: Summary Statistics – Equilibrium Predictions.** This table presents summary statistics for the dependent variables in Section 5.1 to Section 5.3.

| | 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 C.7: Firm Defaults – Evidence based on Amadeus Data.** This table presents estimation results from Specification (3). 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 3.2 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

| | 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 C.8: 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.

| | ΔCPI | ΔCPI | ΔCPI | Idle Capacity | Idle Capacity | Idle Capacity |
|---|---|---|---|---|---|---|
| Share $\text{Zombies}_{t-1}$ | −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* $\textit{Zombies}_{t-2}$ | −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* $\textit{Zombies}_{t-3}$ | | −0.009 | −0.001 | | 1.551 | 4.110 |
| | | (0.007) | (0.009) | | (2.597) | (3.944) |
| *Share* $\textit{Zombies}_{t-4}$ | | | 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 C.9: CPI Growth – Dynamics.** This table presents estimation results from Specification (3), but additionally including *Share* $\textit{Zombies}_{t-2}$ (Columns 1 and 4), *Share* $\textit{Zombies}_{t-2}$ and *Share* $\textit{Zombies}_{t-3}$ (Columns 2 and 5) or *Share* $\textit{Zombies}_{t-2}$, *Share* $\textit{Zombies}_{t-3}$, and *Share* $\textit{Zombies}_{t-4}$ (Columns 3 and 6). The dependent variable is the annual CPI growth rate (inflation) from $t-1$ to $t$. *Share Zombies*, *Share* $\textit{Zombies}_{t-2}$, *Share* $\textit{Zombies}_{t-3}$, and *Share* $\textit{Zombies}_{t-4}$ 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 3.2 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 | 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 C.10: 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 3.2 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 | 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 C.11: Value Added and Productivity.** This table presents estimation results from Specification (3). The dependent variables are *ln(Value Added)* (Panel A) and asset-weighted productivity (*log(sales)–2/3*log(employment)–1/3*log(fixed assets)*, 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 3.2 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.

| 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 |

**Table C.12: 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.

# Appendix D Additional Figures

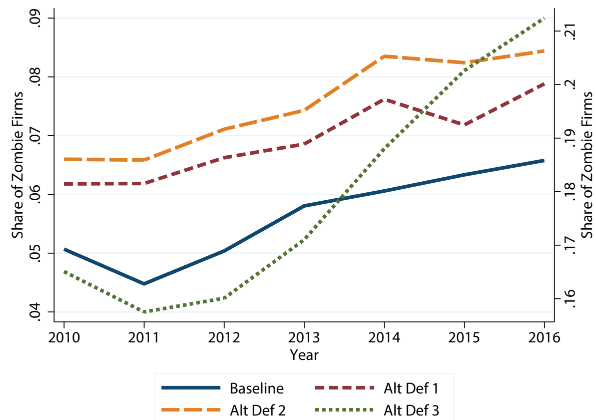


**Figure D.1: Alternative Zombie Classifications.** This figure shows the evolution of the zombie share for alternative zombie definitions. The blue solid line replicates our main measure of the zombie share (scale on left y-axis). Alt Def 1 (red dashed line; left y-axis) calculates median values for 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.

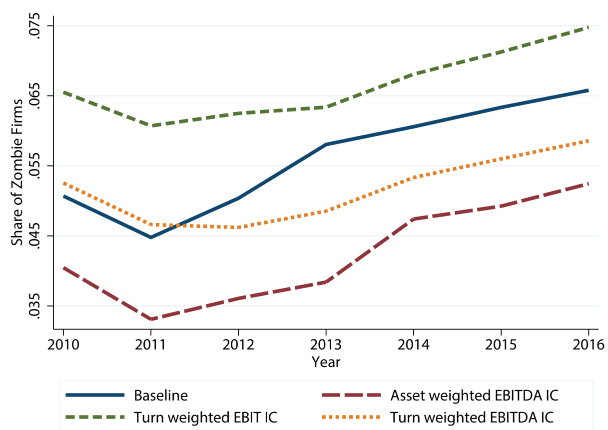


**Figure D.2: Alternative Zombie Share Weighting.** This figure shows the evolution of the zombie share for alternative zombie definitions. The blue solid line replicates our main zombie share measure (i.e., asset-weighted aggregation and IC ratio based on EBIT). The red long dashed line shows the evolution 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.

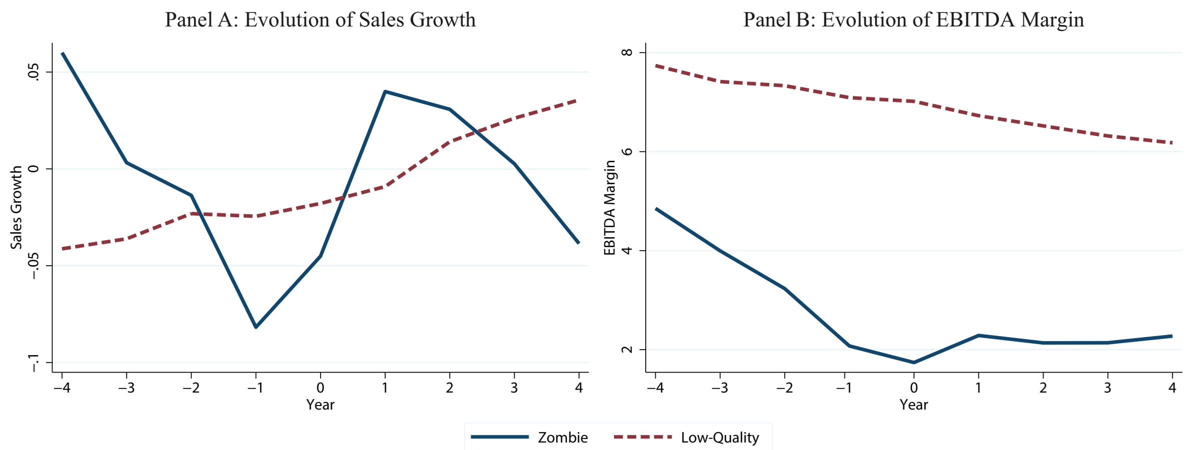


**Figure D.3: Evolution of Sales Growth and EBITDA Margin.** This figure shows the evolution of sales growth and profitability for zombie firms. Year 0 corresponds to the first sample year when a firm is classified as zombie. The zombie status can change after year 0, i.e., the zombie condition is not 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).

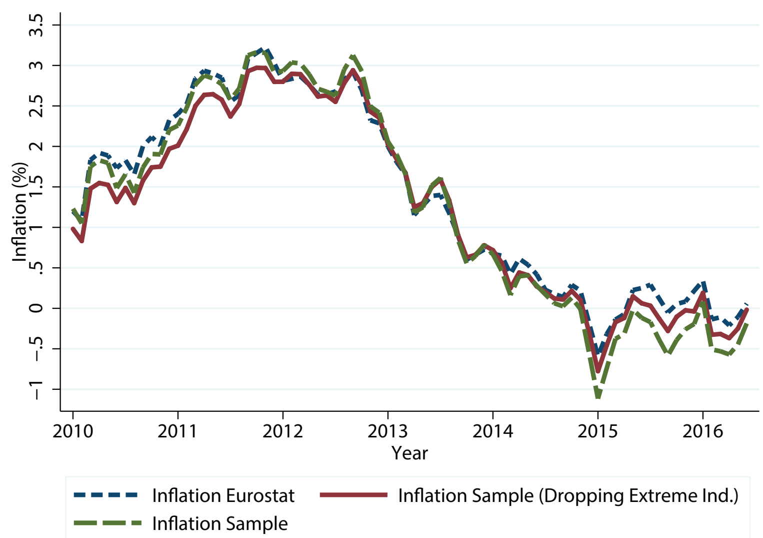


**Figure D.4: Sample vs. Official Inflation.** This figure shows evolution of the official inflation for our 12 sample countries from Eurostat (blue short dashed line), the inflation aggregated from our industry-country dataset with (red solid line) and without (green long dashed line) dropping extreme markets with less than -50% or more than +50% annual price growth.

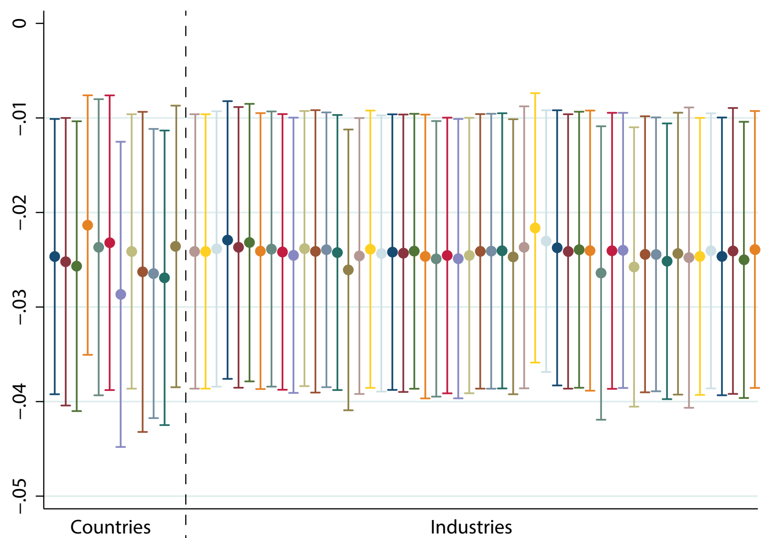


**Figure D.5: CPI Growth – Exclusion of Individual Countries and Industries.** This figure presents estimation results from Specification (3). Each bar shows the coefficient for *Share Zombies* and its 95% confidence interval for the regression of CPI growth rate (inflation) from $t-1$ to $t$ on *Share 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 country-industry, 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 3.2 for more details).

# Appendix E 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 et al. (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 E.1 splits the instruments into those with positive and negative bank-specific Rotemberg weights, denoted $\alpha_b$. 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 et al., 2020).

Some negative $\alpha_b$ raise the possibility of (but do not imply) nonconvex weights on $\beta_{hj}$, 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 $\beta_{hj}$ (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 and high vs. low fixed cost sectors). Hence, we cannot rule out that there are negative weights on the $\beta_{hj}$.

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

**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**

| | $\alpha_b$ | *Loan Growth*$_c$ | $\beta_b$ | $F_b$ | var($Share_{hjb}$) |
|---|---|---|---|---|---|
| $\alpha_b$ | 1 | | | | |
| *Loan Growth*$_c$ | −0.016 | 1 | | | |
| $\beta_b$ | −0.015 | 0.471 | 1 | | |
| $F_b$ | 0.113 | −0.032 | −0.023 | 1 | |
| var($Share_{hjb}$) | 0.140 | −0.019 | −0.092 | −0.073 | 1 |

**Panel C: Variation Across Years in $\alpha_b$**

| | 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. $\alpha$ | Total Assets (in bn) | Tier-1 Ratio |
|---|---|---|---|
| Top Ten | 0.069 | 756 | 7.32% |
| Other | 0.0012 | 340 | 9.94% |

**Panel E: Estimates of $\beta_b$ for Positive and Negative Weights**

| | $\alpha$-weighted Sum | Share of overall $\beta$ | Mean |
|---|---|---|---|
| Negative | 0.109 | −0.895 | 0.098 |
| Positive | −0.231 | 1.895 | 0.079 |

**Table E.1: 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 (*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($Share_{hjb}$)). 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.

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 E.2 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.

| | 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 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

**Table E.2: 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.

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 ($\beta_b$). 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 E.1 shows the relationship between the Rotemberg weights and the first-stage F-statistic. Specifically, the x-axis is the first-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 $\alpha_b$ 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., $\beta_{hj}$).

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 heteroge-

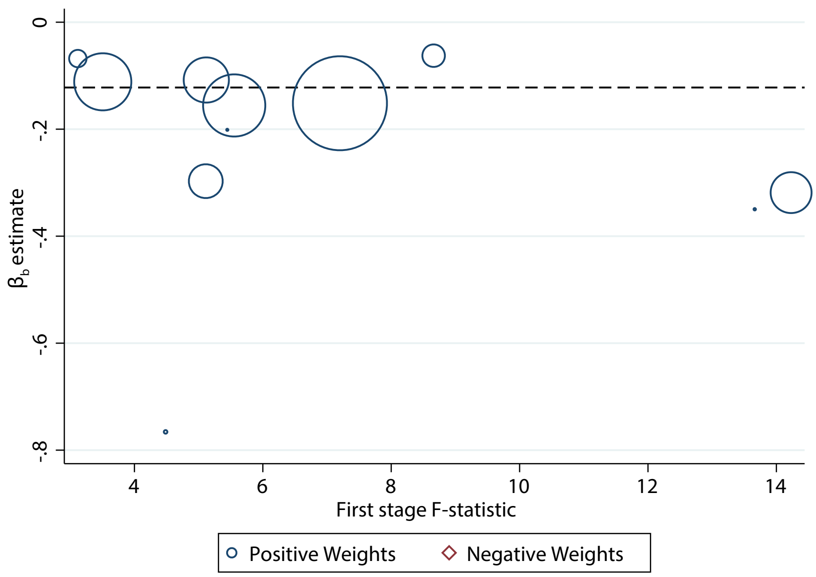


**Figure E.1: Heterogeneity of $\beta_b$.** This figure plots the relationship between each instruments' $\hat{\beta}_b$, first-stage F-statistics, and the Rotemberg weights. Each point is a separate instrument estimate. The figure plots the estimated $\hat{\beta}_b$ for each instrument on the y-axis 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 4. The figure excludes instruments with first-stage F-statistics below 3.

neous 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 $\beta_{hj}$. However, the visual tests alleviate this concern. Finally, the diagnostic tests do not raise concerns about potential violations of the exclusion restriction.

# Appendix F Data on Bank Supervision Strictness

The test in Section 6.2 is based on 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.

# Appendix G 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 G.1 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 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.

| | $\Delta$PPI | $\Delta$weighted PPI | $\Delta$weighted 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 | ✓ | ✓ | ✓ |

**Table G.1: 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 3.2 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.

# Appendix H 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 H.1 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 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

| | 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 | ✓ | ✓ | ✓ | ✓ |

**Table H.1: 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 3.2 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.

channel for CPI growth.[47] 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.

[47]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.