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Abstract

We show that "zombie credit"—cheap credit to impaired firms—has a disinflationary effect. By helping distressed firms to stay afloat, such credit creates excess production capacity, thereby putting downward pressure on product prices. Granular European data on inflation, firms, and banks confirm this mechanism. Industry-country pairs affected by a rise of zombie credit show lower firm entry and exit rates, markups, and product prices, as well as a misallocation of capital and labor, which results in lower productivity, investment, and value added. Without a rise in zombie credit, inflation in Europe would have been 0.4 percentage point higher post-2012.

Key words: zombie lending, undercapitalized banks, disinflation, firm productivity, eurozone

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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" bears a striking resemblance to Japan's "lost decades." Besides a deflationary pressure, both economies have been characterized by a persistent low interest rate environment and "zombie lending" (i.e., cheap credit to impaired firms) by weakly-capitalized banks (e.g., Caballero et al., 2008, Giannetti and Simonov, 2013, and Acharya et al., 2019). These forces have pushed borrowing costs to record lows, even for high-risk firms. Since 2012, the ECB's cost-of-borrowing indicator for corporate loans more than halved, the share of Euro-denominated leveraged loans that are "covenant-lite" soared from 5% to 99%, while the average yield on European corporate junk bonds dropped by roughly two-thirds (with some junk bonds even starting to trade at sub-zero yields).[2]

There is an active debate about whether this glut of cheap debt led to a "zombification"

[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] Sources: "cost of borrowing for corporations" series from http://sdw.ecb.europa.eu; "Leveraged Finance", European Banking Authority, 2002; https://fred.stlouisfed.org/series/BAMLHE00EHYIEY; "Sub-Zero Yields Start Taking Hold in Europe's Junk-Bond Market", *Bloomberg*, July 2019.

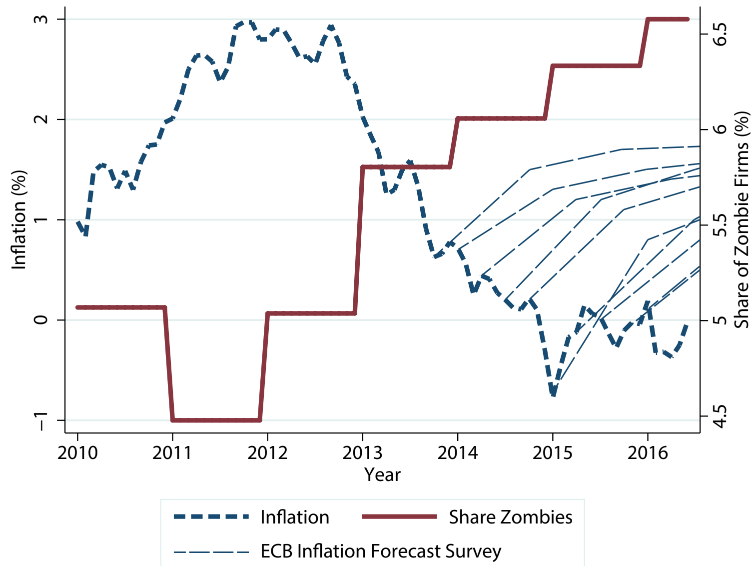

Figure 1: Zombie Credit and Inflation. This figure shows the year-over-year (yoy) growth of the CPI on the left axis and the asset-weighted share of zombie firms on the right axis in our sample. A firm is classified as zombie if it is low-quality (i.e., above median leverage and below median interest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

(or "Japanification") of the European economy by keeping non-viable firms afloat (see, e.g., Borio and Hofmann, 2017). The Covid-19 crisis, the resulting deterioration of firm and bank health, as well as the belief that central banks will keep interest rates low indefinitely, has further brought these concerns into the academic and policy spotlight.

In this paper, we propose a *zombie credit channel* that can explain the concurrence of the rise of zombie credit and the disinflationary pressure shown in Figure 1. Coinciding with the adoption of extraordinary monetary easing measures in Europe, inflation dropped from roughly 3% to zero and the share of zombie firms increased from 4.5% to 6.7% (with a large cross-sectional variation across countries and industries). During the same time, inflation forecasts started to significantly overshoot the actual inflation rate.

Building on Caballero et al. (2008), we illustrate in a simple model that by keeping impaired firms alive that would otherwise default, zombie credit hampers the adjustment in the aggregate production capacity that usually follows a negative demand shock. The resulting excess capacity puts downward pressure on firms' markups and product prices. In equilibrium, zombie credit causes a decrease in firm entry and exit rates, markups, and product prices, 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.[4] Using input-output 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 (very 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—strongly suggesting that their access to cheap credit is not due to a positive future 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 stronger increase in the share of zombie firms subsequently have a lower CPI growth. In our most stringent specification, we include

[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.

[4]The European setting is well-suited for our analysis since Europe was hit by negative demand shocks in the first half of our sample period and the European banking system remained weakly-capitalized.

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 affect firm quality. Our estimates suggest that without a rise in zombie credit, the annual CPI growth in Europe during 2012-2016 would have been 0.4 percentage points (pp) higher, which can explain about 48% of the overshooting in the ECB inflation survey forecast shown in Figure 1.

To further address potential omitted variable biases, we instrument a market's zombie share exploiting that weaker banks have stronger zombie lending incentives (see, e.g., Acharya et al., 2019). In particular, we employ two Bartik-style shift-share instruments (see Bartik, 1991) that are based on the ex-ante capitalization of the banks connected to the firms in the respective market and proxies for time-varying country-level bank shocks (aggregate loan and non-performing loan growth). 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 country's economic conditions decline. Our instruments thus get all of the cross-sectional variation in exposure to weak banks from *pre-existing* lending shares, and all of their time-series variation from country-level time-varying shocks. Our instrumental variable regression estimates confirm the negative effect of zombie credit on CPI growth.

Consistent with the zombie credit channel, we further 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, (ii) lower firm exit and entry rates, (iii) lower average markups, (iv) higher average material and labor costs, (v) higher aggregate sales growth, and (vi) lower value added. The positive correlation between zombie credit and firm input costs is consistent with relatively more firms demanding the same inputs sustaining their prices. The positive correlation between zombie credit and sales growth provides further evidence that the negative correlation between zombie credit and CPI growth is not due to lower demand in markets with more zombie credit (as lower demand with an elastic supply-side adjustment would *lower* sales). While zombie credit attenuates the aggregate sales reduction that usually follows a negative demand shock, the concurrent price decrease and costs increase associated with a higher zombie prevalence reduces value added; this, in turn, decreases the GDP contribution of these markets.

At the firm-level, we find, in line with the predictions of the zombie credit channel, that these market-level outcomes are at least partly caused by negative spillover effects to non-zombie firms, and not solely due to compositional effects (i.e., the increased number of zombie firms relative 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.

Finally, our results show that zombie credit 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 excess production capacity and the lower allocative efficiency in these markets result in lower average net investment and labor productivity; furthermore, they lead to lower employment growth for non-zombie firms in zombie markets compared to that for non-zombie firms in non-zombie markets.

We conduct several robustness checks. First, we show that employing the share of low-quality firms (without conditioning on cheap credit) instead of the zombie share does not yield any significant results, confirming that our results are not simply driven by changes in average firm quality. Second, we control for two other (financial frictions-induced) supply-side channels, namely the cost channel (Barth III and Ramey, 2001) and the liquidity squeeze channel (Chevalier and Scharfstein, 1996). Including proxies for these channels does not alter the explanatory power of the zombie credit channel for CPI growth. Third, we show that our results are robust to using several alternative definitions of zombie firms and alternative measures for the firm exit rates.

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 1990s (see Peek and Rosengren, 2005, Caballero et al., 2008, and Giannetti and Simonov, 2013).[5] 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. (2019) show that zombie lending in Portugal increased input misallocation across firms reducing firm productivity; Schivardi et al. (2019) show that non-viable Italian firms obtained favorable bank credit; and Acharya et al. (2019) link zombie lending to the ECB's OMT program.[6] We build on this literature and show that, by allowing non-viable firms to stay afloat, zombie lending creates excess production capacity, affecting product prices.

Second, we contribute to the literature on the effects of financial frictions on inflation. Chevalier and Scharfstein (1996) suggest 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) propose the "cost channel," arguing that firms' marginal costs depend on their funding conditions, which implies an increase (decrease) in inflation after a monetary tightening (loosening). Christiano et al. (2015) show that the cost channel helps to explain the modest disinflation in the U.S. during the Great Recession. Our results suggest that, while these supply-side channels (and the demand channel) likely also contributed to the disinflationary trend in Europe, the zombie credit channel was a distinctive additional driver for the observed low inflation.

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

[6] Angelini et al. (2020) and Bonfim et al. (2020) find that banks became less likely to engage in zombie lending after regulatory bank inspections.

Third, we contribute to the literature on resource misallocation.[7] Most related to our work, Bertrand et al. (2007) analyze 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. (2020) show 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) show that an interest rate reduction led to capital misallocation in Southern Europe in the 90s.

Our results have several further implications. First, they may help reconcile the weakened link between cost and price inflation (e.g., Del Negro et al., 2020). Second, they suggest that the global rise of zombie firms could be a driver for the secular slowdown in GDP growth. Third, in light of the Covid-19 crisis, they highlight that zombie credit—while likely well-suited for highly temporary, economy-wide problems—might suppress economic growth and inflation when provided for too long. A central bank that implements policy measures that contribute to a persistent zombification of the economy with the objective of restoring inflation and growth thus might end up working against its own objectives.

The rest of the paper is structured as follows. Section 2 presents the intuition of the zombie credit channel (Appendix A presents a formal model). Section 3 explains the data. Section 4 links zombie credit to CPI growth, our main variable of interest. We analyze further model predictions in Section 5 and real effects in Section 6. Section 7 provides several robustness tests. Section 8 discusses the global implications, while Section 9 concludes.

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

2 Mechanism of the Zombie Credit Channel

In this section, we lay out the intuition of the zombie credit channel. In Appendix A, we present a formal model which develops a framework building on Caballero et al. (2008).

Our goal is to study the effect of zombie credit on product prices through its impact on the aggregate production capacity. To this end, we consider an environment with imperfect competition among firms. Firms produce a single good and choose its price, where the demand for this good is exogenous and the supply is the sum of the production by incumbent and entrant firms. Incumbent and potential entrants are subject to an idiosyncratic shock. Incumbent firms that receive a bad shock might be forced to exit and entrant firms that receive a good shock might enter. In equilibrium, holding demand constant, a higher number of firms leads to a lower product price.

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'.

Without zombie credit, the demand shock causes the price and quantity to decrease along the supply curve S to the new equilibrium N. The shock causes a direct 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 incumbent firms has a positive effect on price, but not enough to offset the initial decline.

In the case with zombie credit, the demand shock causes the price and quantity to decrease, but along a *flatter* supply curve S^Z to the new equilibrium Z. The shock causes a direct drop in price making the economy less attractive for both entrant and incumbent firms. Similar to the adjustment without zombie credit, fewer potential entrant firms enter. However, the adjustment through exit is weaker as zombie credit keeps afloat some incumbent

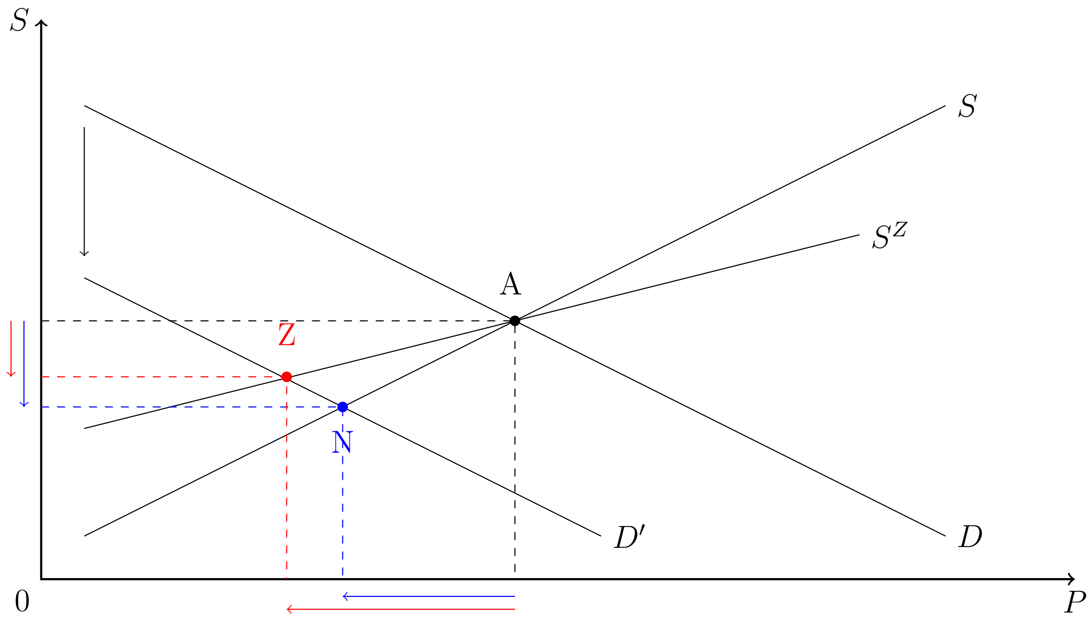

Figure 2: Intuition. This figure shows how zombie credit affects the equilibrium quantity and price.

firms that would otherwise default. The result is a flatter supply curve: a reduction in price leads to a muted effect on quantities.

Formally, consider a linear demand $P = \alpha - Q$. Given that the good is produced by surviving incumbent and entrant firms, a demand shock (lower α) affects the price of the good in three ways:

$$\frac{dP}{d\alpha} = \underbrace{\frac{\partial P}{\partial \alpha}}_{>0} + \underbrace{\frac{\partial P}{\partial Entry}\frac{\partial Entry}{\partial \alpha}}_{<0} + \underbrace{\frac{\partial P}{\partial Exit}\frac{\partial Exit}{\partial \alpha}}_{\substack{<0 \\ =0 \text{ with zombie credit}}}. \tag{1}$$

First, the direct effect: a lower demand (lower α) reduces the equilibrium price. Second, the offsetting indirect effect through entry: a lower price causes fewer firms to enter, increasing the price. Third, the offsetting indirect effect through exit: a lower price causes more firms to default, increasing the price. The last two effects only partially offset the direct effect. Crucially, in an economy with zombie credit, the equilibrium effect through exit is muted.

In sum, zombie credit causes (i) a reduction in product prices, firm markups, firm defaults and entry, value added, and productivity; and, (ii) an increase in firm input costs, aggregate sales, and number of active firms. In our empirical analysis, we compare quantities and prices in markets with a high versus low prevalence of zombie firms. In other words, in the spirit of Figure 2, we compare equilibria in markets that, because of the heterogeneity in the prevalence of zombie firms, have a different supply curve slope.

Note that in our theoretical framework, we develop predictions on how zombie credit affects product prices normalized by costs. In our empirical work, we test the effect of zombie credit on both, CPI growth and firm markups (i.e., price over marginal costs); we also test the effect on input prices directly. On the latter our framework predicts a positive effect of zombie credit on input prices as "too many" firms demand the same input factors.[8]

3 Data and Empirical Work

In this section, we describe our data and our strategy to identify zombie firms. We test our model predictions in the context of the European economy during the 2009-2016 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.[9] 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

[8]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).

[9]The contribution of domestic demand to GDP in the Euro area was negative from 2008Q4 to 2009Q4 and from 2011Q4 to 2013Q2. From 2013Q3 to 2019Q4 it has then been positive. Source: ECB Domestic Demand - Euro Area 19 - Ratio to GDP, Contribution to Growth rate data series available on the ECB Statistical Data Warehouse.

lending behavior (see, e.g., Acharya et al., 2019).

3.1 Data

Our 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.[10] 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) show 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.

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 at the industry (NACE) level, while the inflation data are at the product (COICOP) 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 average of all COICOP (consumer price categories) that are related to a NACE (two digits) industry. Consider, for example, the textiles industry (NACE 13). The CPI of this industry 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

[10]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 banks of a firm. 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.

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. With this procedure, we obtain a measure of the monthly CPI at the industry-country level.

Our final sample consists of 1,167,460 firms for 12 European countries and 65 industries. The twelve European countries are Austria, Belgium, Germany, Denmark, Spain, Finland, France, Italy, Poland, Portugal, Sweden, and Slovakia.[11]

3.2 Identifying Zombie Firms

Since our objective is to analyze the effect of zombie credit (i.e., cheap credit to impaired firms) on product prices, we need to identify (i) whether a firm is in distress and (ii) whether a firm receives cheap debt financing. Hence, in the spirit of Caballero et al. (2008) and Acharya et al. (2019), we classify a firm as zombie firm if it meets the following two criteria that capture these two elements of zombie credit.[12] 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 industry-country-year level. Note that we use a two-year average for the IC ratio criterion to avoid misclassification.[13] Low-quality firms are thus impaired in the sense that they have both operational problems (captured via the IC ratio criterion) as well as high debt (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

[11] 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.

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

[13] 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.

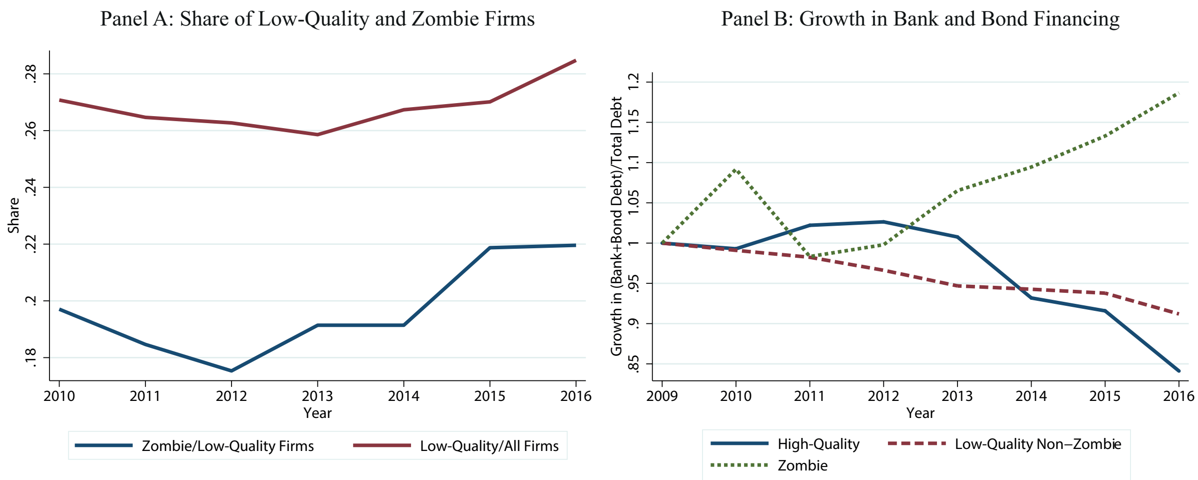

Figure 3: Firm Shares and Firm Financing. Panel A shows the share of zombie firms relative to all low-quality firms (blue line) and the share of low-quality firms relative to all firms (red line). Panel B shows the growth rate in bank and bond financing as a fraction of total debt relative to the beginning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

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.[14] In Section 7.2, we show that our results are robust to using alternative zombie firm classifications.

Figure 1 shows that the share of zombie firms in our sample increased from roughly 4.5% to 6.7% between 2012 and 2016.[15] In Figure 3, we document that this rise of zombie firms is 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

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

[15] The standard deviation in the annual growth rate of the share of zombie firms is 7.5%. In Figure 9, 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***

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. Tangibility is fixed assets/total assets. Leverage is debt/total assets. IC Ratio is EBIT/interest expense. Total assets is measured in thousand euro. The estimation of firm markups is discussed in Appendix B. Material cost is material input cost/turnover. Net Worth is total shareholders funds and liabilities−current and non current liabilities−cash, divided by assets. The last column is a test for the difference in between Column (2) and Column (3).

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 (even negative) IC ratio, a lower EBITDA/Assets ratio, lower net worth, and a higher leverage. Nevertheless, these firms pay extremely low interest rates, even compared with high-quality firms. Given their high leverage and low profitability, these firms would have likely had a higher default rate if they had to pay a higher rate on their 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 financing costs of zombie firms also does not seem to be due to differences in collateral availability as zombie firms have less tangible assets to pledge for new loans. 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.

Next, we track the performance of the firms that 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 future outlook that allows them to obtain cheap debt financing. In Figure 4 and Figure 5, we plot the time-series evolution of the leverage and the incurred interest rate, as well as the evolution of sales growth and EBITDA margin, respectively, where year zero corresponds to the first sample year where the respective firm is classified as zombie.

Figure 4, Panel A 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) show that this rate reduction for zombie firms is driven by both, very advantageous interest 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 a zombie, these firms experience an increase in their leverage. Since zombie firms have on average a negative IC (even though they benefit from advantageous interest rates), they are unable to meet their current interest payments from the earnings generated. 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 5 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

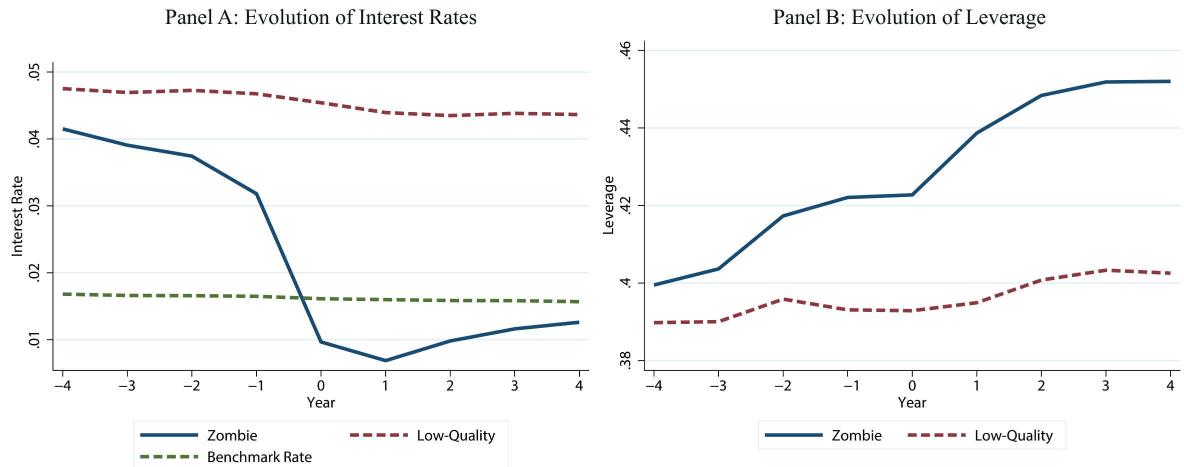

Figure 4: Evolution of Leverage and Interest Rates. This figure shows the evolution of interest rates and leverage for zombie firms. Year 0 corresponds to the first sample year where a firm is classified as zombie. The zombie status can change after Year 0, i.e., the zombie condition is not imposed for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

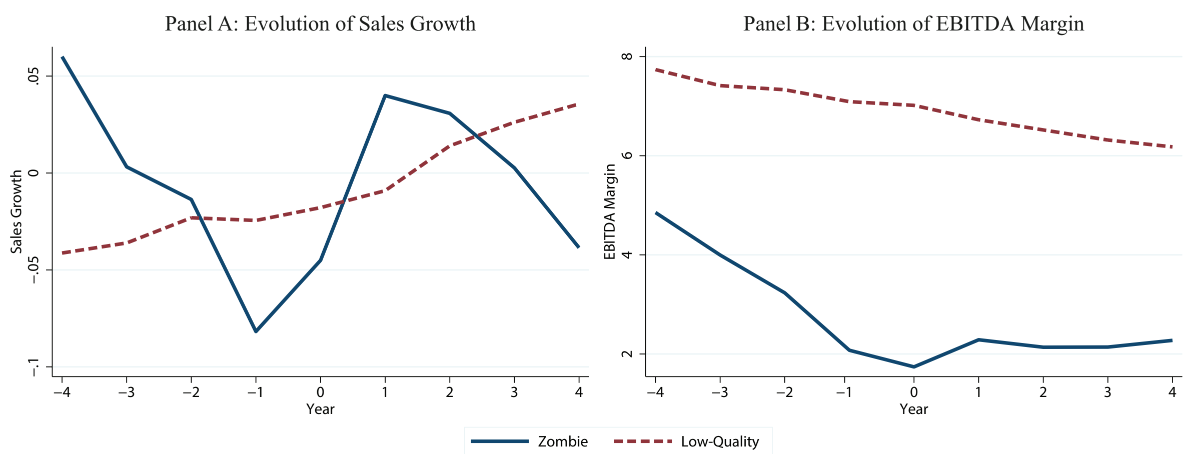

Figure 5: Evolution of Sales Growth and EBITDA Margin. This figure shows the evolution of sales growth and profitability for zombie firms. Year 0 corresponds to the first sample year where a firm is classified as zombie. The zombie status can change after Year 0, i.e., the zombie condition is not imposed 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, while Panel B shows the evolution of the asset-weighted EBITDA margin (i.e., EBITDA/sales ratio).

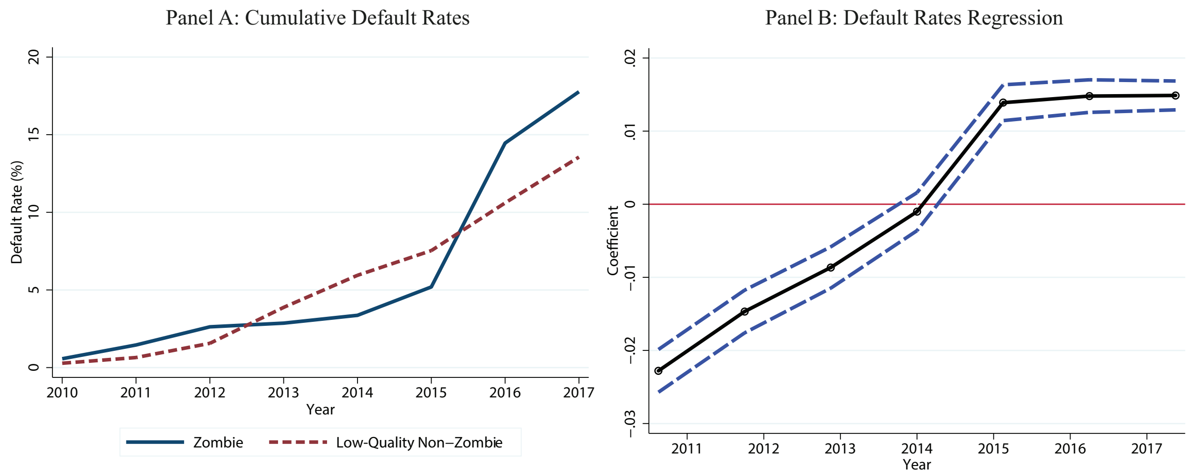

Figure 6: Ex-Post Firm Default Rates. Panel A shows the cumulative ex-post default rate of zombie firms (firms that have been zombies continuously since at least 2012) and low-quality non-zombie firms (low-quality non-zombie firms that were never classified as zombies). Panel B shows the coefficients from Specification (2).

temporarily increases after turning into a zombie, their (very low) profitability does not materially improve. The fact that the interest rates paid by zombie firms is not generally lower, but goes down exactly at the time when their profitability deteriorates supports the notion that these firms indeed benefit from subsidized interest rates.

In Figure 6, we analyze ex-post defaults, non-parametrically in Panel A and parametrically in Panel B.[16] Panel A shows that the default rate of zombie firms increased toward the end of the sample period, suggesting that (at least some) zombie firms 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

[16]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. For details on how we identify firm defaults using Amadeus data see Section 7.3.

every year τ:

$$Default_{ihjt} = \alpha + \beta_\tau \mathcal{I}_{t\tau} \times Zombie_{ihjt} + \gamma X_{ihjt} + \eta_{hjt} + \epsilon_{ihjt}, \quad (2)$$

where i is a firm, j the industry, h the country, and t the year. $\mathcal{I}_{t\tau}$ is a yearly indicator variable equal to 1 if $t = \tau$ and 0 otherwise and η_{hjt} are industry-country-year fixed effects. The vector X_{ihjt} includes the uninteracted *Zombie* variable as well as other firm characteristics. The coefficient β_τ plotted in Panel B of Figure 6 confirms that zombie firms default more often than non-zombie firms toward the end of our sample period.

These figures suggest that zombie firms, even though they obtained cheap debt financing, still underperformed other firms, including low-quality non-zombie firms. This ex-post evidence validates our measure of zombie firms, suggesting that our measure does not capture only temporarily weak firms that are actually positive NPV projects for the lender. Moreover, this evidence rules out that the cheap credit is provided due to relationship lending and superior firm information.

4 Zombie Firms and CPI Growth

In this section, we provide evidence consistent with the presence of zombie firms adding to disinflationary pressures. In Section 4.1, we document a robust negative correlation between the presence of zombie firms and CPI growth. In Section 4.2, we conduct an IV estimation to address potential omitted variable biases.

4.1 OLS Estimation

We start by providing non-parametric evidence on the correlation, across markets, between the share of zombie firms and CPI growth, our main variable of interest. Figure 7 shows the year-over-year CPI growth separately for markets with a high (above median) and low (below

Figure 7: 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.

median) growth of zombie firms over our sample period. Consistent with the rise of zombie firms in the aggregate starting in 2012, we see that beginning in mid-2012, markets with a higher increase in the share of zombie firms experience a stronger decline in CPI growth compared with markets with a lower zombie share increase.[17] The start of this divergent drift of the inflation dynamics coincides with the adoption of extraordinary monetary easing measures by the ECB and other European central banks (e.g., the ECB's OMT program and ultra low interest rates).

To formally test the effect of the zombie credit channel on CPI growth, we estimate the

[17] In Figure D.1 in the Appendix, 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 in total). All regression results are insensitive to whether we include or exclude these outlier markets (see Table C.1).

following specification:

$$Y_{hjt} = \beta \times Share\ Zombies_{hjt-1} + \gamma_{ht} + \nu_{jt} + \mu_{jh} + \epsilon_{hjt}, \tag{3}$$

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.

As illustrated before, our setting is characterized by a negative demand shock in the first half of the sample period and is, therefore, well-suited to analyze the effect of zombie credit. Our fixed effects setting allows 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. In particular, 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), while 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. In Section 4.2, we present an instrumental variable strategy to further alleviate concerns about confounding factors.

The estimation results in Table 2, Panel A confirm that markets that experience an increase in the share of zombie firms subsequently have a lower CPI growth. The estimated coefficient is stable as we add different layers of fixed effects.

A simple counterfactual exercise shows that these magnitudes are economically significant. Suppose that the share of zombie firms would have remained at its 2012 level in each market and year. Using our estimates, we can (i) calculate, for each market, what the CPI growth would have been in each year under this counterfactual scenario in the post-2012 period and (ii) aggregate these counterfactual inflation rates across all markets, using the CPI industry and country weights. We present the results in Figure 8, where the solid line is the observed

Panel A: Baseline	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: Quality Control	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: CPI Growth. This table presents estimation results from Specifications (3) and (4). 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.

inflation and the red dashed line is the counterfactual inflation. Our partial equilibrium estimates suggest that the CPI growth would have been on average 0.4pp higher if the share of zombies would have stayed at its 2012 level.

The actual and the counterfactual inflation rate begin to diverge with the adoption of extraordinary monetary easing measures by the ECB and other European central banks in mid-2012 and the contemporary increase in the zombie share (see Figure 1). During the same time, inflation forecasts started to significantly overshoot the actual inflation rate. The

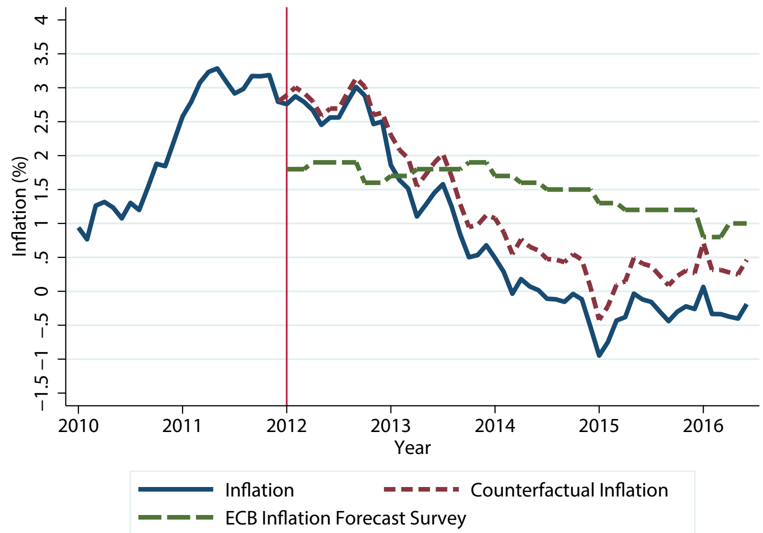

Figure 8: CPI Growth Counterfactual. This figure shows the actual inflation rate in our sample and a counterfactual inflation rate. The counterfactual inflation rate is measured as the inflation rate that would have prevailed from 2012 to 2016, if the share of zombie firms had stayed at the 2012 level in each year and market. These values are aggregated across markets using actual weights for the aggregate CPI. The inflation forecasts are from the ECB Survey of Professional Forecasters (one year ahead).

green dotted line in Figure 8 plots the inflation forecasts from the ECB Survey of Professional Forecasters made one year prior to the respective point on the x-axis.[18] When comparing the forecasting error with the actual inflation rate and our counterfactual inflation rate, the zombie credit channel can explain on average 48% of the forecast overshoot.

In Table 3, we present some examples of markets that experienced a large zombie share change in the post-2012 period. Consider, for example, the manufacturing industry in France, which experienced a strong increase in the share of zombie firms by 38.5%.[19] Based on our

[18]The ECB Survey of Professional Forecasters is conducted four times a year, in January, April, July, and October. Respondents to the survey are experts employed by financial or non-financial institutions, such as economic research institutions.

[19]French non-financial companies are heavily indebted. In France, non-financial corporate debt, loans and debt securities as a percentage of GDP amounts to 141%, which is among the highest levels in Europe. Source: IMF Global Debt Database.

Panel A: Industries with a Zombie Share Increase

Country	Industry	CPI Growth (%)	ΔShare Zombie	Effect (pp)	Counterfactual CPI Growth (%)
France	Manufacturing	-4.19	38.5	-0.89	-3.30
Italy	Transportation and Storage	-0.30	28.41	-0.65	0.35
Portugal	Arts, Entertainment and Recreation	0.58	28.3	-0.65	1.23
Slovenia	Manufacturing	-2.39	26.44	-0.61	-1.78
Italy	Manufacturing	-2.60	22.44	-0.52	-2.08

Panel B: Industries with a Zombie Share Decrease

Country	Industry	CPI Growth (%)	ΔShare Zombie	Effect (pp)	Counterfactual CPI Growth (%)
France	Transportation and Storage	2.00	-54.7	1.26	0.74
France	Other Service Activities	2.90	-34.9	0.80	2.10
Spain	Information and Communication	2.80	-6.6	0.15	2.65
Germany	Information and Communication	2.70	-1.0	0.02	2.68
Germany	Manufacturing	2.60	-0.5	0.01	2.59

Table 3: CPI Growth Counterfactuals – Examples. This table presents examples for industries that experienced a strong increase (Panel A) or decrease (Panel B) in the zombie share post-2012. CPI growth is the actual CPI growth between 2012 and 2016 for the respective market. ΔShare Zombie is the change in the asset-weighted share of zombie firms post-2012. We use the coefficient -0.023, obtained from the most restrictive specification in Panel A of Table 2 to calculate the effect (i.e., $-0.023 \times \Delta$Share Zombie). The counterfactual CPI growth shows what the inflation rate would have been without a change in the zombie share.

estimates from Panel A of Table 2, the CPI growth in this market would have been 0.89pp higher than the observed CPI growth if the share of zombie firms would have remained at its 2012 level.

Next, to mitigate the concern that the negative correlation between the zombie share and CPI growth could be driven by a negative demand shock, which might simultaneously reduce price levels and increase the number of low-quality firms (and, in turn, zombie firms), we add a control for the share of low-quality firms in a particular market ($\textit{Share Low-Quality}_{hjt-1}$) to Specification (3):

$$\begin{aligned} Y_{hjt} &= \beta_1 \times \textit{Share Zombies}_{hjt-1} + \beta_2 \times \textit{Share Low-Quality}_{hjt-1} \\ &+ \gamma_{ht} + \nu_{jt} + \mu_{jh} + \epsilon_{hjt}, \end{aligned} \tag{4}$$

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*. In Panel C, we conduct an additional placebo test and substitute *Share Zombies* in Specification (3) with *Share Low-Quality*. The coefficient for *Share Low-Quality* remains insignificant.[20]

Finally, we investigate whether the negative effect of an increase in the prevalence of zombie firms on CPI growth is more pronounced in noncompetitive than competitive markets. When a market is very competitive, firms are essentially price takers and already operate at a price point where the quantity of output equates price and marginal cost and thus cutting the price further may be difficult. Hence, the downward pressure on prices due to the zombie credit channel should be stronger in noncompetitive markets where firms still have some pricing wiggle room. To measure an industry's competitiveness, we use the Herfindahl-Hirschman index (HHI) and split our sample at the median in competitive and noncompetitive industries. The results in Table C.2 show that there is indeed only an effect of an increase in the share of zombie firms on CPI growth in noncompetitive markets, which provides further evidence for the zombie credit channel, that is, that zombie credit affects the CPI growth through the supply side.

4.2 IV Estimation

To address potential omitted variable biases and, in particular, further rule out that the negative correlation between the presence of zombie firms and CPI growth is driven by demand effects, we run an instrumental variable (IV) regression. Specifically, we focus on

[20] Our results also do not materially change if we drop one country at the time or if we drop one industry at the time (see Figure D.2).

the zombie lending incentives of weakly-capitalized banks as a predictor for the increase in the zombie prevalence. This zombie lending channel is identified in the literature as a main cause for the rise of zombie credit (see, e.g., Banerjee and Hofmann, 2018 and Acharya et al., 2019).[21]

In particular, by extending loans at very low interest rates, weakly-capitalized banks can provide their impaired borrowers with the liquidity necessary to meet payments on other outstanding loans (see Peek and Rosengren, 2005). Thereby, these banks can avoid, or at least defer, realizing loan losses (and the resulting regulatory repercussions) in the hope that the respective borrowers will eventually regain solvency. Schivardi et al. (2019), Acharya et al. (2019), Blattner et al. (2019), and Bonfim et al. (2020) provide evidence for such zombie lending behavior in Europe in the aftermath of the recent sovereign debt crisis.

To capture this zombie lending mechanism, we employ two Bartik-style shift-share instruments (see Bartik, 1991). Specifically, we instrument a market's zombie share with the product between the weighted Tier-1 capital ratio in 2009 of banks connected to the firms in this market (weighted by the banks' number of firm relationships) and proxies for time-varying country-level shocks to the health of the banking sector of the country in which the respective market is located.[22] To proxy for shocks to the health of a country's banking sector, we use (i) the country-level loan growth in each year and, (ii), the country-level growth in non-performing loans (NPLs) in each year.[23] There is ample evidence that a drop in loan supply and an increase in NPLs are strong indicators for a stressed banking sector (for the European context see, e.g., Bofondi et al., 2018, Balduzzi et al., 2018, Acharya et al., 2018,

[21]Given that European firms rely heavily on bank credit, zombie lending is particularly relevant in our setting.

[22]Acharya et al. (2019) show that the banks' Tier-1 capital ratio is a good predictor for their zombie lending incentives.

[23]We obtain data about the country-level loan and NPL growth from the ECB data warehouse.

De Marco, 2019, and Blattner et al., 2019).[24]

The logic behind our Bartik-style shift-share instruments is the following: The average health of banks connected to firms in the respective markets (i.e., country-industry pairs) differs across markets at the beginning of the sample period. Accordingly, markets linked to lower quality banks are more likely to see an increase in zombie lending when the macroeconomic conditions decline. Our instruments thus get all of the cross-sectional variation in exposure to weak banks from pre-existing lending shares, and all of their time-series variation from country-level loan and NPL growth, respectively. These instruments thus bring additional information even with the inclusion of country-industry, industry-year, and country-year fixed effects because they have 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.[25]

Table 4 presents the results for the IV specification where we proxy shocks to the health of a country's banking sector using the country-level loan growth. In our preferred IV specification, we determine the bank-firm relationships using both Amadeus and DealScan (see Table 4, Column 1). As a robustness check, we redo our analysis using (i) bank-firm relationships solely from Amadeus (Column 2) and (ii) bank-firm relationship from DealScan for Italy (Amadeus does not contain bank-firm relationships for Italy) and from Amadeus for other countries (Column 3).[26]

[24]For U.S. evidence see, for example, Ivashina and Scharfstein (2010), Cornett et al. (2011), and Chodorow-Reich (2014).

[25]Goldsmith-Pinkham et al. (2020) show that the Bartik instrument is equivalent to using a weighted-average of a large set of instruments based on cross-sectional shares, with weights based on time-varying aggregate shocks. In our setting, the instruments represent each market's pre-existing exposure to weak banks, and the weights depend on the aggregate country-level bank shocks. The usual identification assumption holds, which is that the instrument needs to be uncorrelated with the error term.

[26]Given that Amadeus does not report the firms' main banks for all countries, our sample size decreases

Panel A: Second Stage	ΔCPI	ΔCPI	ΔCPI
$\widehat{Share\ Zombies}$	-0.174**	-0.192***	-0.174**
	(0.071)	(0.072)	(0.071)
Observations	2,080	1,839	2,080

Panel B: First Stage	Share Zombie	Share Zombie	Share Zombie
Tier-1 2009 × Loan Growth	-11.702***	-13.877***	-11.663***
	(3.591)	(4.294)	(3.582)
F-Test	24.0	26.5	23.9
Observations	2,080	1,839	2,080
R-squared	0.693	0.693	0.693
Sample	Amadeus + DealScan	Amadeus Only	Amadeus + DealScan Italy
Country-Industry FE	✓	✓	✓
Industry-Year FE	✓	✓	✓
Country-Year FE	✓	✓	✓

Table 4: Instrumental Variable Estimation with Loan 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 average tier-1 ratio of the banks linked to the firms in the particular market in 2009 (weighted by the banks' number of firm relationships). *Loan Growth* measures the annual loan growth rate at the country-level. 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). All regressions control for the asset-weighted share of low-quality firms. Standard errors clustered at the industry-country level reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The first stage, shown in Panel B of Table 4, explains the share of zombie firms at time $t-1$ in a particular market (*Share Zombies*) using its *Tier-1 2009* × *Loan Growth* where the loan growth is measured from $t-2$ to $t-1$, controlling for lagged market quality (i.e., its share of low-quality firms) as well as stringent sets of fixed effects. The instrument always has a negative and significant effect on *Share Zombies*. The F-statistic ranges between 23.9

when focusing on Amadeus data only. Whenever available, we can augment firm-bank links using syndicate loan data from DealScan. Still, in some country-industry pairs syndicated lending is quite rare. As a result, our overall sample size is lower for our IV estimation.

and 26.5, while the p-value is always below 0.01, confirming the strength of the instrument. In the second-stage estimation, shown in Panel A of Table 4, we replace the *Share Zombies* with the predicted $\widehat{Share\ Zombies}$ from the first stage. The IV estimated coefficients confirm our results from Table 2, alleviating concerns that our effect might be driven by an omitted variable bias.

The IV estimate of the inflation elasticity to the zombie share (-0.174) is roughly 7 times larger than our OLS estimate (-0.024). The IV estimate corresponds to the change in inflation due to changes in the zombie lending behavior of (weakly-capitalized) banks. The OLS estimate corresponds to a regression of inflation on the change in the zombie share, induced by *all* zombie credit drivers (e.g., zombie lending by weak banks, search-for-yield behavior, and ultra low interest rate environment) and demand factors. When these factors are uncorrelated, the variations in other zombie credit factors and demand are equivalent to measurement error, and the OLS estimate is biased towards zero due to standard attenuation bias. We can thus use the magnitude of the OLS bias to back out the importance of zombie lending relative to other zombie credit drivers and the demand channel (see, e.g., Paravisini et al., 2015). In our setting, the magnitude of the attenuation bias increases with the fraction of the zombie share variation that is explained by other factors than the banks' zombie lending behavior. Based on the standard measurement error bias formula, $\beta/\beta_{OLS} = 1 + \sigma^2_{of}/\sigma^2_{zl}$, where *zl* stands for "zombie lending" and "*of*" for "other factors", our estimates indicate that zombie lending explains roughly 14% of the total variation in the zombie share.

Table 5 presents the results for the IV specification where we employ the country-level NPL growth to measure shocks to the health of a country's banking sector. Specifically, the first stage (see Panel B) explains the $Share\ Zombies_{t-1}$ in a particular market with the market's *Tier-1 2009* × *(-NPL Growth)*, where the *NPL Growth* is measured from $t-2$ to $t-1$. Again, we control for the lagged share of low-quality firms and several fixed effects.

While the strength of this instrument is lower compared to the IV specification where

Panel A: Second Stage	ΔCPI	ΔCPI	ΔCPI
$\widehat{Share\ Zombies}$	-0.175*	-0.220**	-0.174*
	(0.089)	(0.101)	(0.089)
Observations	2,080	1,839	2,080
Panel B: First Stage	**Share Zombie**	**Share Zombie**	**Share Zombie**
Tier-1 2009 x (-NPL Growth)	-0.642***	-0.674***	-0.642*
	(0.170)	(0.201)	(0.170)
F-Test	13.9	12.2	13.9
Observations	2,080	1,839	2,080
R-squared	0.691	0.690	0.691
Sample	Amadeus + DealScan	Amadeus Only	Amadeus + DealScan Italy
Country-Industry FE	✓	✓	✓
Industry-Year FE	✓	✓	✓
Country-Year FE	✓	✓	✓

Table 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 average tier-1 ratio of the banks linked to the firms in the particular market in 2009 (weighted by the banks' number of firm relationships). *NPL Growth* measures the annual growth rate in non-performing loans to total loans at the country-level. 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). All regressions control for the asset-weighted share of low-quality firms. Standard errors clustered at the industry-country level reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

we employ the country-level loan growth as proxy for banking sector shocks, it also has a negative and significant effect on *Share Zombies*. The second-stage estimation results in Panel A of Table 5 confirm our previous IV estimation results.

5 Other Predictions

In this section, we test our other model predictions at the market- and the firm-level. In particular, at the market-level, our model predicts that markets with a higher zombie prevalence have more active firms, as well as lower default and entry rates. Moreover, the zombie credit channel suggest that these markets have lower average firm markups, higher aggregate sales, higher average input costs, and, as a result, lower added value compared to markets with a lower zombie prevalence. At the firm-level, the zombie credit channel predicts that an increase in the share of zombie firms has negative spillover effects to non-zombie firms, that is, these firms have lower markups, profitability, and sales growth, as well as higher input costs.

5.1 Market-Level Evidence

We test the other model predictions at the market-level using Specification (4). First, we find that a higher zombie prevalence is indeed associated with more active firms, fewer firm defaults, and fewer firms entering a market (see Table 6). These variables are obtained from Eurostat, which releases official data at the industry-country level over time.[27] The intuition from our model is that a higher share of zombie firms in a market amounts to a higher number of firms that would likely default if they did not receive zombie credit. The resulting excess production capacity reduces product prices and firm markups, making the market less attractive for potential entrants. These findings are also consistent with the empirical 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.

Second, in line with our model predictions, we find that a higher zombie prevalence is indeed associated with lower firm markups (see Table 7, Panel A).[28] We measure firm 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 deter-

[27] We can also calculate firm default rates using Amadeus data. In Table 16, we show that we obtain similar results on firm defaults if we rely on the Amadeus database to classify firms as defaulted.

[28] Consistent with our findings, Lewis and Poilly (2012) and Lewis and Stevens (2015) provide evidence that markups are negatively related to the number of competitors in an industry.

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
Country-Industry FE	✓	✓	✓	✓
Year FE	✓			
Industry-Year FE		✓		✓
Country-Year FE			✓	✓

Table 6: Number of Active Firms, Firm Defaults, and Firm Entry. This table presents estimation results from Specification (4). The dependent variable is the change in the number of firms (Panel A), the share of firm exits (Panel B), and the share of firm entries (Panel C). *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

mine markups for each firm.[29] This approach has the advantage that it only requires firms' financial statements information and no assumptions on demand and how firms compete. Following De Loecker et al. (2019), we aggregate the firm markups in the respective market using the firms' turnover as weight.

Third, we confirm that a higher zombie prevalence is associated with a less pronounced

[29]See Appendix B for more details on the markup estimation.

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 Zombie	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 Zombie	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 (4). The dependent variable 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. *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.

input costs reduction in response to the negative demand shock and thus relatively higher input costs (material costs in Panel B and labor costs in Panel C of Table 7). The larger number of active firms in markets with a high zombie presence leads to a higher demand for labor and intermediate inputs in these markets relative to non-zombie markets, causing, in turn, higher material and labor costs.

Interestingly, Panel C shows that 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 above median job vacancy rate. We use the annual change in the Eurostat Labour Cost Index to measure the firms' labor costs.[30] 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 Table 7, Column 4 imply that a 10pp increase in the share of zombie firms is associated with a 46 basis points (bp) increase in material costs, a 4bp raise in labor costs for a market with the average zombie share (i.e., 3.3%), and a 73bp decrease in markups. Comparing these economic magnitudes to the CPI growth magnitudes in Table 2 shows that the joint effect of the input costs increase and markup reduction matches very well the 23bp decrease in the CPI associated with a 10pp zombie share increase.

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. On the one hand, the zombie credit channel prevents a downwards adjustment in average input costs after a negative demand shock and, thereby, leads to relatively higher production costs in markets affected by an increase in the zombie prevalence. On the other hand, the zombie credit channel leads to a significant markup reduction. The observed decrease in the CPI growth rate for markets with a higher zombie prevalence thus implies that the zombie credit channel induced firms in these markets to lower markups, and, in turn, prices to such an

[30]This index is designed to capture the labor cost pressure. The job vacancy rate is also 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. Importantly, the labor cost index is provided at less granular industry classifications, which leads to a significant reduction in the number of observations.

Panel A	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

Panel B	ΔValue Added	ΔValue Added	ΔValue Added	ΔValue Added
Share Zombie	-0.122**	-0.134***	-0.100**	-0.109***
	(0.052)	(0.044)	(0.047)	(0.040)
Observations	4,020	4,020	4,020	4,020
R-squared	0.257	0.419	0.328	0.488
Country-Industry FE	✓	✓	✓	✓
Year FE	✓			
Industry-Year FE		✓		✓
Country-Year FE			✓	✓

Table 8: Sales Growth and Value Added. This table presents estimation results from Specification (4). The dependent variable are sales growth from $t-1$ to t, measured as $\frac{Turnover_t - Turnover_{t-1}}{0.5(Turnover_t + Turnover_{t-1})}$ (Panel A) and growth in value added, measured as $\frac{ValueAdded_t - ValueAdded_{t-1}}{0.5(ValueAdded_t + ValueAdded_{t-1})}$ (Panel B), respectively. *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.

extent that it overcompensates the relatively higher input costs. Thereby, the zombie credit channel weakens the link between product and cost inflation.

In line with our mechanism, Taylor (2000) documents that the cost inflation-price inflation relationship weakened as many countries experienced lower inflation since the nineties. A growing body of empirical literature documents this weakened link, mostly focusing on labor costs. For the U.S. economy, Peneva and Rudd (2017) and Daly and Hobijn (2014) suggest that the recent relationship between wages and inflation is consistent with an improved anchoring of inflation expectations and downward wage rigidity in a period of low inflation, respectively. Bobeica et al. (2019) document this weakened relationship in Germany, France, Italy, and Spain. Del Negro et al. (2020) explain the recent disconnect between inflation and real activity with the muted reaction of prices to cost pressures.

Finally, the estimation results in Panel A of Table 8 document a positive correlation, in the cross-section of markets, between the presence of zombie firms and aggregate sales growth. This evidence is consistent with the zombie credit channel since zombie credit leads to a flatter supply curve in the respective markets compared to markets without an inflow of zombie credit. The resulting depressed output prices slightly increase aggregate demand, which leads to relatively higher aggregate sales. As a result, markets with a higher zombie prevalence will experience a relatively lower drop in sales growth in response to a negative demand shock. Moreover, note that this result provides further evidence that our results are not solely driven by a drop in demand and a subsequent deterioration in firm quality as this demand channel would predict lower aggregate sales growth in markets with a high zombie prevalence.

Panel B in Table 8 shows that, in the cross-section of markets, a higher zombie prevalence is associated with a lower growth in value added (obtained from Eurostat).[31] 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. Therefore, our results suggest that the global rise in zombie firms (see Banerjee and Hofmann, 2018) is an important contributing factor to the observed secular slowdown in GDP growth.

5.2 Firm-Level Evidence

Next, we take advantage of our detailed firm-level data to confirm 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

[31] Table C.3 provides a robustness check for this test where we use *ln(Value Added)* instead of the value added growth. The results are qualitatively similar.

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).

In particular, according to the zombie credit channel, a rise of zombie credit leads to a higher number of active firms and excess production capacity, which results in a sales *decrease* and negative price pressure for individual non-zombie firms as more firms have to share a given demand level.[32] Moreover, non-zombie firms in markets with a high zombie prevalence face higher input prices due to an increased number of active firms that demand the same resources.

Following Caballero et al. (2008), we test these predictions by estimating the following regression at the firm-year level:

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

where i is a firm, h a country, j an industry, and t a year. Our dependent variables are firm markup, EBIT/Sales, sales growth, and material cost. We include industry-country-year fixed effects to absorb country-industry specific shocks. Our coefficient of interest is β_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 9 shows that non-zombie firms in markets with a low zombie prevalence have higher markups than zombie firms in the same market. However, consistent with our results at the industry-country level, markups of non-zombie firms tend to be lower the higher the share of zombie firms active in the same market. Results are very similar

[32]Recall that, at the industry-country level, the zombie credit channel predicts an increase in aggregate sales for zombie markets due to the downward adjusted output prices and the resulting slightly higher aggregate demand. Table 8, Panel A confirms this prediction.

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

Table 9: Markups, EBIT/Sales, Sales Growth, and Material Costs – Firm-Level Evidence. This table presents estimation results from Specification (5). The dependent variables are a firm's markup, EBIT/sales, sales growth, or material cost (material input cost/turnover). *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, the natural logarithm of 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.

for the EBIT margin (Column 2). The results in Columns (3) and (4) confirm that non-zombie firms that face an increase in the zombie share in their respective markets experience a lower sales growth and have to pay higher material costs relative to non-zombie firms in non-zombie markets.[33]

These results further suggest 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 not only suffer because they have lower individual sales growth due to the higher number of active firms, but also because their profitability drops due to the excess-capacity-induced higher price pressure and higher input costs in these markets. 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.

Finally, we conduct a placebo test for the firm-level results presented in Table 9. In

[33]We only observe a very noisy measure of labor costs at the firm-level.

particular, instead of employing the share of zombie firms as the main variable of interest, we use the share of low-quality firms; thus, muting the advantageous interest rate criterion. The results presented in Table C.4 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 cheap 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). These impaired firms need to have been kept alive by readily available cheap credit, inducing a drop in default rates, to cause downward pressure on product prices.

6 Real Effects

In a final step, we determine the impact of an increase in the share of zombie firms on firms' investment and employment policies.

Using Specification (4), we find that, in the cross-section of markets, a stronger increase in the zombie share is associated with lower average net investment (see Table 10, Column 1).[34] In particular, a 10pp increase in the share of zombie firms in a given market implies a 68bp lower net investment ratio.[35]

Moreover, employing the firm-level test from Specification (5), we find that non-zombie firms that are active in a market with a high zombie prevalence invest less compared to

[34] To measure net investment, we employ the Amadeus firm-level data and aggregate the firms' non-negative change in fixed assets (i.e., if a firm's fixed asset change is negative it is set to zero) to the market-level with the firms' assets as weights.

[35] To gain some perspective, the net investment ratio in Europe ranged on average between 0% and 2% in the last decade.

non-zombie firms in non-zombie markets (see Table 12, Column 1). The observed weak investment climate in zombie markets can be a result of (i) the excess production capacity 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.

To formally test to what extent a rise in the zombie share is associated with a misallocation of capital across firms, 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 the capital misallocation since aggregate output could be increased by reallocating capital from firms with a low MRPK to firms with a higher MRPK.[36]

To calculate the firms' MRPK, we exploit that it can be decomposed into the value of the marginal product ($VMPK_{ijt}$) and the inverse-markup (μ_{ijt}^{-1}):

$$MRPK_{ijt} \equiv \frac{\partial (P_{ijt}(Q_{ijt})Q_{ijt})}{\partial K_{ijt}} = \underbrace{P_{ijt}\frac{\partial Q_{ijt}}{\partial K_{ijt}}}_{VMPK_{ijt}} \underbrace{\left(1 + \frac{Q_{ijt}}{P_{ijt}}\frac{\partial P_{ijt}}{\partial Q_{ijt}}\right)}_{\mu_{ijt}^{-1}} = \theta_{ijt}^{K}\frac{P_{ijt}Q_{ijt}}{K_{ijt}}\frac{1}{\mu_{ijt}}, \qquad (6)$$

where $P_{ijt}Q_{ijt}$ is total sales (price times quantity), K_{ijt} is capital, and θ_{ijt}^{K} denotes the output elasticity of capital. To estimate the firms' markup and output elasticity of capital, we rely

[36]An example for a distortion due to zombie lending is that zombie firms benefit from subsidized (cheap) credit, while non-zombie firms can only borrow at regular market rates. As a result, the MRPK of zombie firms is likely lower than the MRPK of non-zombie firms and reallocating capital from zombie to non-zombie firms would thus increase the allocative efficiency of capital.

	Net Investment	Capital Misallocation
Share Zombies	-0.068**	0.142**
	(0.028)	(0.063)
Observations	3,464	2,976
R-squared	0.397	0.920
Country-Industry FE	✓	✓
Industry-Year FE	✓	✓
Country-Year FE	✓	✓

Table 10: Net Investment and Capital Misallocation. This table presents estimation results from Specification (4). The dependent variables are net investment (measured as the growth in fixed assets and set to zero if negative) and capital misallocation (measured as the standard deviation of log(MRPK)). *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.

on the procedure outlined in Appendix B.[37]

Employing Specification (4), we find that, across markets, a rise in the share of zombie firms is indeed associated with an increase in the MRPK dispersion (see Table 10, Column 2), measured as the standard deviation of log(MRPK). This evidence suggests that the weak investment climate in markets affected by zombie credit is caused by a combination of the resulting excess production capacity and a misallocation of capital.

Next, we analyze the impact of zombie credit on employment. Using Specification (4), we find that an increase in a market's zombie prevalence does not affect its aggregate employment growth (see Table 11, Column 1). In general, there are two opposing effects of zombie credit on employment growth. By its very nature, zombie credit prevents layoffs at zombie firms by keeping these firms afloat. Descriptively, our data confirms that indeed employment

[37] In a slight deviation from the procedure in Appendix B, we include for the misallocation tests 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.

	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 11: Employment Growth, Labor Misallocation, and Labor Productivity. This table presents estimation results from Specification (4). The dependent variables 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.

growth is slightly less negative for zombie firms compared to low-quality non-zombie firms.

Thereby, however, the zombie credit channel hampers an efficient reallocation of labor from zombie to non-zombie firms and reduces the available labor supply for non-zombie firms. Through these spillovers, the zombie credit channel negatively affects the employment growth of non-zombie firms that are active in markets with a high zombie prevalence. Employing Specification (5), we confirm that there is indeed a lower employment growth for non-zombie firms that are active in markets with a high zombie prevalence compared to non-zombies firms that operate in non-zombie markets (see Table 12, Column 2).[38]

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 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

[38] Caballero et al. (2008) find similar negative spillover effects of zombie lending on employment at non-zombie firms in the context of the Japanese crisis in the 1990s.

	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
Industry-Country-Year FE	✓	✓
Firm-Level Controls	✓	✓

Table 12: 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. *Share Zombies* measures the asset-weighted share of zombie firms in a particular market at $t-1$. Firm-level controls include net worth, leverage, the natural logarithm of 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.

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 missallocation 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

$$MRPL_{ijt} \equiv \frac{\partial(P_{ijt}(Q_{ijt})Q_{ijt})}{\partial L_{ijt}} = \underbrace{P_{ijt}\frac{\partial Q_{ijt}}{\partial L_{ijt}}}_{VMPL_{ijt}} \underbrace{\left(1 + \frac{Q_{ijt}}{P_{ijt}}\frac{\partial P_{ijt}}{\partial Q_{ijt}}\right)}_{\mu_{ijt}^{-1}} = \theta_{ijt}^{L}\frac{P_{ijt}Q_{ijt}}{L_{ijt}}\frac{1}{\mu_{ijt}}. \tag{7}$$

Following Gopinath et al. (2017), we measure the labor input, L_{ijt}, with the firm's deflated wage bill.[39] Table 11, Column (2) confirms that a higher zombie prevalence is associated

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

with a higher MRPL dispersion, that is, a lower allocative efficiency of labor across firms.

Finally, Column (3) of Table 11 highlights that the factor misallocation due to zombie credit drags down the labor productivity in zombie markets, which is 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 a reduction in the growth of the value added (see Table 8, Panel B) and a reduction of the allocative efficiency of labor. Both effects reduce the labor productivity. Panel B of Table C.3 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)*.

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 credit can raise productivity and labor productivity by improving the allocative efficiency across firms and thereby spur economic growth and inflation.[40]

7 Robustness

This section provides several robustness tests. In Section 7.1, we jointly test for the zombie credit channel and other supply channels identified in the literature, namely the "cost channel" and the "liquidity squeeze channel." In Section 7.2, we employ alternative zombie firm classifications. In Section 7.3, we redo our default rate tests employing a different data set.

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

7.1 Other Supply-Side Channels

While the evidence presented in Section 4 to Section 6 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.

The cost channel (see, e.g., Barth III and Ramey, 2001) suggests that the access to cheap debt decreases the zombie firms' marginal production cost because it lowers the costs associated with financing their working capital. This cost reduction potentially gave zombie firms more wiggle room to cut output prices. The liquidity squeeze channel (see, e.g., Chevalier and Scharfstein, 1996) suggests that low-quality non-zombie firms have an incentive to raise prices to increase their current cash flows (assuming that they are liquidity constraint), while zombie firms do not have the necessity to react this way due to their access to cheap credit. Hence, the observed negative correlation, across markets, between the zombie share and CPI growth is also consistent with the cost channel and the liquidity squeeze channel.

To rule out that our results are driven by these alternative supply-side channels and to evaluate their relative contributions to the decline in CPI growth, we redo our analysis from Table 2 and include additional controls 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 the firms' average marginal financing costs associated with their net working capital. Following Gilchrist et al. (2017), we proxy for the liquidity squeeze channel using the firms' average liquidity ratio, which is defined as the ratio of cash and short-term investments to total assets.

Table 13 shows the estimation results. While both alternative supply-side channels seem to be also active, including proxies for these channels neither changes the point estimate of the zombie share nor significantly alters the explanatory power of the zombie credit channel for CPI growth. 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.

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

Table 13: Other Supply-Side Channels. This table presents estimation results from Specification (4). 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. *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.

This conclusion is also supported by our results discussed in Section 5. Neither the cost nor the liquidity squeeze channel make any predictions about the correlation between the zombie share and (i) firm defaults, (ii) firm entry rates, (iii) average input costs, and (iv) average firm productivity, nor do they predict spillover effects from zombie to non-zombie firms.

7.2 Alternative Zombie Classifications

To ensure the robustness of our results with respect to the zombie classification and the zombie prevalence measurement, we employ alternative zombie definitions and zombie share weighting metrics and redo our analysis from Table 2.

In Table 14, we employ alternative criteria to classify a firm as low-quality firm and, in turn, as zombie firm. First, we calculate median values for leverage and the IC ratio at the industry-year level instead of the industry-country-year level (Panel A). Second, we

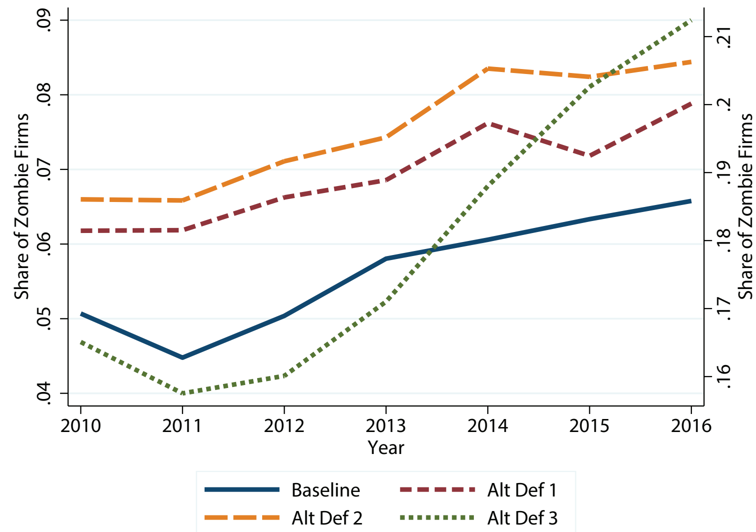

Figure 9: Alternative Zombie Classifications. This figure shows the evolution of the zombie share for alternative zombie definitions. The blue solid line replicates our main measure of the zombie share (scale on left y-axis). Alt Def 1 (red dashed line; left y-axis) calculates median values for leverage 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.

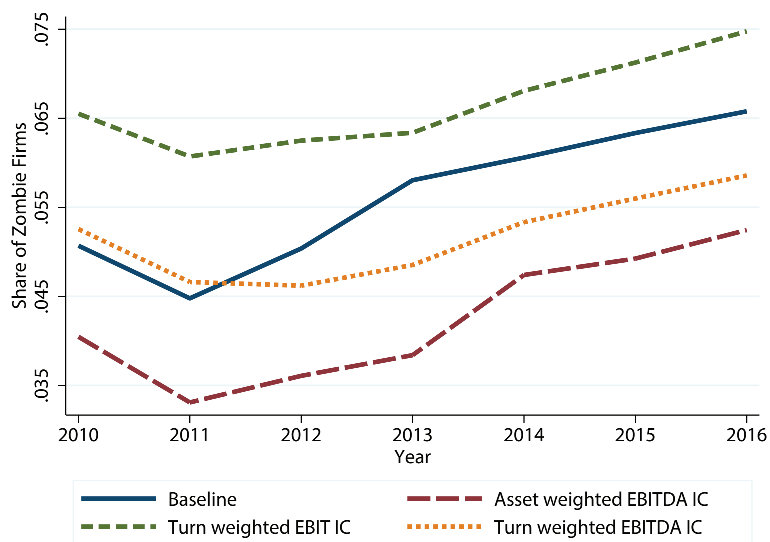

Figure 10: Alternative Zombie Share Weighting. This figure shows the evolution of the zombie share for alternative zombie definitions. The blue solid line replicates our main zombie share measure (i.e., asset-weighted aggregation and IC ratio based on EBIT). The red dashed line shows the evolution of the asset-weighted share of zombie firms using the IC ratio based on EBITDA/interest expenses. The green 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.

Panel A: Alternative Def. #1	ΔCPI	ΔCPI	ΔCPI	ΔCPI
Share Zombies	-0.009*	-0.007*	-0.012**	-0.011***
	(0.005)	(0.004)	(0.005)	(0.004)
Observations	3,880	3,880	3,880	3,880
R-squared	0.491	0.723	0.521	0.754
Panel B: Alternative Def. #2	**ΔCPI**	**ΔCPI**	**ΔCPI**	**ΔCPI**
Share Zombies	-0.010**	-0.008**	-0.013***	-0.010***
	(0.005)	(0.004)	(0.005)	(0.004)
Observations	3,880	3,880	3,880	3,880
R-squared	0.491	0.723	0.521	0.754
Panel C: Alternative Def. #3	**ΔCPI**	**ΔCPI**	**ΔCPI**	**ΔCPI**
Share Zombies	-0.009**	-0.007**	-0.012**	-0.010***
	(0.005)	(0.004)	(0.005)	(0.004)
Observations	3,880	3,880	3,880	3,880
R-squared	0.491	0.723	0.521	0.754
Panel D: Alternative Def. #4	**ΔCPI**	**ΔCPI**	**ΔCPI**	**ΔCPI**
Share Zombie	-0.024**	-0.019*	-0.028**	-0.023**
	(0.012)	(0.011)	(0.012)	(0.010)
Observations	3,880	3,880	3,880	3,880
R-squared	0.496	0.732	0.525	0.764
Country-Industry FE	✓	✓	✓	✓
Year FE	✓			
Industry-Year FE		✓		✓
Country-Year FE			✓	✓

Table 14: CPI Growth – Alternative Zombie Classifications. This table presents estimation results from Specification (4). 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). Panel A calculates median values for leverage and IC ratio at industry-year-level. Panel B considers solely the IC ratio criterion to define a firm as low-quality. Panel C considers only the leverage criterion to define a firm as low-quality. Panel D calculates the IC ratio using EBITDA/interest expenses. 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: Turnover Weight / EBIT	ΔCPI	ΔCPI	ΔCPI	ΔCPI
Share Zombies	-0.022***	-0.016**	-0.024***	-0.019***
	(0.008)	(0.007)	(0.008)	(0.007)
Observations	3,880	3,880	3,880	3,880
R-squared	0.496	0.732	0.526	0.764
Panel B: Turnover Weight / EBITDA	**ΔCPI**	**ΔCPI**	**ΔCPI**	**ΔCPI**
Share Zombies	-0.025**	-0.019*	-0.029**	-0.023**
	(0.012)	(0.011)	(0.012)	(0.010)
Observations	3,880	3,880	3,880	3,880
R-squared	0.496	0.732	0.525	0.764
Country-Industry FE	✓	✓	✓	✓
Year FE	✓			
Industry-Year FE		✓		✓
Country-Year FE			✓	✓

Table 15: CPI Growth – Alternative Weighting and IC Ratio Measure. This table presents estimation results from Specification (4). The dependent variable is the annual CPI growth rate (inflation) from $t-1$ to t. *Share Zombies* measures the turnover-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. Panel A calculates the IC ratio using EBIT/interest expenses. Panel B calculates the IC ratio using EBITDA/interest expenses. All regressions control for the turnover-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.

consider solely the IC ratio criterion instead of both the IC ratio and leverage (Panel B). Third, we use solely the leverage criterion (Panel C). Fourth, we calculate the IC ratio using EBITDA/interest expenses instead of EBIT/interest expenses (Panel D).

In Table 15, we weight firms by their turnover instead of their assets for the calculation of the share of zombie firms in each market. Moreover, in Panel A, we calculate the IC ratio for the low-quality firm classification as EBIT/interest expenses, while we calculate it as EBITDA/interest expenses in Panel B.

Finally, Figure 9 and Figure 10 show that these alternative zombie share measures yield a similar time-series pattern as our baseline classification. Taken together, this analysis shows that our results are robust to using alternative zombie classifications and to employing a turnover instead of an asset weighting metric for the zombie share measurement.

	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 16: Firm Defaults – Evidence based on Amadeus Data. This table presents estimation results from Specification (4). The dependent variable is the share of firm defaults at time 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

7.3 Alternative Default Rate Measure

As a further robustness check, we redo our analysis of the effect of zombie credit on default rates from Panel B of Table 6, but use the legal status variable from Amadeus instead of the Eurostat data to determine the default frequency in a specific market.[41] In particular, to identify default events for our sample firms we flag firms that according to the legal status variable are in distress, insolvent, or bankrupt.[42] In Table 16, we show that this robustness test yields similar results for the effect of a rise of zombie credit on firm defaults.

[41] Eurostat does not distinguish between different exit types (i.e., insolvency or dissolved for other reasons).

[42] That is, we identify firms that have one of the following legal status in Amadeus: "Active (default of payments)", "Active (insolvency proceedings)", "Active (rescue plan)", "Bankruptcy", "Dissolved (bankruptcy)", "Dissolved (liquidation)", or "In liquidation".

8 Global Implications

Our results have broader implications outside Europe as a few recent studies document an increase in the prevalence of zombie firms around the world, even before the Covid-19 crisis (see, e.g., Banerjee and Hofmann, 2018 and McGowan et al., 2018).

A prominent example for a non-European market affected by zombie credit is China. In response to the global financial crisis, the Chinese government injected funds indiscriminately into struggling state firms. These subsidies created an excess capacity for the Chinese industry of 13.1% in 2015, which pushed producer prices and profits down and forced many firms to take on more debt to cover existing loan repayments.[43] In steelmaking, for example, China's surplus capacity in 2015 was larger than the entire production of Japan, the U.S., and Germany combined. The resulting flood of cheap Chinese steal into foreign markets put significant pressure on global steel prices, which collapsed by roughly 40% in 2015.

The share of zombie firms has also considerably increased in the U.S. in recent years.[44] For example, the share of Russell 3000 firms for which profits are less than the interest rate paid on their debts for at least 3 consecutive years increased from 8% in 2009 to 13% in 2019. A good portion of the U.S. zombie firms is in the shale oil industry.[45] Fueled by cheap credit, U.S. shale producers borrowed heavily to invest in drilling, causing the volume of bonds and syndicated loans to the U.S. energy industry and, in turn, the U.S. oil production, to roughly triple over the past decade. This surge made the U.S. the largest oil producer in the

[43] "The march of the zombies", *Economist*, February 27, 2016.

[44] "Reasons to fear the march of the zombie companies", *Financial Times*, June 24, 2020; and "Pandemic debt binge creates new generation of 'zombie' companies", *Financial Times*, September 14, 2020.

[45] "Bailing out the oil industry brings a fate worse than death", *Financial Times*, April 19, 2020; "Oil and debt", *BIS Quarterly Review*, March, 2015; "Do U.S. Shale Drillers Deserve To Exist In Free Markets?", *yahoo!finance*, April 19, 2020; "Bankruptcy Bust: How Zombie Companies Are Killing the Oil Rally", *Wall Street Journal*, October 24, 2016; and "What negative US oil prices mean for the industry", *Financial Times*, April 21, 2020.

world, overtaking Russia and Saudi Arabia. Over the same period, the global oil demand increased by merely 16%. As a result, in 2019, less than 10% of U.S. shale companies were operationally cash flow positive over CAPEX. The excess production capacity and depressed prices forced some U.S. oil and gas companies into Chapter 11 bankruptcy; however, with the ongoing support of their lenders, these firms continued to produce about the same as before they declared bankruptcy. This excess capacity and price pressure culminated when oil demand decreased following the Covid-19 outbreak.

Our results also have broader implications in light of the Covid-19 crisis, which together with the associated government response measures will likely further swell the zombie firm ranks. First, the crisis will negatively affect firm profits and health in several sectors. Second, once the deteriorating firm health translates into loan losses and a reduction in bank capitalization, zombie lending incentives will likely proliferate. Third, the prospect of low growth and higher indebtedness will deepen and lengthen the period of very low interest rates and borrowing costs, with many central banks already having declared an extended low interest rate environment period. Fourth, many governments have implemented measures in an attempt to "freeze" the economy in place during the pandemic, which includes measures like job-retention schemes, allowing firms to delay filing for bankruptcy, allowing lenders to put off recognising bad loans, providing state-backed subsidized loans to struggling firms, and bailing out large firms threatened with bankruptcy.[46]

Against this background, our results call for the development of models to determine the general equilibrium effects of zombie credit. While zombie credit likely has a temporarily positive stabilizing effect in terms of economic activity, our evidence suggests that in the medium to long term, zombie credit depresses inflation and growth. There is thus a delicate balance to be struck between allowing some zombie credit in the direct aftermath of a

[46] "Rise of the zombies? Europe faces insolvency balancing act", *Reuters*, September 25, 2020.

negative economy-wide shock and curbing it too late which hampers necessary structural and supply-side adjustments.

9 Conclusion

The low-growth low-inflation environment that prevails in Europe since its sovereign debt crisis bears a striking resemblance to Japan's "lost decades" in the aftermath of its crisis in the early 1990s. Similar to the Bank of Japan's crisis response, 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 will 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 a novel supply-side channel which shows that policy measures enabling cheap debt financing for impaired firms have a disinflationary side effect, thereby providing an explanation for the persistent low inflation rates in Europe. The ready availability of cheap debt reduces financial pressure and thereby fuels the survival of weak firms with unsustainable business models. As these zombie firms proliferate, the adjustment in aggregate supply in response to a negative demand shock is hampered. The resulting excess capacity puts downward pressure on producer 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 that experienced a stronger rise of zombie firms subsequently experienced lower product prices, lower firm markups, higher material and labor costs, higher aggregate sales, higher misallocation of capital and labor, as well as fewer firm defaults, lower productivity, lower labor productivity, lower net investment, and lower value added.

These results draw attention to the often-neglected impact of supply-side financial frictions on inflation. 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.

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Internet Appendix

Online Appendix for

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

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Appendix A Model

In this appendix, we develop a simple dynamic model to analyze the relationship between zombie credit and inflation. 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).

A.1 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.

Our goal is to study the effect of excess production capacity—induced by a drop in default rates due to zombie credit—on product prices. To this end, the aggregate quantity has to be somewhat exogenous, while firms have to be able to choose prices. We implement this by assuming that the problem of firms at each date t is as follows. First, firms (incumbents and potential entrants) pay a cost I to set up their capacity that allows them to draw their production y_{it} from a uniform distribution $y_{it} \sim U[0, 1]$. Second, incumbent firms simultaneously set prices.

To be able to disentangle the effects of the zombie credit channel from the cost channel, marginal production costs have to be independent from financing conditions in our model. To implement this, we assume that firms learn the realization of their production y_{it} leading to profits $(p_t - c)y_{it} - I$, 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.[47]

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 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 incumbents 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 profit by increasing the expected quantity sold.[48] Because of the production constraint, firms charge a positive markup $(p_t - c)/c$.[49]

After the price is set, firms learn the realization of their production. An incumbent firm that generates negative profits is forced to default. Hence, the mass of defaulting firms D_t

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

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

[49]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.

and the mass of surviving incumbent firms S_t are:

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

A potential entrant firm that generates profits enters the market. The mass of entrants is:

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

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

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

A.2 Equilibrium

In this section, we define an equilibrium with and an equilibrium without zombie credit.

Definition 1. *Given the demand parameter α, setup 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 equals the sum of production by surviving incumbent and entrant firms according to (A4), and the number of incumbent follows $m_{t+1} = N_t$.*

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 entrants and surviving incumbent firms at t.

In the steady state equilibrium, the number of incumbent firms is constant ($m_{t+1} = N_t =$

m) and defaults are exactly offset by entry:

$$\frac{mI}{p-c} = e\left(1 - \frac{I}{p-c}\right) \tag{A5}$$

The equilibrium with zombie credit (EqZ) is characterized by an exogenous number of firms $\overline{S}$ that survive each period, leading to a total production of

$$N_t = e\left(1 - \frac{I}{p_t - c}\right) + \overline{S} \tag{A6}$$

Following Caballero et al. (2008), the idea is that favourable funding conditions might keep some firms alive that otherwise would default. Formally, the definition of EqZ is as follows:

Definition 2. *Given the demand parameter α, setup cost I, marginal cost c, and survivors $\overline{S}$, 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 equals the sum of production by surviving incumbent and entrant firms according to (A6), defaults are such that surviving firms are $\overline{S}$, and the number of incumbent follow $m_{t+1} = N_t$.*

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 and production of the, now exogenously set, incumbent firms that survive. Third, defaults are such that surviving firms are constant at $\overline{S}$. Fourth, the incumbent firms at $t+1$ are the sum of entrants and surviving incumbent firms at t.

A.3 Mechanism of the Zombie Credit Channel

We analyze the effects of zombie credit by comparing the equilibrium without zombie credit and the equilibrium with zombie credit following a negative demand shock, captured by a permanent decrease in α.[50] More specifically, we consider the case where EqN and EqZ are, before the shock, identical in a steady state equilibrium (the number of survivors $\overline{S}$ in EqZ is set equal to the number of survivors in EqN). Figure A.1 shows this comparison, where the solid lines correspond to EqN and the dashed lines correspond to EqZ. In both equilibrium concepts, the negative demand shock causes a contemporaneous collapse in prices. The adjustment to the new steady state depends on the type of equilibrium.

In EqN, the collapse in price leads to a contemporaneous decrease in entries and increase in defaults. One period after the shock, the lower number of active firms causes the price to rebound (higher production capacity), which induces more firms to enter the market and fewer incumbent firms to default. Two periods after the shock, the now higher number of incumbent firms leads to a reduction in price and, in turn, an increase in defaults and a decrease in entries. This adjustment continues until the economy reaches the new EqN steady state where the price, defaults, and entry are lower and there are fewer incumbent firms compared with the pre-shock steady state.

In EqZ, the collapse in price also induces a contemporaneous decrease in entries but defaults are held constant so as to keep the number of surviving firms also constant. This lack of adjustment through defaults causes the number of incumbent firms to go down less than in EqN one period after the shock. The price rebound also leads to an increase in entries, but this adjustment is muted compared to EqN. The lower number of incumbent firms causes a reduction in defaults in order to keep the number of survivors constant. Two periods after the shock, the number of incumbent firms is lower than in the previous period but higher than in EqN. This adjustment continues until the economy reaches the new steady state. Compared with the EqN steady state, the price, entry, and defaults are lower and

[50]In Figure A.2, we show that the intuition of the model holds when we compare the equilibrium without zombie credit and the equilibrium with zombie credit following a *temporary* demand shock.

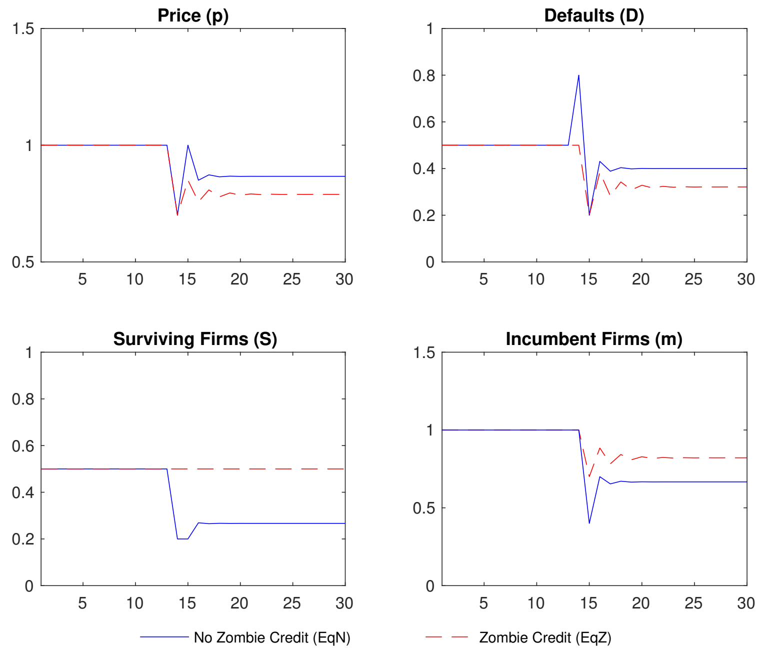

Figure A.1: Negative Demand Shock. This figure shows how equilibrium quantities and prices respond to a permanent decrease in α in EqN (solid lines) and in EqZ (dashed lines).

there are more incumbent firms. More formally:

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. The steady state conditions in EqN are $p = \alpha - \frac{m}{2}$ and $\frac{mI}{p-c} = e\left(1 - \frac{I}{p-c}\right)$. By combining them, we obtain:

$$m = \frac{e(\alpha - c - I)}{I + \frac{e}{2}} \qquad \text{and} \qquad p = \frac{2\alpha I + e(c+I)}{2I + e}$$

The steady state conditions in EqZ are $\widetilde{p} = \alpha - \frac{1}{2}\widetilde{m}$, $\widetilde{m} = e\left(1 - \frac{I}{p-c}\right) + \overline{S}$, and $\widetilde{D} = \widetilde{m} - \overline{S}$. Suppose that $\overline{S}$ is such that the EqN and EqZ equilibria are identical, namely

$$\overline{S} = \frac{2e(\alpha - c - I)^2}{(I + e/2)(2\alpha + e - 2c)}$$

Suppose $\alpha' < \alpha$. Combining the steady state conditions, we obtain a contradiction if $\widetilde{p}(\alpha') \geq p(\alpha')$. From $\widetilde{p}(\alpha') \geq p(\alpha')$, it follows that $S \leq m(\alpha')\left(1 - \frac{I}{p(\alpha')-c}\right)$. But it is easy to show that $S > m(\alpha')\left(1 - \frac{I}{p(\alpha')-c}\right)$.

Hence, the contradiction. It follows that $m(\alpha') < \widetilde{m}(\alpha')$ and $p(\alpha') > \widetilde{p}(\alpha')$. It also trivially follows that entry, defaults, and markups are lower in EqZ compared with EqN. □

In the equilibrium with zombie credit, some firms that would default in the equilibrium without zombie credit are kept alive preventing a downward adjustment in the number of active firms and, in turn, causing a reduction in price. Let $p(\alpha, E(\alpha), S(\alpha))$ be the steady state price, expressed as a function of α. Note that the price functions are different in EqN and EqZ. Differentiating with respect to α yields:

$$\frac{dp}{d\alpha} = \frac{\partial p}{\partial \alpha} + \frac{\partial p}{\partial E}\frac{\partial E}{\partial \alpha} + \underbrace{\frac{\partial p}{\partial S}\frac{\partial S}{\partial \alpha}}_{= 0 \text{ in EqZ}} \tag{A7}$$

Demand affects the price in three ways. First, the direct effect: a lower demand reduces the price in equilibrium. Second, a lower demand reduces firm entry, causing an increase in price. Third, a lower demand induces more firms to default, which leads to an increase in price. This third effect disappears in EqZ, where the number of surviving firms is not affected by the change in demand.

A.4 Effect on Input Costs

In a variation of the baseline model, we show in this section that input costs are higher in the equilibrium with zombie credit compared with the equilibrium without zombie credit.

The differences with the baseline model environment are as follows. First, the product price is now exogenous. Second, there is an exogenous supply of input $L_t = c_t - \mu_t$, where c_t is the price of input and marginal cost for each firm i. Third, after paying the setup 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

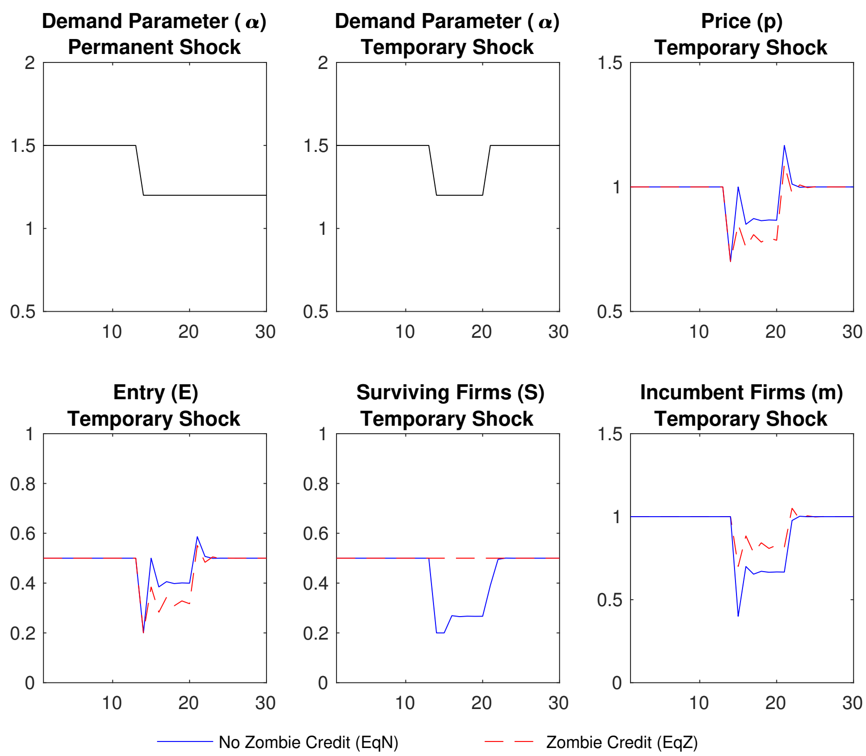

Figure A.2: Temporary Negative Demand Shock. This figure shows how equilibrium quantities and prices respond to a temporary decrease in α in EqN (solid lines) and in EqZ (dashed lines).

total demand for the input equals its supply at the price c_t.

Similar to Section A.3, we can analyze the effect of a permanent decrease in the (now exogenous) product price on the (now endogenous) marginal cost. In the equilibrium without zombie credit, the negative demand shock reduces total production as the lower price reduces entry and increases exit. In the next period, the lower number of incumbent firms reduces the input price, causing more entry and less exit. The resulting production increase causes a rebound in the number of incumbent firms in the next period. This adjustment continues until the economy reaches the new steady state with fewer active firms and lower input costs. Again, this adjustment is muted in the equilibrium with zombie credit.

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) follow 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 country-industry 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 Ω_{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:

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

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

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

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

$$\theta_{ijt}^{v} \equiv \frac{\partial Q(\cdot)}{\partial V_{ijt}} \frac{V_{ijt}}{Q_{ijt}} = \frac{1}{\lambda_{ijt}} \frac{P_{ijt}^{V} V_{ijt}}{Q_{ijt}}. \tag{B4}$$

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

$$\mu_{ijt} = \theta_{ijt}^{v} \frac{P_{ijt} Q_{ijt}}{P_{ijt}^{V} V_{ijt}}. \tag{B5}$$

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

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 two digits NACE level).

For a given industry h in country j, we consider the translog production function (TLPF):[51]

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

where lower cases denote logs.[52] 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 ϵ_{ijt} is the unanticipated shock to output.[53] 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 (ϵ_{ijt}) are purged using a non-parametric projection of output on the inputs and the control variable:

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

[51]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).

[52]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.

[53]De Loecker and Warzynski (2012) show 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 β, where $\beta = (\beta_{v1}, \beta_{k1}, \beta_{v2}, \beta_{k2})$, using $\omega_{ijt}(\beta) = \widehat{\phi}(\beta_{v1}v_{ijt} + \beta_{k1}k_{ijt} + \beta_{v2}v_{ijt}^2 + \beta_{k2}k_{ijt}^2)$. By nonparametrically regressing $\omega_{ijt}(\beta)$ on its lag, $\omega_{ijt-1}(\beta)$, we recover the innovation to productivity given β, $\varepsilon_{ijt}(\beta)$.

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

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

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.

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 A 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.

Panel A: Competitive	ΔCPI	ΔCPI	ΔCPI	ΔCPI
Share Zombies	0.011	0.011	0.002	-0.008
	(0.015)	(0.009)	(0.016)	(0.009)
Observations	1,960	1,960	1,960	1,960
R-squared	0.484	0.793	0.529	0.836

Panel B: Non-Competitive	ΔCPI	ΔCPI	ΔCPI	ΔCPI
Share Zombies	-0.032***	-0.029***	-0.033***	-0.033***
	(0.010)	(0.009)	(0.011)	(0.010)
Observations	1,920	1,920	1,920	1,920
R-squared	0.524	0.719	0.557	0.750
Country-Industry FE	✓	✓	✓	✓
Year FE	✓			
Industry-Year FE		✓		✓
Country-Year FE			✓	✓

Table C.2: CPI Growth – Competitiveness. This table presents estimation results from Specification (4). 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). To measure the competitiveness of an industry, we use the Herfindahl-Hirschman index (HHI) and split our sample at the median in competitive and noncompetitive industries (Panel A and B, 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	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.3: Value Added and Productivity. This table presents estimation results from Specification (4). 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.

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

Table C.4: Firm-Level Evidence – Robustness. This table presents estimation results from Specification (5). The dependent variables are a firm's markup, EBIT/Sales, sales growth, material cost (material input cost/turnover), 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, the natural logarithm of 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.

Appendix D Additional Figures

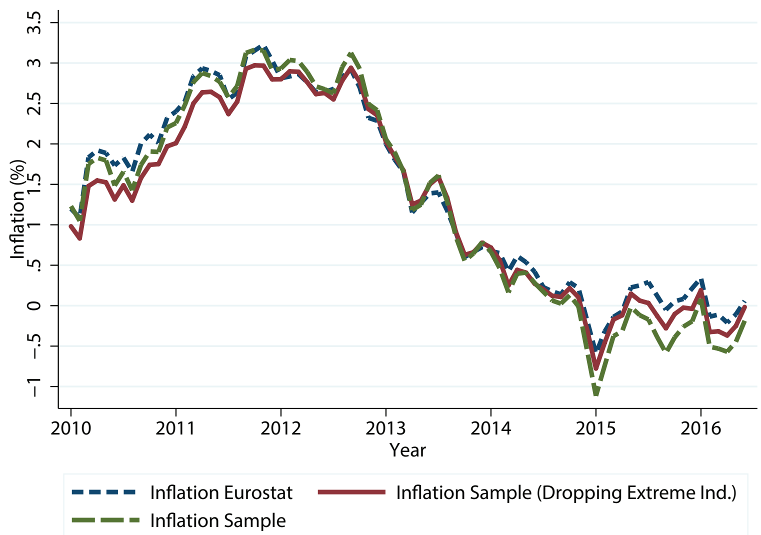

Figure D.1: Sample Vs. Official Inflation. This figure shows evolution of the official inflation for our 12 sample countries from Eurostat (blue dashed line), the inflation aggregated from our industry-country dataset with (red solid line) and without (green dashed line) dropping extreme markets with less than -50% or more than +50% annual price growth.

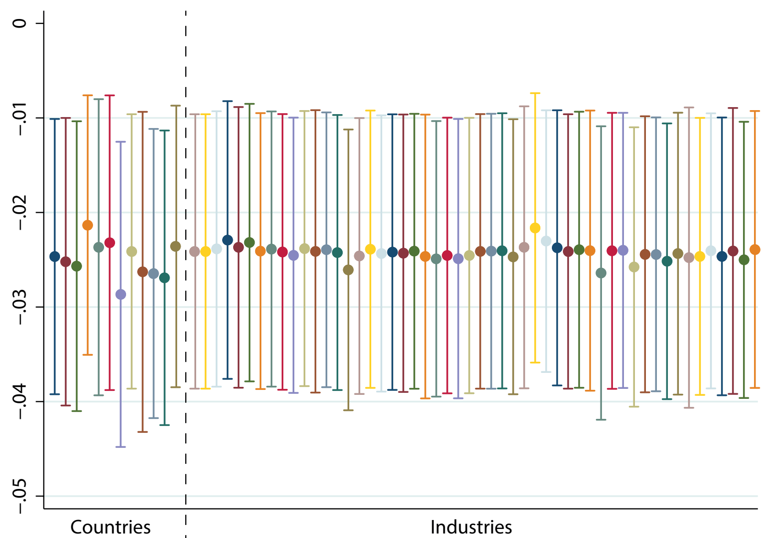

Figure D.2: CPI Growth – Exclusion of Individual Countries and Industries. This figure presents estimation results from Specification (4). Each bar shows the coefficient for *Share Zombies* and its 95% confidence interval for the regression of CPI growth rate (inflation) from $t-1$ to t on *Share Zombies*, 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).