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

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Abstract

We show that cheap credit to impaired firms has a disinflationary effect. By helping distressed firms to stay afloat, "zombie credit" creates excess production capacity reducing, in turn, prices and markups. Granular European inflation and firm-level data confirms this mechanism. At the industry-country level, a rise of zombie credit is associated with a decrease in product prices, markups, firm default, entry, and productivity, and an increase in input costs and sales. Without a rise in zombie credit, inflation in Europe would have been 0.4 percentage points higher post-2012. We also document adverse spillover effects from zombie to healthy firms.

JEL: E31, E44, G21.

Keywords: Zombie Lending, Undercapitalized Banks, Disinflation, Firm Productivity, Eurozone Crisis

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1 Introduction

More than ten years after the global financial crisis, Europe's economic growth and inflation remain depressed, even though the European Central Bank (ECB) and other European central banks provided substantial monetary stimulus, including negative deposit rates, longer-term refinancing operations, and large-scale asset purchase programs. In former ECB President Mario Draghi's own words, *"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 ultra accommodative central bank policies and zombie lending (i.e., cheap credit to impaired firms) by undercapitalized banks (Caballero et al., 2008, Giannetti and Simonov, 2013, Acharya et al., 2019). Along with search-for-yield behavior of investors, these forces have pushed borrowing costs to record lows, even for high-risk firms.[2] It has been suggested that this glut of cheap debt has allowed many non-viable firms to stay afloat, leading to a "zombification" of the economy (e.g., Borio and Hofmann, 2017).

In this paper, we propose a "zombie credit channel" that can explain the co-occurrence of the rise of zombie credit and the drop in inflation shown in Figure 1. Building on Caballero et al. (2008), we illustrate in a simple model that, by keeping alive impaired firms that would otherwise default,

[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]Since 2012, 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), while the ECB's cost-of-borrowing indicator for corporate loans more than halved. Sources: https://fred.stlouisfed.org/series/BAMLHE00EHYIEY, http://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=124.MIR.M.U2.B.A2I.AM.R.A.2240.EUR.N, and "Sub-Zero Yields Start Taking Hold in Europe's Junk-Bond Market", Bloomberg, July 9, 2019.

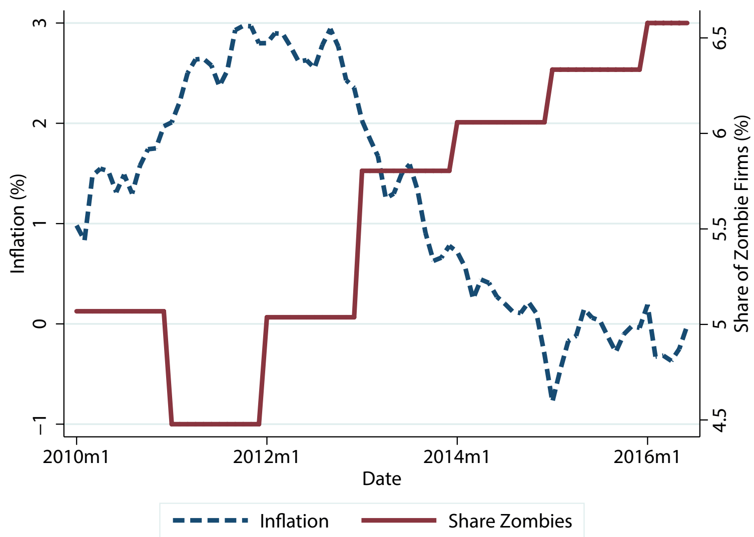

Figure 1: Zombie Credit and Inflation. This figure shows the year-over-year (yoy) growth of the CPI on the left axis and the asset-weighted share of zombie firms on the right axis in our sample. A firm is classified as zombie if it is low-quality (i.e., above median leverage and below median interest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

zombie credit dampens the downward 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.[3] In equilibrium, zombie credit causes a (i) decrease in product prices, markups, firm default, entry, and productivity, and (ii) an increase in aggregate sales, number of active firms, and firm input costs.

In our empirical work, we test the zombie credit channel for Europe by examining the effect on both consumer price inflation and firm markups; we also test the effect on input prices directly. We combine product-country level Consumer Price Index (CPI) data from Eurostat with detailed firm-level information from Bureau van Dijk's Amadeus for 1.1 million firms from 12 European countries

[3]For example, the Italian concrete and cement industry suffered from a global demand shock in 2008. Many firms subsequently struggled to pay interests and relied on their banks to remain alive and produce. 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.*" Industry representatives obtained in 2017 a Senate hearing (link) to discuss the ongoing crisis. In that hearing, they stated that "*the excessive production capacity caused an unprecedented price competition that, in turn, caused firms to realize large losses.*"

across 65 industries. 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) their interest coverage (IC) ratio is below the median and their leverage ratio is above the median—where medians are calculated at the industry-country level—and (ii) their borrowing costs are lower than the costs paid by their most creditworthy industry peers. Zombie firms' ex-post financial and real outcomes suggest that their access to cheap credit is not driven by a positive future outlook. In particular, while non-zombie firms on average deleveraged and maintained a stable profitability, zombie firms increased their leverage, experienced a drop in their profitability, and defaulted more frequently in the long-term.

Our empirical results in the cross section of countries and industries support the zombie credit channel. We find that industry-country pairs (henceforth called "markets") that experience an increase in the share of zombie firms subsequently have: (i) lower price inflation, (ii) lower average markups, (iii) higher average material and labor costs, (iv) fewer firm defaults and entries, (v) more active firms, (vi) higher aggregate sales growth, and (vii) lower average productivity compared with markets with a lower zombie firm prevalence.[4] Our partial equilibrium 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 higher.

Our specifications include country-industry, country-year, and industry-year fixed effects to capture potential omitted variables such as country- and industry-specific shocks. The positive correlation between zombie credit and aggregate sales growth suggests that the negative correlation between zombie credit and CPI growth is not driven by lower demand in markets with more zombie

[4]Our results help potentially reconcile the recent weakening of the link between cost and price inflation (e.g., Taylor, 2000 Del Negro et al., 2020).

credit. The negative correlation with average firm productivity suggests that zombie credit is extended to actual zombie firms and not to firms that are only temporarily weak. The positive correlation with average firm input costs confirms the zombie credit channel as more firms compete for the same factor inputs driving up their prices. To further mitigate endogeneity concerns, we instrument a market's zombie share with the lagged average Tier-1 capital ratio of the banks connected to the firms in this market.[5] Our instrumental variable regression estimates confirm the negative effect of the share of zombie firms on CPI growth.

Finally, our results are robust to controlling for two other (financial frictions-induced) supply-side channels. First, the cost channel (e.g., Barth III and Ramey, 2001) suggests that lower financing cost lead to lower marginal production cost and potentially lower product prices. Second, the liquidity squeeze channel (e.g., Chevalier and Scharfstein, 1996) suggests that financially constrained firms have an incentive to increase prices in order to generate higher cash flows in the short-run.

At the firm-level, we document that the increased prevalence of zombie firms affects healthy firms active in the same market. In particular, we find that healthy firms that compete with a growing number of zombie firms have lower markups, profitability, and sales growth, as well as higher input costs. These correlations are consistent with healthy firms trying to prevent a drop in market share and capacity utilization by pricing more aggressively.

2 Related Literature

Our paper contributes to three strands of literature. First, our paper relates to the literature on zombie credit that started with the evidence from Japan in the 1990s. In that context, Peek and

[5]The intuition behind this instrument is that weakly-capitalized banks have strong zombie lending incentives (see, e.g., Acharya et al., 2019 and Blattner et al., 2019).

Rosengren (2005) document that banks close to the regulatory capital constraint extended credit to their weak borrowers to avoid realizing losses on outstanding loans. Caballero et al. (2008) show that this zombie lending affected healthy firms, reducing their investment and employment growth. Giannetti and Simonov (2013) find that capital injections can prevent zombie lending if they are large enough. For OECD countries, Adalet McGowan et al. (2018) show that the share of zombie firms increased over the period 2003-2013 and that the resulting market congestion is associated with lower investment and employment growth. Similarly, using firm-level data on listed firms in 14 advanced economies, Banerjee and Hofmann (2018) document a rise in the prevalence of zombie firms since the late 1980s, which they link to reduced financial pressure due to lower interest rates. A few recent papers provide evidence that zombie credit dynamics are also at work in Europe in the aftermath of its sovereign debt crisis. Acharya et al. (2019) show that the ECB's Outright Monetary Transactions (OMT) program induced zombie lending by banks that remained weakly-capitalized. Schivardi et al. (2019) confirm that non-viable Italian firms obtained favorable bank credit during the recent crises. Using Portuguese data, Blattner et al. (2019) show that zombie lending caused a decline in productivity. Exploiting information on Portuguese on-site bank inspections, Bonfim et al. (2020) find that inspected banks became less likely to engage in zombie lending. We contribute to this literature by documenting the effect of zombie credit on product prices, firm markups, and firm input costs.

Second, our paper relates to the literature on the effect of competition on firm price setting behavior. Campbell and Hopenhayn (2005), Lewis and Poilly (2012), and Lewis and Stevens (2015) show that markups are negatively related to the number of competitors in an industry. Aghion et al. (2018) find that the monetary easing induced by the OMT program announcement fostered growth especially for credit-constrained firms, and more so for a high degree of product market competition. The authors argue that, if competition is high, weak firms can only avoid exit when funding is readily available. These findings support the notion that zombie credit, and a resulting lower exit rate, can lead to excess capacity, which puts downward pressure on markups and prices.

Third, our paper adds to the literature that studies the impact of financial frictions on inflation dynamics. Chevalier and Scharfstein (1996) highlight a "liquidity squeeze channel," arguing that liquidity-constrained firms have an incentive to raise prices to increase their current cash flows (assuming sticky customer relationships). Gilchrist et al. (2017) and de Almeida (2015) incorporate this mechanism into a general equilibrium model to explain the pricing behavior of U.S. and European firms in response to the 2007-08 financial crisis, respectively. Barth III and Ramey (2001) propose the "cost channel" as a possible explanation for an increase (decrease) in inflation after a monetary tightening (loosening). This channel suggests that firms' marginal production costs and, in turn, pricing decisions are related to funding conditions as firms usually depend on credit to finance production. Employing a New Keynesian model, Christiano et al. (2015) show that the cost channel helps to explain the only modest disinflation in the U.S. during the Great Recession. We add to this literature by proposing a novel supply-side channel through which funding conditions impact product price levels.

3 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

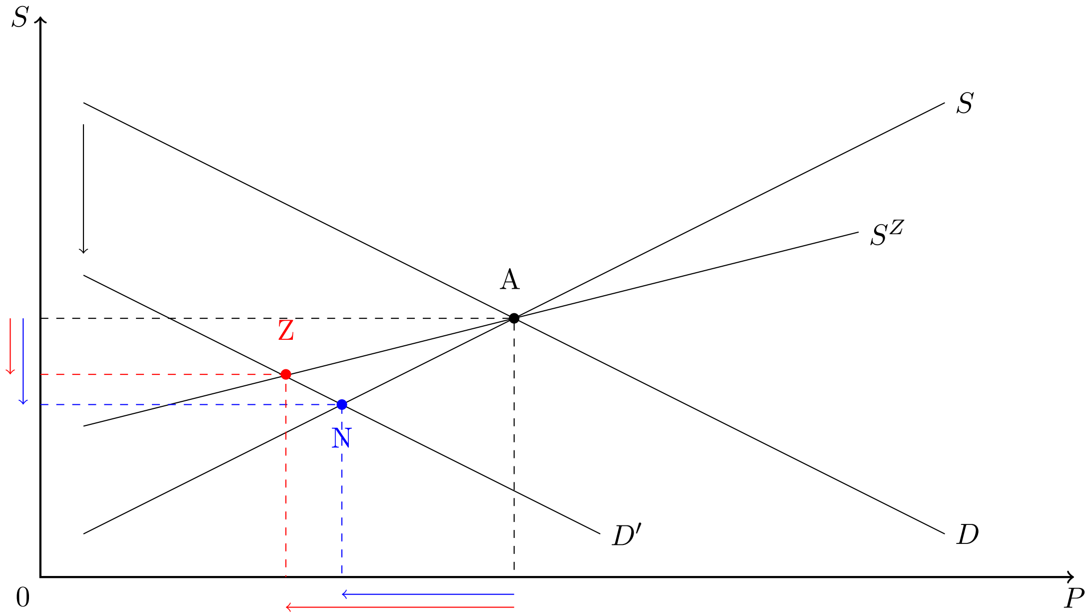

Figure 2: Intuition. This figure shows how zombie credit affects the equilibrium quantity and price.

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 entrant firms. The equilibrium is illustrated by 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 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:

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

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 equilibrium price. Third, the offsetting indirect effect through exit: a lower price causes more firms to default, increasing the equilibrium 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, and productivity; and, (ii) an increase in firm input costs, aggregate sales, and number of active firms.

In the next section, we test the model predictions in the context of the European economy during the 2009-2016 period. In our empirical strategy, 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.

In addition to the increase in zombie credit documented in Figure 1, Europe was hit by a negative demand shock in the first half of our sample period, caused by the global financial crisis and the subsequent sovereign debt crisis.[6] 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 compete for the same input factors.[7]

4 Data and Empirical Work

In this section, we describe our data and our strategy to identify zombie firms.

4.1 Data

Our data set combines detailed firm-level and product-level inflation data from 2009 to 2016. The firm-level data are financial information and firm characteristics from Bureau van Dijk's (BvD) Amadeus database.[8] BvD obtains the data, which is initially collected by local Chambers of Commerce, through roughly 40 information providers including business registers. Kalemli-Ozcan et al. (2019) show for selected European countries that Amadeus covers roughly 75-80% of the economic activity reported in Eurostat.

The inflation data are 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

[6]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.

[7]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).

[8]The data coverage from the Amadeus 2017 version is incomplete before 2009.

at the five-digit COICOP (product category) level. We also use Eurostat to obtain official data on firm entry, firm exit, firm labor costs, and job's vacancy rates.

Note that the firm data are at the industry (NACE) level and 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 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.

4.2 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 whether a firm is (i) in distress and (ii) whether it 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. First, the firm is of low-quality, which we define as having an interest coverage ratio below the median and a leverage ratio above the median, where the medians are calculated

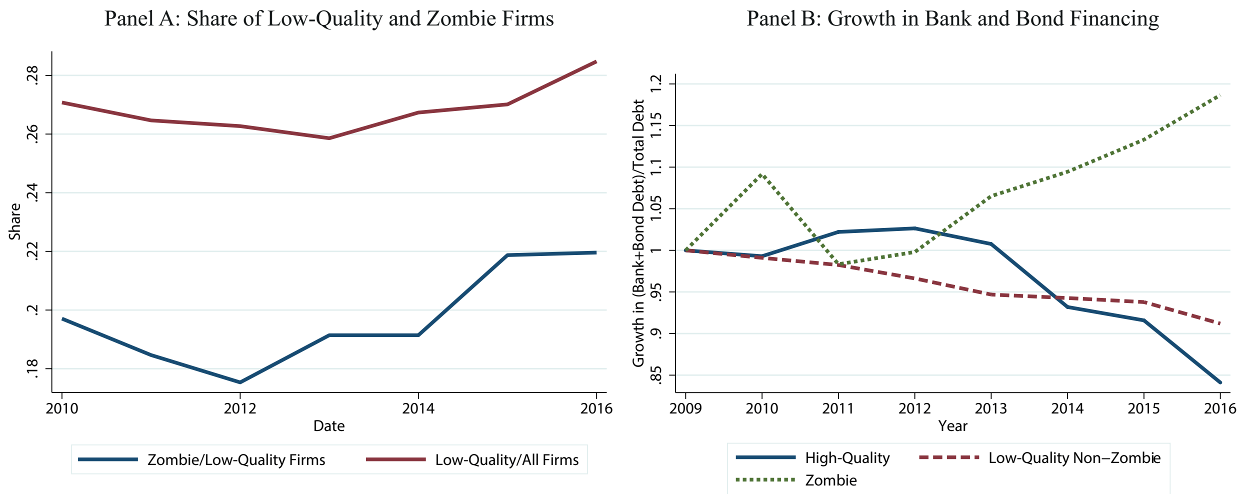

Figure 3: Firm Shares and Firm Financing. Panel A shows the share of zombie firms relative to all low-quality firms (blue line) and the share of low-quality firms relative to all firms (red line). Panel B shows the growth rate in bank and bond financing as a fraction of total debt relative to the beginning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

at the industry-country-year level.[9] Low-quality firms are thus impaired in the sense that they have both, operational problems (captured via the IC ratio criterion), as well as financial problems (captured via the leverage criterion). Second, the firm obtains credit at very low interest rates, i.e., the ratio of its interest expenses relative to the sum of its outstanding loans, credit, and bonds in a given year is below the interest paid by its most creditworthy industry peers, namely AAA-rated firms in the same industry and year in our sample.[10]

Figure 1 shows that the share of zombie firms in our sample increased from roughly 4.5% to 6.7% between 2012 and 2016.[11] In Figure 3, we document that this rise of zombie firms is driven by the fact that 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

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

[10]We infer ratings of firms from their interest coverage ratio as in Acharya et al. (2019).

[11]In Figure 9, we show that alternative zombie definitions yield a similar time-series pattern.

		Low-Quality		
	High-Quality	Non-Zombie	Zombie	
	(1)	(2)	(3)	(2)-(3)
Markup	1.13	1.05	1.01	0.040***
EBITDA Margin	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 interest coverage 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/assets. Leverage is debt/assets. IC Ratio is EBIT/interest expense. Total assets is measured in thousand euro. The estimation of firm markups is discussed in Appendix C. 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).

firms relative to low-quality firms increased from 17.5% to 22% between 2012 and 2016. Panel B shows that bank loans and bonds play an increasingly important role in the debt funding mix of zombie firms.

Table 1 presents descriptive statistics for our sample firms separately for high-quality firms, low-quality non-zombie firms, and zombie firms. Zombie firms are weaker than low-quality non-zombie firms along several observable dimensions. Zombie firms have on average a lower (even negative) interest coverage ratio, lower EBITDA margin (EBITDA/sales), lower net worth, and a higher leverage. Nevertheless, these firms pay extremely low interest rates, even compared to 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) also find no significant differences between zombie and low-quality non-zombie firms in other loan characteristics like loan size, maturity, or loan type.

We also confirm that the firms that we classify as zombies are not only temporarily weak firms, 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. To this end, we track their ex-post leverage, profitability, and default rates. In Figure 4, we plot the time-series evolution of leverage and EBITDA margin, respectively, for firms that have been zombies continuously since 2012 (solid line) and low-quality firms that were never classified as zombies (dashed line). Panel A shows that, starting in 2011, zombie firms increased their leverage as they obtained cheap debt financing. In contrast, low-quality non-zombie reduced their leverage during the same period. Panel B shows a significant drop in profitability for zombie firms compared to low-quality non-zombie firms, which maintained their initial EBITDA margin.

In Figure 5, we analyze ex-post defaults, both non-parametrically in Panel A and parametrically in Panel B.[12] 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

[12] 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 7.2.

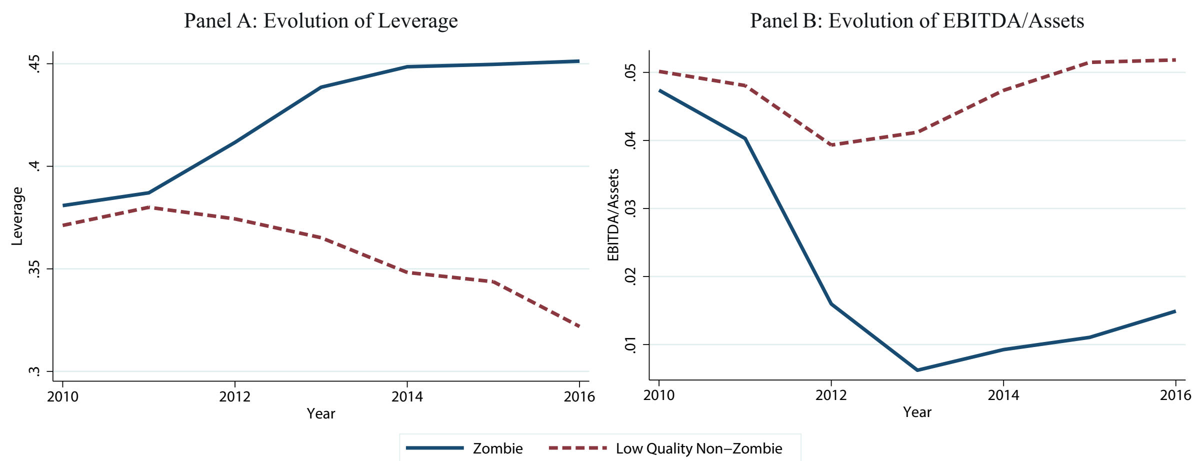

Figure 4: Ex-Post Firm Leverage and Profitability. This figure shows the ex-post evolution of leverage and profitability for zombie firms (firms that have been zombies continuously since 2012) and low-quality non-zombie firms (low-quality non-zombie firms that were never classified as zombies). Panel A shows the evolution of the asset-weighted leverage and Panel B shows the evolution of the asset-weighted EBITDA/Assets ratio.

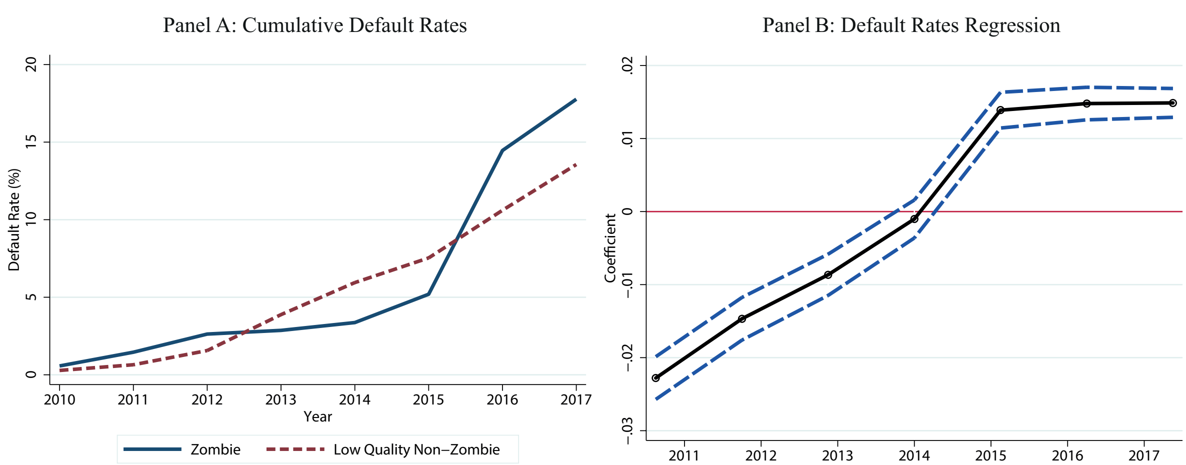

Figure 5: Ex-Post Firm Default Rates. Panel A shows the cumulative ex-post default rate of zombie firms (firms that have been zombies continuously since at least 2012) and low-quality non-zombie firms (low-quality non-zombie firms that were never classified as zombies). Panel B shows the coefficients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

low-quality firms, the following specification separately for every year τ:

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

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 5 confirms that zombie firms default more often than non-zombie firms toward the end of our sample period.

These figures suggest that zombie firms, as they obtained continued cheap debt financing, 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.

5 Industry-Country Level Evidence

In this section, we test the model predictions at the industry-country ("market") level. In Section 5.1, we document a robust negative correlation between the presence of zombie firms and CPI growth. In Section 5.2, we show that this correlation is not driven by lower demand driving both zombie presence and CPI growth. In Section 5.3, we test the other model predictions, namely the effect of the presence of zombie firms on markups, sales growth, number of active firms, default and entry rates, productivity, and input costs. In Section 5.4, we attempt to disentangle the zombie credit channel from other supply channels identified in the literature, namely the "cost channel" and the "liquidity squeeze channel."

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

5.1 Zombie Firms and CPI Growth

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 6 shows the year-over-year CPI growth separately for markets with a high (above median) and low (below 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 decline in CPI growth compared with markets with a lower zombie share increase.[13] The start of this divergent drift of the inflation dynamics coincides with the adoption of extraordinary monetary easing measures, including negative rates, by the ECB and other national central banks.

[13]In Figure B.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 outliers, 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 B.1).

	ΔCPI	ΔCPI	ΔCPI	ΔCPI
Share Zombies	-0.021**	-0.017**	-0.025***	-0.021***
	(0.008)	(0.007)	(0.009)	(0.007)
Observations	3,880	3,880	3,880	3,880
R-squared	0.491	0.723	0.522	0.754
Country-Industry FE	✓	✓	✓	✓
Year FE	✓			
Industry-Year FE		✓		✓
Country-Year FE			✓	✓

Table 2: CPI Growth: Industry-Country Evidence. This table presents estimation results from Specification (2). 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 4.2 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.

Next, we estimate the following specification:

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

where the unit of observation is country h, industry j, and year t. Y_{hjt} is the annual CPI growth rate. Our key explanatory variable is the lagged (asset-weighted) share of zombie firms in a particular market: $Share\ Zombies_{hjt-1}$. In the most conservative specification, we control for industry-country, country-year, and industry-year fixed effects. 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. The inclusion of country-time and industry-time fixed effects allows us to isolate the effect of zombie credit on various outcome variables, holding constant the time-varying demand at the industry- and country-level. In Section 5.2, we present an instrumental variable strategy to further alleviate concerns about confounding demand channels.

The estimation results in Table 2 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.

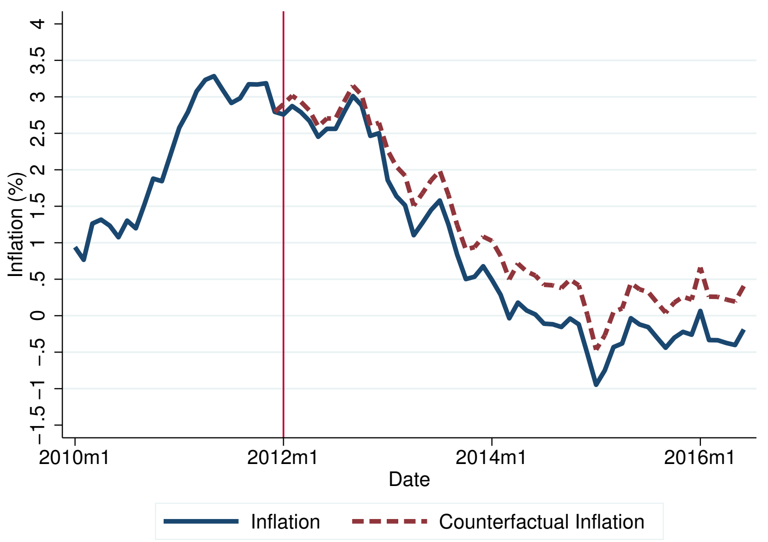

Figure 7: CPI Growth Counterfactual. This figure shows the actual inflation rate in our sample and a counterfactual inflation rate. The counterfactual inflation rate (at market-level) is measured as the inflation rate that would have prevailed from 2012 to 2016, if the share of zombie firms had stayed at the 2012 level in each year and market. These values are aggregated across markets using actual weights for the aggregate CPI.

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	-0.81	-3.38
Italy	Transportation and Storage	-0.30	28.41	-0.60	0.30
Portugal	Arts, Entertainment and Recreation	0.58	28.3	-0.60	1.18
Slovenia	Manufacturing	-2.39	26.44	-0.56	-1.83
Italy	Manufacturing	-2.60	22.44	-0.47	-2.13

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	1.15	0.85
France	Other Service Activities	2.90	-34.9	0.73	2.17
Spain	Information and Communication	2.80	-6.6	0.14	2.66
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 some industries that experienced a strong increase (Panel A) and 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 -0.021, obtained from the most restrictive specification in Table 2. The effect is calculated as $-0.021 \times (\Delta\text{Share Zombie})$. The counterfactual CPI growth shows what the inflation rate would have been without an increase in the zombie share.

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 weights. We present the results in Figure 7, where the solid line is the observed inflation and the dashed line is the counterfactual inflation. Our partial equilibrium estimates suggest that the CPI growth would have been on average 0.4 percentage points higher if the share of zombies would have stayed at its 2012 level.

In Table 3, we present some examples of markets that experienced a large zombie share increase 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%.[14] Based on our estimates from Table 2, the CPI growth in this market would have been 0.81 percentage points higher than the observed CPI growth if the share of zombie firms would have remained at its 2012 level.

5.2 Are Our Results Driven By Lower Demand?

We have documented, in the cross-section of markets, a negative correlation between the presence of zombie firms and CPI growth. This correlation is consistent with the mechanism outlined in Section 3: zombie credit allows some distressed firms to avoid default, increasing the aggregate production capacity in their market and putting, in turn, a downward pressure on product prices. However, the negative correlation between the presence of zombie firms and CPI growth is also consistent with a negative product demand shock, which might simultaneously reduce price levels

[14] 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.

	Sales Growth	Sales Growth	Sales Growth	Sales Growth
Share Zombies	0.287**	0.400***	0.320***	0.420***
	(0.123)	(0.148)	(0.114)	(0.129)
Observations	3,894	3,894	3,894	3,894
R-squared	0.179	0.251	0.409	0.476
Country-Industry FE	✓	✓	✓	✓
Year FE	✓			
Industry-Year FE		✓		✓
Country-Year FE			✓	✓

Table 4: Sales Growth: Industry-Country Evidence. This table presents estimation results from specification (2). The dependent variable is sales growth 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 4.2 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.

and increase the number of zombie firms.

We address this potential omitted variable bias in two ways. First, we estimate Specification (2), where the dependent variable is aggregate sales growth. The estimation results in Table 4 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 and inconsistent with a demand channel as the latter would predict lower aggregate sales growth in markets with a high zombie prevalence.

Second, we run an instrumental variable (IV) regression, where we focus on the zombie lending incentives of weakly-capitalized banks as a predictor for the increase in the zombie prevalence. Besides search-for-yield behavior and ultra accommodative central bank policies, 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).

In particular, we instrument a market's share of zombie firms with the lagged average capitalization (Tier-1 capital to risk-weighted assets ratio) of the banks connected to the firms in this market, weighted by the number of firm relationships. We denote this instrument as *Average Tier-1 Ratio*. This instrument is based on the idea, introduced in Peek and Rosengren (2005),

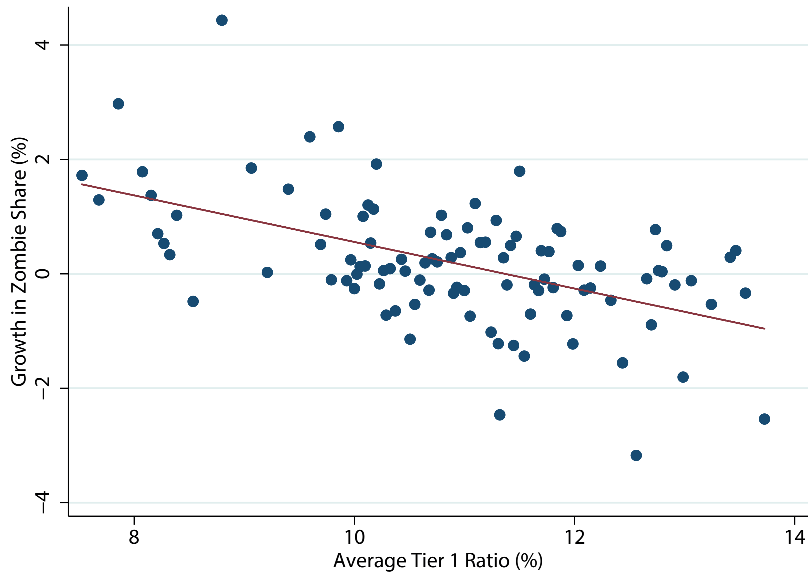

Figure 8: Bank Capitalization and Zombie Growth. This figure presents a binscatter plot showing the relation between the lagged Tier-1 capital ratio (x-axis) and the growth in the share of zombie firms (y-axis). To calculate the average Tier-1 capital ratio of an industry-country pair we use the banks' number of firm links as weight.

that weakly-capitalized banks have an incentive to evergreen loans to distressed borrowers.[15] By extending loans at very low interest rates, these banks provide their impaired borrowers with the liquidity necessary to meet payments on other outstanding loans. Thereby, these banks avoid (or at least defer) realizing immediate loan losses 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. Figure 8 confirms this conjecture by documenting a pronounced negative relationship between a market's *Average Tier-1 Ratio* and its zombie share growth.

Of course, banks' capitalization is closely linked to the performance of the industries they are exposed to. Specifically, a larger exposure to firms in markets that experienced a strong negative demand shock could result in larger loan losses and thus lower capital levels. However, our analysis

[15] Given that European firms rely heavily on bank credit, this instrument is particularly relevant in our setting.

of data from the European Banking Authority's EU-wide stress tests and capital exercises shows that the capitalization of European banks is to a large extent determined by the value loss of their government bond holdings from stressed European countries during the recent sovereign debt crisis, and not loan losses. In particular, the rank correlation between the banks' pre-crisis (i.e., 2009) sovereign debt holdings from stressed European countries and their equity change between between 2009 and 2012 is -0.49 (linear correlation is -0.53).[16] While we ideally would like to use the banks' sovereign debt holdings as an instrument for the share of zombie firms, data on their sovereign bond holdings are only available for a small subset of our sample banks.

In our preferred IV specification, we determine the bank-firm relationships using both Amadeus and DealScan (see Table 5, 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).[17]

The first stage, shown in Panel B of Table 5, explains the share of zombie firms at time $t-1$ in a particular market (*Share Zombies*) using the market's *Average Tier-1 Ratio* at $t-2$, 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 13.9 and 14.6, 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 5, we replace the *Share*

[16] A cross-sectional regression where we use a bank's 2009 sovereign debt holdings over total asset ratio to explain the change in its equity ratio between 2009 and 2012 yields a large negative coefficient (significant at the 1% level) and an R^2 of 0.4. This estimation suggests that their pre-crisis sovereign debt holdings explain a significant share of the equity losses of European banks.

[17] Given that Amadeus does not report the firms' main banks for all countries, our sample size goes down 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.

Panel A	ΔCPI	ΔCPI	ΔCPI
$\widehat{Share\ Zombies}$	-0.196**	-0.198**	-0.194**
	(0.096)	(0.099)	(0.096)
Observations	2,080	1,939	2,080

Panel B	Share Zombie	Share Zombie	Share Zombie
Average Tier-1 Ratio	-1.177***	-1.380***	-1.171***
	(0.310)	(0.371)	(0.307)
F-Test	14.6	13.9	14.5
Observations	2,080	1,939	2,080
R-squared	0.747	0.748	0.747
Sample	Amadeus	Amadeus	Amadeus
	+ DealScan	Only	+ DealScan Italy
Country-Industry FE	✓	✓	✓
Industry-Year FE	✓	✓	✓
Country-Year FE	✓	✓	✓

Table 5: Instrumental Variable Estimation. 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 $t-1$. Average Tier-1 Ratio measures the average tier-1 ratio of the banks linked to the firms in the particular market at $t-2$ (weighted by the banks' number of firm relationships). Bank relationships are determined using Amadeus and DealScan in Column (1), solely Amadeus in Column (2), as well as Amadeus plus DealScan for Italian firms in Column (3). Standard errors clustered at the industry-country level reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Zombies with the predicted $\widehat{Share\ Zombies}$ from the first stage. The IV estimated coefficients confirm our results from Table 2, further alleviating concerns that our effect might be driven by changes in demand.

The IV estimate of the inflation elasticity to the zombie share (-0.196) is about 9 times larger than the OLS estimate (-0.021). 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 banks, search-for-yield behavior, and ultra-accommodative central bank policies) and demand factors. When these factors are uncorrelated, the variations in other

	ΔMarkup	ΔMarkup	ΔMarkup	ΔMarkup
Share Zombies	-0.052**	-0.054**	-0.057**	-0.063**
	(0.024)	(0.026)	(0.025)	(0.027)
Observations	3,261	3,261	3,261	3,261
R-squared	0.148	0.315	0.172	0.337
Country-Industry FE	✓	✓	✓	✓
Year FE	✓			
Industry-Year FE		✓		✓
Country-Year FE			✓	✓

Table 6: Markups: Industry-Country Evidence. This table presents estimation results from Specification (2). The dependent variable is the turnover-weighted change in markups 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 4.2 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.

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 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 11% of the total variation in the zombie share.

5.3 Further Model Predictions

In this section, we test our further model predictions using Specification (2). In particular, our model predicts that markets with a higher zombie prevalence display lower firm markups, more active firms, lower default and entry rates, higher input costs, and lower productivity compared with markets with a lower zombie prevalence.

Consistent with our model, we indeed find that a higher zombie prevalence is associated with lower firm markups (see Table 6). We measure firm markups following De Loecker and Warzynski

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 7: Number of Active Firms, Firm Defaults, and Firm Entries: Industry-Country Evidence. This table presents estimation results from Specification (2). 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 4.2 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

(2012) and De Loecker et al. (2019), i.e., we rely on optimal input demand conditions obtained from standard cost minimization to determine markups for each firm.[18] 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.

In Table 7, we show that a higher zombie prevalence is associated with more active firms, fewer firm defaults, and fewer firms entering a market. These variables are obtained from Eurostat, which

[18] See Appendix C for more details on the markup estimation.

Panel A	Material Cost	Material Cost	Material Cost	Material Cost
Share Zombies	0.055**	0.055**	0.050**	0.050**
	(0.023)	(0.023)	(0.023)	(0.024)
Observations	3,701	3,701	3,701	3,701
R-squared	0.943	0.951	0.945	0.953
Panel B	**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
Panel C	**Productivity**	**Productivity**	**Productivity**	**Productivity**
Share Zombies	-0.283***	-0.281**	-0.259**	-0.248*
	(0.103)	(0.124)	(0.105)	(0.126)
Observations	3,811	3,811	3,811	3,811
R-squared	0.868	0.885	0.874	0.890
Country-Industry FE	✓	✓	✓	✓
Year FE	✓			
Industry-Year FE		✓		✓
Country-Year FE			✓	✓

Table 8: Input Costs and Productivity: Industry-Country Evidence. This table presents estimation results from Specification (2). The dependent variables are the industry material cost (material input cost/turnover, Panel A), the industry labor cost (Eurostat's labor cost index, Panel B), and asset-weighted productivity (*log(sales)–2/3*log(employment)–1/3*log(fixed assets)*, 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 4.2 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

releases official data at the industry-country level over time.[19] 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 would not receive zombie credit. The resulting excess production capacity reduces product prices and firm markups, making the market less attractive for potential entrants.

In Table 8, we confirm that a higher zombie prevalence is associated with higher input costs

[19]We can also calculate firm default rates using Amadeus data. In Table 12, we show that we obtain similar results on firm defaults if we rely on the Amadeus database to classify firms as defaulted.

(material costs in Panels A and labor costs in Panel B) and lower productivity (Panel C).[20] The excessive production capacity in markets with high zombie presence leads to a higher demand for labor and materials causing, in turn, higher material and labor costs. Interestingly, Panel B shows that the 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.[21] The insignificant coefficient for *Share Zombies* suggests that the higher average labor cost for (some) zombie markets is indeed induced by a higher number of active firms and the resulting competition for inputs.

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. In particular, while the zombie credit channel pushes production costs upwards due to an increase in average input costs, it also 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 extent that it overcompensated the input cost increase. Thereby, the zombie credit channel weakens the link between product and cost inflation.

In line with our mechanism, Taylor (2000) document that the cost inflation-price inflation relationship weakened as many countries experienced lower inflation since the nineties. A growing

[20]We measure productivity as *log(sales)–2/3*log(employment)–1/3*log(fixed assets)*, following Caballero et al. (2008).

[21]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.

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. (2018) 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.

5.4 Alternative Supply-Side Channels

While the collective evidence presented in Section 5.1 to Section 5.3 is consistent with the zombie credit channel, the literature has suggested further (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

	ΔCPI	ΔCPI	ΔCPI
Share Zombies	-0.019***	-0.020***	-0.018***
	(0.007)	(0.007)	(0.007)
Liquidity Ratio	-0.054*		-0.052*
	(0.028)		(0.028)
Working Capital Costs		0.533**	0.537**
		(0.233)	(0.229)
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 9: Alternative Channels: Industry-Country Evidence. This table presents estimation results from Specification (2). 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 $t-1$. *Working Capital Costs* is defined as the firms' average asset-weighted (net working capital/total assets)*(interest expenses/sales). *Liquidity Ratio* is defined as the firms' average asset-weighted ratio of cash and short-term investments to total assets. A firm is classified as zombie if it is low-quality and paid advantageous interest rates (see Section 4.2 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.

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 9 shows the estimation results. While both alternative supply-side channels seem to be also active, including proxies for these channels does neither change the point estimate of the zombie share nor significantly alter the explanatory power of the zombie credit channel for CPI growth. These results suggest that, while the alternative supply-side channels likely contributed to the European dis-inflationary trend, the zombie credit channel was a distinctive driver for the observed low inflation level in Europe.

Finally, regarding our further model predictions discussed in Section 5.3, 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.

The empirical findings in Section 5.3 thus provide further evidence for the distinctive impact of the zombie credit channel.

6 Firm-Level Analysis

In this section, we take advantage of our detailed firm-level data to test a unique prediction of the zombie credit channel, namely the existence of spillover effects on non-zombie firms active in markets with a high zombie prevalence.

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.[22] Non-zombie firms in markets with a high zombie prevalence also face higher input prices due to an increased number of active firms that compete for a limited amount of resources.

In sum, for non-zombie firms in zombie markets, the zombie credit channel predicts lower sales growth, lower markups, and higher input costs compared with individual non-zombie firms in non-zombie markets. Following Caballero et al. (2008), we test these predictions by estimating the following regression at the firm-year level:

$$\begin{aligned} Y_{ihjt} &= \beta_1 \times Non-Zombie_{ihjt} + \beta_2 \times Non-Zombie_{ihjt} \times Share\ Zombies_{hjt-1} \\ &+ \eta_{hjt} + \epsilon_{ihjt}, \end{aligned} \tag{3}$$

where i is a firm, h a country, j an industry, and t a year. Our dependent variables are firm

[22] 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 4 confirms this prediction.

	Markups	Sales Growth	Material Costs	EBIT/Sales
Non-Zombie	0.060***	0.061***	-0.022***	0.086***
	(0.006)	(0.007)	(0.002)	(0.008)
Non-Zombie	-0.226***	-0.176***	0.064***	-0.198***
× Share Zombies	(0.043)	(0.034)	(0.019)	(0.033)
Observations	4,211,633	5,922,959	4,653,410	5,910,165
R-squared	0.584	0.032	0.521	0.151
Industry-Country-Year FE	✓	✓	✓	✓
Firm-Level Controls	✓	✓	✓	✓

Table 10: Markups, Sales Growth, Material Costs, EBIT/Sales: Firm-Level Evidence. This table presents estimation results from Specification (3). The dependent variables are a firm's markup, sales growth, material cost (material input cost/turnover), or EBIT/sales. *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 interest coverage ratio. A firm is classified as zombie if it is low-quality and paid advantageous interest rates (see Section 4.2 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.

markup, sales growth, material cost, and EBIT/Sales. 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 10 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. In Column (2), we find a lower sales growth for individual non-zombie firms active in a market with a large zombie share increase. The results in Column (3) confirm that non-zombie firms that have to compete against a higher number of zombie firms (relative to non-zombie firms in non-zombie markets) indeed have to pay higher material costs.[23]

Moreover, the results in Column (5) of Table 10 suggest that there might be a zombie contagion

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

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 fiercer competition 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, the results in this section help to further separate the zombie credit channel from the cost and the liquidity squeeze channel, which do not predict spillover effects from zombie to non-zombie firms.

7 Robustness

This section provides several robustness tests. In Section 7.1, we use alternative zombie firm classifications. In Section 7.2, we redo our default rate tests employing a different data set. In Section 7.3, we conduct a placebo test for our firm-level analysis.

7.1 Alternative Zombie Classifications

To ensure the robustness of our results with respect to the zombie classification, we use various alternative zombie definitions and redo our analysis from Table 2.

First, we calculate median values for leverage and the interest coverage ratio at the industry-year level instead of the industry-country-year level. Second, we consider solely the interest coverage ratio criterion instead of both the interest coverage ratio and leverage to define a firm as low-quality. Third, we use solely the leverage criterion to define a firm as low-quality. Figure 9 shows that these alternative classifications yield a similar time-series pattern for the (increasing) share of zombie firms. Table 11 shows that our results on the effect of a rise in zombie credit on CPI growth are robust to using alternative zombie classifications.

Panel A	ΔCPI	ΔCPI	ΔCPI	ΔCPI
Share Zombies (Alt. Def. #1)	-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	ΔCPI	ΔCPI	ΔCPI	ΔCPI
Share Zombies (Alt. Def. #2)	-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	ΔCPI	ΔCPI	ΔCPI	ΔCPI
Share Zombies (Alt. Def. #3)	-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
Country-Industry FE	✓	✓	✓	✓
Year FE	✓			
Industry-Year FE		✓		✓
Country-Year FE			✓	✓

Table 11: Inflation: Industry-Country Evidence under Alternative Zombie Classifications. This table presents estimation results from Specification (2). 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 4.2 for more details. Panel A calculates median values for leverage and interest coverage ratio at industry-year-level (instead of industry-country-year level). Panel B considers solely the interest coverage ratio criterion to define a firm as low-quality. Panel C considers only the leverage criterion to define a firm as low-quality. Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

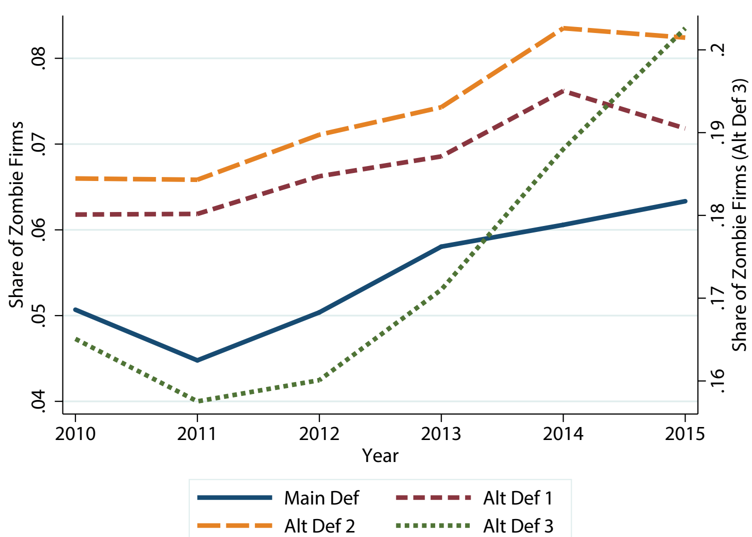

Figure 9: Alternative Zombie Definitions. This figure shows the evolution of the zombie share for alternative zombie definitions. The blue solid line replicates our main measure of the zombie share. Alt Def 1 (red dashed line) calculates median values for leverage and interest coverage ratio at the industry-year-level (instead of industry-country-year level). Alt Def 2 (orange dashed line) considers solely the interest coverage ratio criterion to define a firm as low-quality. Alt Def 3 (green dotted line) considers only the leverage criterion to define a firm as low-quality.

	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 12: Firm Defaults: Industry-Country Evidence based on Amadeus Data. This table presents estimation results from Specification (2). 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 4.2 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

7.2 Alternative Default Rate Measure

The Eurostat data used in Table 7 to analyse the effect on exit rates does not distinguish between different types of exit (i.e., insolvency or dissolved for other reasons).

Hence, as a robustness check, we redo this analysis using the legal status variable from Amadeus. 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.[24] In Table 12, we show that we obtain similar results on the effect of a rise of zombie credit on firm defaults if we rely on the Amadeus default data.

7.3 Firm-Level Robustness

Finally, we conduct a placebo test for the firm-level results presented in Section 6. In 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.

[24] 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".

	Markup	Sales Growth	Material Cost	EBIT/Sales
Non-Zombie	0.040***	0.037***	-0.017***	0.065***
	(0.010)	(0.006)	(0.004)	(0.006)
Non-Zombie	0.017	0.037	-0.002	0.022
× Share Low-Quality	(0.038)	(0.024)	(0.009)	(0.033)
Observations	4,211,633	5,922,959	4,653,410	5,910,165
R-squared	0.565	0.033	0.5128	0.157
Industry-Country-Year FE	✓	✓	✓	✓
Firm-Level Controls	✓	✓	✓	✓

Table 13: Firm-Level Analysis: Robustness. This table presents estimation results from Specification (3). The dependent variables are a firm's markup, sales growth, material cost (material input cost/turnover), or EBIT/Sales. *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 an industry-country-year. Firm-level controls include net worth, leverage, the natural logarithm of total assets, and the interest coverage ratio. A firm is classified as low-quality if it has a below median interest coverage 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.

The results presented in Table 13 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.

8 Conclusion

The low-growth low-inflation environment that prevails in Europe after 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 that shows that policy measures that make cheap debt financing readily available to impaired firms have a disinflationary side effect, thereby providing an explanation for the persistent low inflation rates in Europe. Accommodative policy measures reduce financial pressure and thereby fuel the survival of weak firms with unsustainable business models. As these zombie firms proliferate, aggregate supply increases compared to the case where the business cycle runs its normal course. The resulting excess capacity puts downward pressure on producer prices, and, ultimately, depresses inflation levels.

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, as well as fewer firm defaults, and lower productivity.

These results draw attention to the often-neglected impact of supply-side financial frictions on inflation. Specifically, our findings highlight that while monetary and macroprudential policies are important to achieve macroeconomic and financial stability, closely monitoring their interaction with financial frictions at the micro-level and teasing out their precise transmission to the real economy are equally important. Otherwise, financial frictions can lead to unintended macroeconomic consequences of accommodative policies and work precisely against the policies' stated and assumed objectives of generating inflation and growth. Conversely, accommodative monetary policy might be more effective in times of a weakening financial sector, if accompanied by a targeted financial sector recapitalization program.

Our results also call for the development of equilibrium models to measure the general equilibrium effects of zombie credit. While our evidence on ex-post performance by zombie firms suggests that zombie credit likely depresses growth in the medium to long term, zombie firms might have a temporarily positive effect on, for example, employment. Finally, our results suggest that, at least for European countries that still have free sovereign debt capacity, a more expansive fiscal policy could potentially be an effective tool to raise inflation, since the resulting positive demand shock would absorb at least part of the zombie-induced excess capacity. Studying such interactions of fiscal and monetary policy tools is an important area for future research.

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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.[25]

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.[26] Because of the production constraint, firms charge a positive markup $(p_t - c)/c$.[27]

[25] 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.

[26] 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.

[27] 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.

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 and the mass of surviving incumbent firms S_t are:

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

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

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

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

$$N_t = (e + m_t) \left(1 - \frac{I}{p_t - c}\right). \tag{A2}$$

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 (A2), 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:

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

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

$$N_t = e\left(1 - \frac{I}{p_t - c}\right) + \overline{S} \tag{A3}$$

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 (A3), 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.[28] 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

[28] 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.

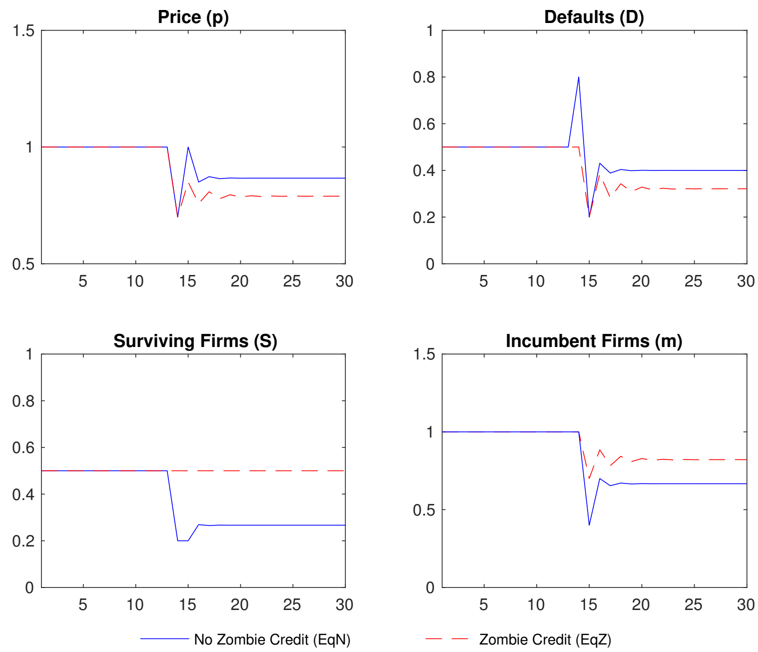

Figure A.1: Negative Demand Shock. This figure shows how equilibrium quantities and prices respond to a permanent decrease in α in EqN (solid lines) and in EqZ (dashed lines).

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 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:

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

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

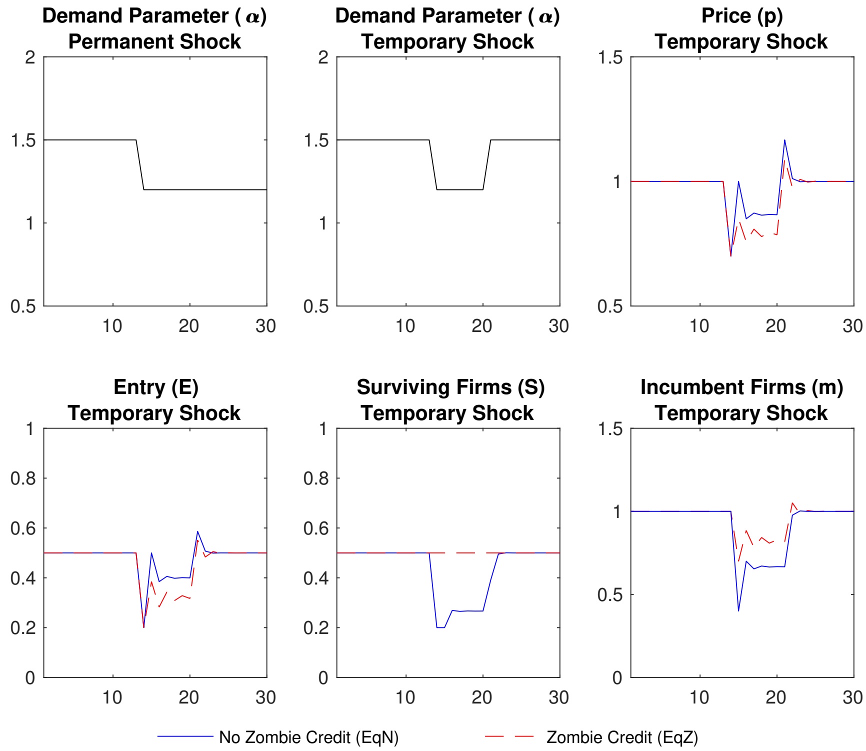

Figure A.2: Temporary Negative Demand Shock. This figure shows how equilibrium quantities and prices respond to a temporary decrease in α in EqN (solid lines) and in EqZ (dashed lines).

the input cost: $c_t = \frac{m_t}{2} + \mu_t$. The intuition for this expression follows the intuition from Lemma 1. Firms set the marginal cost of input c_t such that the total demand for the input equals its supply at the price c_t.

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 an increase in entry and a decrease in 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 a lower number of active firms and lower input costs. Again, this adjustment is muted in the equilibrium with zombie credit.

Appendix B CPI Growth - Additional Robustness

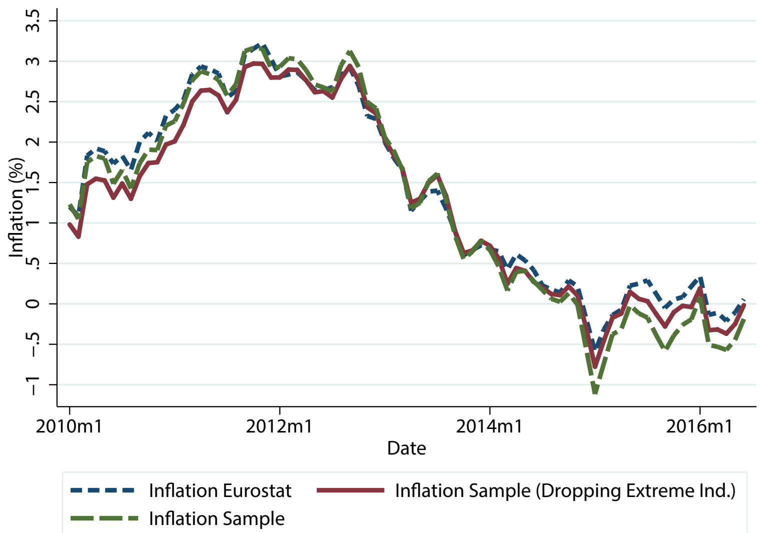

Figure B.1: Sample Vs. Official Inflation This figure shows evolution of the official inflation for our 12 sample countries from Eurostat (blue dashed line), the inflation aggregated from our industry-country dataset with (red solid line) and without (green dashed line) dropping extreme markets with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

	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 B.1: Inflation: Industry-Country Evidence. This table presents industry-country-year level regressions. 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 4.2 for more details). Estimates show results after dropping extreme markets with less than -50% or more than +50% annual price growth. Standard errors are clustered at the industry-country level and reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix C 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:

$$Q_{it} = Q_{it}(\Omega_{it}, V_{it}, K_{it}), \tag{C1}$$

where Q_{it} is the output quantity produced by technology $Q_{it}(\cdot)$, V_{it} the variable input factor, K_{it} the capital stock (treated as a dynamic input in production), and Ω_{it} 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:

$$\mathcal{L}(V_{it}, K_{it}, \lambda_{it}) = P_{it}^{V} + V_{it} + r_{it}K_{it} + F_{it} - \lambda_{it}(Q(\cdot) - \overline{Q}_{it}), \tag{C2}$$

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

$$\frac{\partial \mathcal{L}_{it}}{\partial V_{it}} = P_{it}^{V} - \lambda_{it}\frac{\partial Q(\cdot)}{\partial V_{it}} = 0. \tag{C3}$$

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

$$\theta_{it}^{v} \equiv \frac{\partial Q(\cdot)}{\partial V_{it}}\frac{V_{it}}{Q_{it}} = \frac{1}{\lambda_{it}}\frac{P_{it}^{V}V_{it}}{Q_{it}}. \tag{C4}$$

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:

$$\mu_{it} = \theta_{it}^{v}\frac{P_{it}Q_{it}}{P_{it}^{V}V_{it}}. \tag{C5}$$

Hence, there are two ingredients needed to estimate the markup of firm i: its expenditure share of the variable input, $P_{it}Q_{it}/P_{it}^{V}V_{it}$, which is readily observable in the date, and its output elasticity of the variable input, θ_{it}^{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):[29]

$$q_{it} = \beta_{v1} v_{it} + \beta_{k1} k_{it} + \beta_{v2} v_{it}^2 + \beta_{k2} k_{it}^2 + \omega_{it} + \epsilon_{it}. \tag{C6}$$

where lower cases denote logs.[30] In particular, q_{it} is the log of the realized firm's output (i.e., deflated turnover), v_{it} the log of the variable input factor (i.e., cost of goods sold and other operational expenditures), k_{it} the log of the capital stock (i.e., tangible assets), $\omega_i = ln(\Omega_i)$, and ϵ_{it} is the unanticipated shock to output. 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. (C6), 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 ($\widehat{\phi_{it}}$) and the unanticipated shocks to output (ϵ_{it}) are purged using a non-parametric projection of output on the inputs and the control variable:

$$q_{it} = \phi_{it}(v_{it}, k_{it}) + \epsilon_{it}. \tag{C7}$$

The second stage provides estimates for all production function coefficients by relying on the law

[29]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).

[30]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.

of motion for productivity:

$$\omega_{it} = g_t(\omega_{it-1}) + \varepsilon_{it}. \tag{C8}$$

We can compute productivity for any value of β, where $\beta = (\beta_{v1}, \beta_{k1}, \beta_{v2}, \beta_{k2})$, using $\omega_{it}(\beta) = \widehat{\phi}(\beta_{v1}v_{it} + \beta_{k1}k_{it} + \beta_{v2}v_{it}^2 + \beta_{k2}k_{it}^2)$. By nonparametrically regressing $\omega_{it}(\beta)$ on its lag, $\omega_{it-1}(\beta)$, we recover the innovation to productivity given β, $\varepsilon_{it}(\beta)$.

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

$$E\left(\varepsilon_{it}(\beta)\begin{pmatrix} v_{it-1} \\ k_{it} \\ v_{it-1}^2 \\ k_{it}^2 \end{pmatrix}\right) = 0, \tag{C9}$$

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:

$$\theta_{it}^v = \widehat{\beta}_{v1} + 2\widehat{\beta}_{v2}v_{it}, \tag{C10}$$

which allows us to calculate the markup of firm i.