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, this "zombie credit" creates excess production capacity that, in turn, puts downward pressure on markups and product prices. We test this mechanism exploiting granular inflation and firm-level data from eleven European countries. In the cross-section of industries and countries, we find that a rise of zombie credit is associated with a decrease in firm defaults, average firm markups and product prices, lower investment and productivity, and an increase in aggregate sales as well as material and labor cost. Our results are stronger for prices of non-tradable products, which are more affected by local credit markets, and hold at the firm level, where we document spillover effects to healthy firms in markets with high zombie credit.

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1 Introduction

Ten years after the global financial crisis, Europe's economic growth and inflation rate 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 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 deflationary pressure, both economies have been characterized by ultra accommodative central bank policies, search-for-yield behavior, and zombie lending[2] by undercapitalized banks, which collectively pushed borrowing costs to record lows, even for high-risk firms. 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.[3] This glut of cheap debt allowed many struggling firms to stay afloat, which led to a "zombification" of the economy (e.g., Borio and Hofmann, 2017 and Banerjee and Hofmann, 2018).

In this paper, we provide an explanation for the co-occurrence of a rise of cheap credit to impaired firms and low inflation levels (see Figure 1). Building on Caballero et al. (2008), we show in a simple model that, by keeping distressed firms alive that would otherwise default, a rise of zombie credit prevents an adjustment in the industry-wide production capacity.

[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] Caballero et al. (2008) and Giannetti and Simonov (2013) analyze this zombie lending phenomena in Japan and Acharya et al. (2019) find evidence for zombie lending in Europe.

[3] 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.

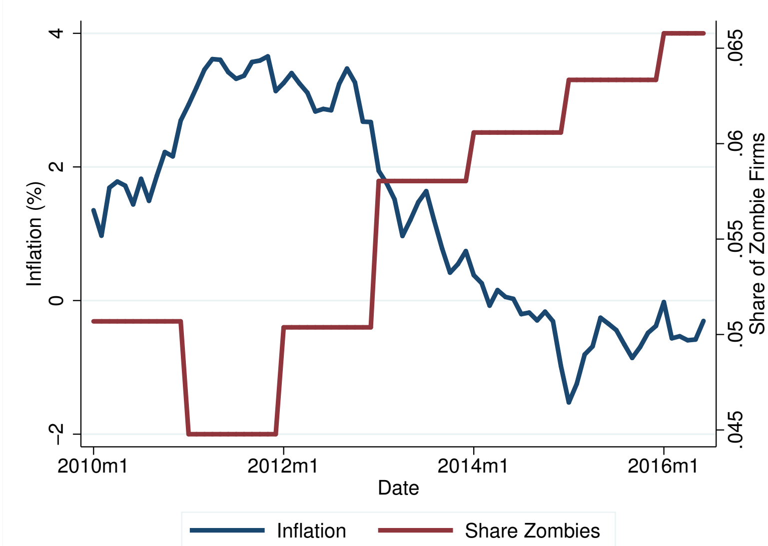

Figure 1: Zombie Credit and Inflation. This figure shows the year-over-year (yoy) growth of the Consumer Price Index (CPI) on the left axis and the asset-weighted share of zombie firms on the right axis in our sample. A firm is classified as zombie if it is low-quality (i.e., above median leverage and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

The resulting excess capacity puts downward pressure on markups and product prices and thereby lowers inflation. We test this channel using granular inflation and firm level data for a sample of 1.1 million firms from 11 European countries across 65 industries, which allows us to measure zombie credit and firm level markups and to observe product level prices. Our empirical analysis supports this zombie credit channel.

We illustrate our mechanism in a dynamic model where firms, potential entrants and incumbents, draw a productivity parameter every period and set prices to exploit their market power. If the productivity realization is high, incumbent firms survive and potential entrants enter. If the productivity realization is low, incumbent firms default and potential entrants do not enter. Following a negative demand shock that causes a price decline, zombie credit keeps alive some firms that would otherwise default, which prevents a downward adjustment in the number of active firms (compared to the case without zombie credit). The resulting excess production capacity puts downward pressure on firms' markups and prices. In equilibrium, zombie credit has four effects: a reduction in firm defaults, firm markups, product prices, and an increase in the number of active firms.

The empirical analysis is based on a new data set, obtained by combining product level inflation data from Eurostat with firm level accounting data from Bureau van Dijk's Amadeus database. Using input-output tables obtained from national statistical institutions, we calculate inflation at the industry level from product level data. Using Amadeus data, we measure zombie credit and firms' markups. We define a firm as zombie if it meets two criteria: (i) the firm's interest coverage ratio is below the median and its leverage ratio is above the median – where medians are calculated at the industry-country level – and (ii) the firm obtains debt financing at a rate lower than the rate paid by the most creditworthy (AAA-rated) comparable firms. Following De Loecker and Warzynski (2012), we estimate markups relying on optimal input demand conditions from standard cost minimization.

Our data supports our four model predictions. In the cross-section of industries and countries, we find that industry-country pairs (henceforth called "markets") that experience a larger increase in the share of zombie firms subsequently have: fewer firm defaults, higher aggregate sales growth, and more active firms, as well as, lower average markups and lower inflation growth than markets with a smaller increase in the prevalence of zombie firms. Our specifications include country-industry, country-year, and industry-year fixed effects to capture potential omitted variables such as country-specific and industry-specific shocks. Finally, the *positive* correlation between zombie credit growth and sales growth rules out that the negative correlation between zombie credit growth and inflation is driven by lower demand in markets with more zombie credit.

We run two additional tests to gather further evidence for the zombie credit channel. First, we show that markets that experience a larger rise of zombie firms subsequently have lower average investment and productivity, as well as, higher input costs (i.e., material and labor costs) than markets with less zombie credit. The negative correlation with investment and productivity confirms that zombie credit is extended to actual zombie firms and not to firms that are only temporarily weak. The positive correlation with input costs confirms the zombie credit induced excess capacity mechanism since more firms compete for the same factor inputs driving up their price. Second, we show that the negative correlations between zombie credit and inflation and between zombie credit and markups primarily occur in non-tradable industries, where local credit conditions are likely particularly important.

Finally, we document, at the firm level, that the increased presence of zombie firms affected healthy firms active in the same market. In particular, we find that healthy firms competing with a growing number of zombie firms have lower markups, investment, and sales growth, as well as, higher input costs compared to healthy firms competing with fewer zombie firms. These correlations are consistent with healthy firms trying to prevent a drop in market share and capacity utilization by pricing more aggressively.

The remainder of the paper is structured as follows. Section 2 reviews the related literature. Section 3 presents an intuitive model linking zombie credit to inflation. Section 4 illustrates our data and empirical work. Section 5 and Section 6 shows our empirical analysis at the industry-country level and at the firm level, respectively. Section 7 concludes.

2 Related Literature

Our paper contributes to three strands of literature. First, our paper relates to the literature on zombie credit, started with the evidence from Japan in the 1990s. In that context, Peek and 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 stop zombie lending behavior if they are large enough. A few recent papers show that similar dynamics are at work in Europe during the 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. (2017) confirm that non-viable Italian firms obtained favorable bank credit from 2004 to 2013. Finally, using Portuguese data, Blattner et al. (2019) show that these distorted lending decisions caused a decline in productivity. 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. We contribute to this literature by documenting the effect of zombie credit on firm markups and inflation.

Second, our paper relates to the literature that studies the effect of competition on firm price setting behavior and inflation. Campbell and Hopenhayn (2005), Lewis and Poilly

(2012), and Lewis and Stevens (2015) provide evidence 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 the more so the higher the 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 literature that draws attention to 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 after the 2007-08 financial crisis, respectively. Barth III and Ramey (2001) suggest the "cost channel" as a possible explanation for an increase (decrease) in inflation after a monetary tightening (loosening). The cost channel states that firms depend on credit to finance production, which implies that their pricing decisions are directly related to credit conditions. Christiano et al. (2015) introduce this cost channel into a New Keynesian model and show that it helps to explain the only modest disinflation in the U.S. during the Great Recession.

3 Model

In this section, 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 the associated quantities and prices. The model adds imperfect competition among firms to a framework similar to Caballero et al. (2008).

3.1 Setup

Time is discrete and the economy is populated by a continuum of firms that produce a single good. There is an exogenous demand $D_t(p_t) = \alpha_t - p_t$ for this good. Firms are identical in size and can be incumbent or potential entrants. The mass of incumbent firms is m_t and the mass of potential entrant firms is e.

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. Third, firms learn the realization of their production y_{it} leading to profits $(p_t - c)y_{it} - I$, where c is the marginal cost. Depending on the realization of their production, potential entrant firms might enter the market and incumbent firms might default.

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

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

Firms set prices knowing that their expected production is 1/2. In the unique Nash 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.[4] Even if competition is in prices, firms end up charging a positive markup $(p_t - c)/p_t$ because of their production constraint.

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

[4] If $\alpha_t \geq \frac{1}{2}(m_t + 1)$, the expected production is small relative to market demand and the marginal revenue is greater than the marginal cost.

and the mass of surviving incumbent firms S_t are:

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

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:

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

3.2 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, mass of incumbents m_t, total production N_t such that the product price is given by (1), total production equals the sum of production by surviving incumbent and entrant firms according to (2), and the number of incumbent firms follow $m_{t+1} = N_t$.*

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

$$N_t = e\left(1 - \frac{I}{p_t - c}\right) + \overline{S} \tag{3}$$

Following Caballero et al. (2008), the idea is that favourable funding conditions might keep some firms that should default alive. 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, mass of incumbents m_t, total production N_t such that the product price is given by (1), total production equals the sum of production by surviving incumbent and entrant firms according to (3), defaults are such that surviving firms are $\overline{S}$, and the number of incumbent firms 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.

3.3 Macroeconomic Effects of Zombie Credit

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.[5] More specifically, we consider the case where the 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 2 shows this comparison, where the

[5]In Appendix A, 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.

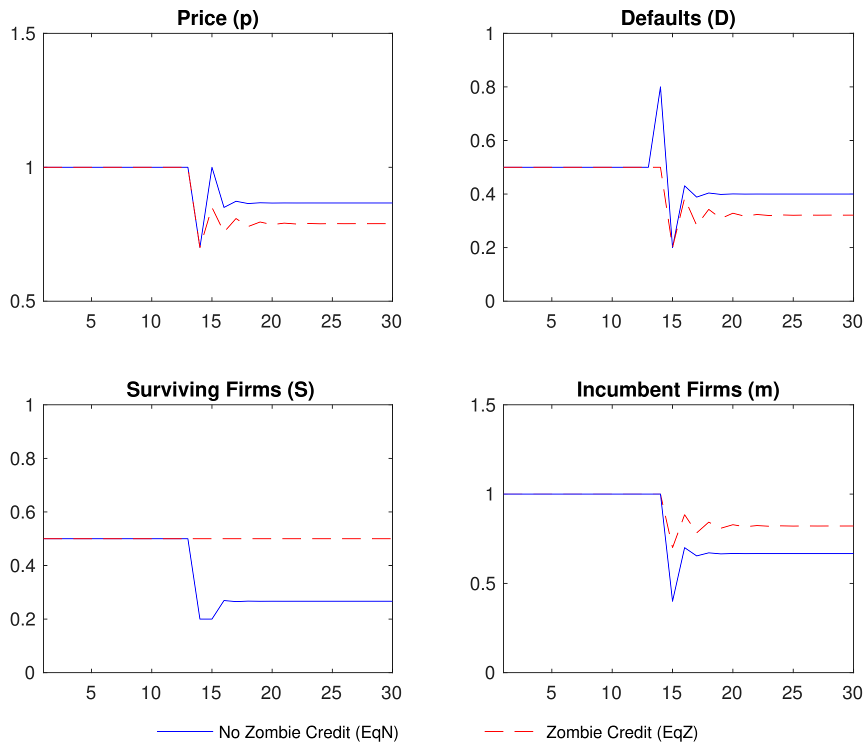

Figure 2: Negative Demand Shock. This figure shows how equilibrium quantities and prices respond to a permanent decrease in α in EqN (solid lines) and in EqZ (dashed lines).

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 causes a contemporaneous decrease in entry and increase in defaults. One period after the shock, the lower number of active firms cause the price to rebound (higher productive capacity) inducing more firms to enter the market and fewer incumbent firms to default. Two periods after the shock, the now higher number of incumbent firms causes a reduction in price and, in turn, an increase in defaults and a decrease in entry. 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 causes a contemporaneous decrease in entry but defaults are held constant so as to keep the number of surviving firms also constant. This lack of adjustment through defaults causes, one period after the shock, the number of incumbent firms to go down less than in EqN. The price rebounds causing entry to also increase but these adjustments are muted compared with EqN. The fewer incumbent firms causes defaults to go down in order to keep the number of survivors constant. Two periods after the shock, the number of incumbent firms is lower than in the previous period but higher than in EqN. This adjustment continues until the economy reaches the new steady state. Compared with the EqN steady state, the price, entry, and defaults are lower and 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 with no zombie credit.*

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.[6] Differentiating with respect to α yields:

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

The demand affects the price in three ways. First, the direct effect: a lower demand reduces the price in equilibrium. Second, a lower demand causes fewer firms to enter causing, in turn, a reduction in price. Third, a lower demand causes more firms to default causing, in turn, a reduction in price. This third effect disappears in EqZ, where the number of surviving firms is not affected by the demand for the good.

[6]The reader is referred to Appendix A for the formal solution of the model.

4 Data and Empirical Work

In this section, we describe our data set and our measures of zombie credit and firm markups.

4.1 Data and Empirical Measures

Our data set combines detailed firm level information and granular inflation data. The firm level data are financial information and firm characteristics from Bureau van Dijk's (BvD) Amadeus database. This database contains information about 21 million public and private companies from 34 countries, including all EU countries. 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. (2015) show for selected European countries that Amadeus covers roughly 75-80% of the economic activity reported in Eurostat.

The inflation data is from Eurostat, which provides data for various consumer and producer price indices for all European countries. This data is very granular: consumer price data are at the product level (COICOP five-digit) and producer price data are at the industry level (NACE four-digit).

A key step is to merge the firm data (at the NACE level) and the inflation data (at the COICOP level). To perform this match, we obtained COICOP-NACE linking tables from several national statistical institutions of European countries. More precisely, we use the linking tables to calculate inflation (consumer price index) at the industry level, by calculating a weighted average of all COICOP (consumer price categories) that are related to a NACE (two digits) industry. Consider as an 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. We exclude utilities and financial and insurance industries from the sample. This provides us with a measure of the consumer price index at the industry-country level for each month in our sample period.

Our final sample consists of 1,167,460 firms for 11 European countries and 65 different industries.

4.2 Empirical Measures: Zombie Credit and Markups

Following Caballero et al. (2008) and Acharya et al. (2019), we define zombie credit as credit that is extended to distressed firms at very low interest rates. Consistent with our model, the intuition is that these "zombie" firms would be more likely to default if they did not receive such credit.

In particular, we classify a firm as zombie firm if it meets the following two criteria. First, the firm is of low-quality, namely its interest coverage ratio is below the median and its leverage ratio is above the median.[7] Second, the firm obtains credit at advantageous low interest rates. That is, the share 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 the most creditworthy firms, namely AAA-rated European firms.[8]

As shown in Figure 1, the average share of zombie firms in our sample countries increased from roughly 4.5% to 6.7% during our sample period.[9] This rise of the zombies is mainly driven by more low-quality firms getting cheap credit at very low interest rates, and not by firms that already enjoy access to cheap credit getting worse in quality. In particular, as shown by Figure C.1, while the share of low-quality firms stayed constant at roughly 27% during our sample period, the share of zombie firms relative to low-quality firms increased from 19% to almost 24% between 2012 and 2015.[10]

In Table 1, we present descriptive statistics for our sample firms separately for high-quality firms, low-quality firms that do not receive zombie credit, and low-quality firms that receive zombie credit. Low-quality zombie firms are weaker than low-quality non-zombie firms along several dimensions: zombie firms have a lower (and negative) interest coverage

[7] We calculate the firms' interest coverage ratio as EBIT/interest expense and measure their leverage ratio as (loans + short term credit + long term debt)/total assets. We calculate the median values at the industry-country-year level.

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

[9] Figure C.2 shows that alternative zombie definitions yield a similar time-series pattern in the share of zombie firms.

[10] Moreover, Figure C.3 shows that bank loans and bonds play an increasingly important role in the debt funding mix of zombie firms.

	High-Quality	Low-Quality No Zombie	Low-Quality Zombie
Markup	1.13	1.05	1.01
EBITDA Margin	0.090	0.046	0.014
Material Cost	0.424	0.476	0.552
Total Assets	1,617	1,726	1,607
Tangibility	0.327	0.312	0.190
Int. Cov.	4.90	1.01	-0.53
Net Worth	0.224	0.107	0.069
Leverage	0.161	0.351	0.437
Interest Rate	0.028	0.039	0.009

Table 1: Firm Quality and Credit. This table presents descriptive statistics for our sample firms. We split firms into high-quality, low-quality non-zombie, and low-quality zombie. A firm is classified as low-quality if it has a below median interest coverage ratio (EBIT/interest expense) and an above median leverage (interest bearing debt/total assets). Median values calculated at industry-country-year level. A firm is classified as zombie if it is low-quality and has interest expenses/debt smaller than that of AAA-rated European firms in a given year.

ratio, lower EBITDA margin (EBITDA/sales), lower net worth, less tangible assets to pledge for new loans, and a higher leverage. Nevertheless, these firms pay extremely low interest rates, even compared to high-quality firms. Given their low profitability, these firms likely would have had a much higher default probability if they would have had to pay a higher (more normalized) interest rate on their debt.

Following De Loecker and Warzynski (2012) and De Loecker and Eeckhout (2019), we rely on optimal input demand conditions obtained from standard cost minimization to determine markups for each firm.[11] 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 and Eeckhout (2019), we aggregate the firm markups in the respective market using the firms' turnover as weight.

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

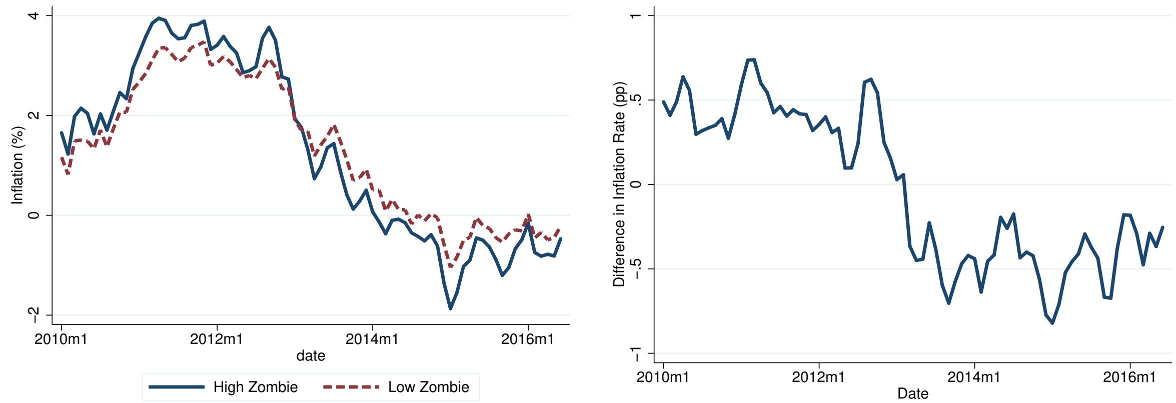

Figure 3: Inflation. The left figure shows inflation (yoy CPI growth) at monthly frequency for markets that saw an above median increase in the asset-weighted share of zombie firms between 2009 and 2014 (High Zombie Growth) and firms with a below median growth in the share of zombie firms (Low Zombie Growth). The right figure shows the difference between the CPI growth of High vs Low Zombie Growth industries. A firm is classified as zombie if it is low-quality and paid advantageous interest rates (see Section 4.2 for more details).

5 Empirical Evidence: Industry-Country Level

We start our empirical analysis of the zombie credit channel with testing our four model predictions at the the industry-country level. In a second step, we consider and discuss alternative supply-side channels that could also have affected the European inflation dynamics.

5.1 Model Predictions

In a first step, we provide non-parametric evidence on the correlation between the share of zombie firms in a specific market and the inflation level in this market, which is our main variable of interest. Figure 3 shows the CPI growth separately for markets that experienced a high (above median) and low (below median) growth in the share of zombie firms over our sample period. Markets with a high zombie increase had initially a higher CPI growth, but, starting in mid-2012, they experienced a decline in CPI growth compared to markets with a lower zombie increase. The timing of this reversal of the inflation dynamics thus coincides with the time when the ECB reduced the deposit facility rate to zero and launched massive unconventional monetary policy programs.

Next, we test parametrically the five model predictions by running the following regression for industry h in country j in year t:

$$Y_{hjt} = \beta \times \Delta ShareZombies_{hjt,t-1} + \gamma_{ht} + \nu_{jt} + \mu_{jh} + \epsilon_{hjt}, \quad (4)$$

where Y_{hjt} is either inflation, change in markups, sales growth, the change in the number of active firms, or firm default rate at the industry-country-year level. Our key explanatory variable is the lagged change in the asset-weighted share of zombie firms in a particular market: $\Delta ShareZombies_{hjt}$. In our preferred specification, we control for country-industry, country-year and industry-year fixed effects. Country-year fixed effects absorb all shocks at the national level (e.g., changes in tax rates and national regulations) that could affect firms' policies and performance. Industry-year fixed effects absorb all shocks at the industry level (e.g., global demand shocks). Finally, country-industry fixed effects control for any time-invariant industry-country characteristics. In our most conservative specification, we also add lagged sales growth at the industry-country level to capture changes in the industry's performance in a particular country.

The estimation results in Panel A of Table 2 confirm the non-parametric evidence from Figure 3: markets that experience a larger increase in the share of zombie firms subsequently have a lower growth in CPI. This result is robust to controlling for different layers of fixed effects. Based on the estimates in Column (4), a 10 percentage points (pp) increase in the share of zombie firms in a given market is associated with a 0.3pp lower inflation rate. This effect corresponds to 13% of the standard deviation of CPI growth.

In Panel B, the dependent variable is the change in the markup in a particular market. In line with our model prediction, the estimated coefficients document a stronger decrease in markups in markets that experienced a larger zombie increase. Based on the estimates in Column (4), a 10pp increase in the share of zombie firms in a given market is associated with a 0.6pp reduction in the change of markups, which corresponds to 12% of the standard deviation.[12]

[12] In Panel A of Table C.1, we show that these results are robust to replacing the markup with the EBITDA margin (EBITDA/Sales), where a 10pp increase in the zombie share in a given market is associated with a

Panel A	ΔCPI	ΔCPI	ΔCPI	ΔCPI	ΔCPI
Δ Share Zombie	-0.027***	-0.028***	-0.028***	-0.029***	-0.029***
	(0.009)	(0.008)	(0.009)	(0.008)	(0.008)
Industry Sales Growth					0.001
					(0.002)
Country-Industry FE	✓	✓	✓	✓	✓
Year FE	✓				
Industry-Year FE		✓		✓	✓
Country-Year FE			✓	✓	✓
Observations	3,210	3,210	3,210	3,210	3,210
R-squared	0.492	0.730	0.511	0.748	0.748

Panel B	ΔMarkup	ΔMarkup	ΔMarkup	ΔMarkup	ΔMarkup
Δ Share Zombie	-0.058***	-0.072***	-0.044**	-0.060***	-0.061***
	(0.019)	(0.021)	(0.020)	(0.023)	(0.023)
Industry Sales Growth					-0.005
					(0.005)
Country-Industry FE	✓	✓	✓	✓	✓
Year FE	✓				
Industry-Year FE		✓		✓	✓
Country-Year FE			✓	✓	✓
Observations	2,715	2,715	2,715	2,715	2,715
R-squared	0.193	0.346	0.217	0.369	0.370

Panel C	ΔSales	ΔSales	ΔSales	ΔSales
Δ Share Zombie	0.278***	0.332***	0.321***	0.394***
	(0.095)	(0.107)	(0.086)	(0.098)
Country-Industry FE	✓	✓	✓	✓
Year FE	✓			
Industry-Year FE		✓		✓
Country-Year FE			✓	✓
Observations	3,215	3,215	3,215	3,215
R-squared	0.142	0.218	0.343	0.411

Table 2: Inflation, Markups, and Sales: Industry-Country Evidence. This table presents industry-country-year level regressions. The dependent variable is the annual CPI growth rate (inflation) from t to $t+1$ in Panel A, the turnover-weighted change in markups from t to $t+1$ in Panel B, and sales growth from t to $t+1$ in Panel C. Δ*Share Zombie* measures the increase in the asset-weighted share of zombie firms in a particular market from $t-1$ to t. *Industry Sales Growth* is the growth in aggregate sales at the industry-country level from $t-1$ to t. 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 clustered at the industry-country level. *** p<0.01, ** p<0.05, * p<0.1.

In Panel C, the dependent variable is sales growth. Again, consistent with our model, we find that markets with a high zombie share growth experienced higher sales growth rates. Note that this positive correlation between the zombie share growth and sales growth suggests that the correlation between the zombie prevalence and inflation is not driven by lower demand at the industry-country level.

In Table 3, we isolate the correlation between changes in the zombie prevalence in a specific market and the number of active firms and firm defaults, respectively. To measure the number of active firms and defaults we rely on publicly available data from Eurostat. Eurorstat reports data on active firms and firm defaults at industry-country-level over time. This ensures that we can accurately measure these two variables and that we do not miss active or defaulted firms in Amadeus due to a potential lack of reported data. Again, we estimate Eq. (4), where now the dependent variable is the change in the number of active firms (Panel A) and the share of firm defaults (Panel B). The estimated coefficients confirm that the change in the zombie prevalence in a particular market is positively correlated with the growth in the number of active firms and negatively correlated with subsequent firm default rates. In Table C.3, we show that we obtain similar results on firm defaults if we rely on the Amadeus database to classify firms as defaulted.

In sum, in line with our model predictions, we find that markets that experience a larger increase in the share of zombie firms subsequently have lower exit rates, a larger growth in the number of active firms, higher sales growth rates, lower markups, and lower CPI growth. Note that the observed negative correlation between the zombie share in a particular market and the inflation level in that market might have been reinforced by the cost channel (see, e.g., Barth III and Ramey, 2001). Specifically, the glut of cheap debt decreased the financial expenses of zombie firms, which gave them more wiggle room to cut output prices. However, the cost channel can neither explain the negative correlation between the zombie share and firm default rates, as well as, average markups, nor the positive correlation with sales growth.

1pp reduction in the EBITDA margin. In Panel B of Table C.1, we show that the results are qualitatively similar if we use the level of markups, rather than the change. Finally Table C.2 provides a robustness test where me measure the change in our independent variable over different time periods.

Panel A	Δ#Active Firms	Δ#Active Firms	Δ#Active Firms	Δ#Active Firms	Δ#Active Firms
Δ Share Zombie	0.022**	0.023*	0.024**	0.026**	0.029***
	(0.011)	(0.012)	(0.010)	(0.010)	(0.011)
Industry Sales Growth					-0.007*
					(0.004)
Observations	3,362	3,362	3,362	3,362	3,181
R-squared	0.479	0.534	0.630	0.681	0.688

Panel B	Default	Default	Default	Default	Default
Δ Share Zombie	-0.013**	-0.013**	-0.014***	-0.014***	-0.015***
	(0.005)	(0.006)	(0.004)	(0.004)	(0.005)
Industry Sales Growth					0.001
					(0.002)
Observations	3,283	3,283	3,283	3,283	3,071
R-squared	0.813	0.829	0.881	0.895	0.894
Country-Industry FE	✓	✓	✓	✓	✓
Year FE	✓				
Industry-Year FE		✓		✓	✓
Country-Year FE			✓	✓	✓

Table 3: Number of Active Firms and Firm Defaults: Industry-Country Evidence. This table presents industry-country-year level regressions. The dependent variable is the change in the number of firms (Panel A) and the share of firm defaults (Panel B). Δ*Share Zombie* measures the increase in the asset-weighted share of zombie firms in a particular market from $t-1$ to t. *Industry Sales Growth* is the growth in aggregate sales at the industry-country level from $t-1$ to t. 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 clustered at the industry-country level. *** p<0.01, ** p<0.05, * p<0.1

Hence, while it might have contributed to the disinflationary trend it was likely not the sole driver for the observed low inflation level in zombie markets.

5.2 Further Results

In this section, we conduct three additional tests at the industry-country level to further analyze the effects of the zombie credit channel and to address potential concerns.

5.2.1 Investment

A possible concern is that the observed aggregate sales growth increase in markets with a strong zombie share increase originates from a positive industry outlook, instead of an increase in the number of active firms (as suggested by the zombie credit channel). To address this concern, we investigate the evolution of investment, which we measure as capital expenditure (Capex)/fixed assets. Specifically, if the zombie channel is the main driver for the increase in aggregate sales growth, we expect to see a drop in investment in markets with a strong rise of zombie credit, while an increase in investment activity would suggest a positive industry outlook as the key driver.

The results in Panel A of Table 4 confirm that markets with a higher zombie prevalence increase experienced a lower investment level in the following year, which is consistent with the prediction of the zombie credit channel. In particular, a 10pp increase in the share of zombie firms in a given market is associated with a 1.3pp investment reduction.

One possible explanation for this investment drop in zombie markets is the liquidity squeeze channel (see Chevalier and Scharfstein, 1996 and Gilchrist et al., 2017), which suggests that (liquidity-constrained) zombie firms lower investments to boost internal cashflows.

5.2.2 Input Costs and Productivity

Next, we check the evolution of the firms' productivity and cost structure. If the results presented in Section 5.1 are indeed due to an increasing number of non-profitable firms that are kept artificially alive by cheap credit, we expect to see in the respective markets (i) a competition-induced positive shock also on the firms' factor input costs, and, (ii) a reduction in the average industry productivity. In particular, regarding hypothesis (i), the higher number of firms in zombie relative to non-zombie industries should shift more negotiation power towards the suppliers (of both labor and material) of this industry as more firms compete for a limited amount of resources.

Panels B and C of Table 4 investigate the evolution of firms' input costs, that is, material and labor cost, respectively. In line with the prediction of the zombie credit channel, an increase in the share of zombie firms in a specific market leads to higher average material costs in that market (see Panel B). The results on labor cost in Panel C also support the zombie credit channel. In particular, the interaction Δ*Share Zombie* $\times$ *High Vacancy* is significantly positive, where the latter is a dummy equal to one for industries with an above median job vacancy rate.[13] However, this positive correlation between the zombie share and average labor costs only exists for markets with a high job vacancy rate and not for markets without a labor supply shortage, as shown by the insignificant coefficient for Δ*Share Zombie*. This evidence suggests that the higher average labor cost for (some) zombie markets is indeed induced by a zombie-induced excess capacity and resulting fiercer competition due to a higher number of active firms.

Table 4, Panel D presents the results for the productivity test, where we measure productivity as *log(sales)–2/3*log(employment)–1/3*log(fixed assets)*. Consistent with the zombie credit channel, the regression shows that markets with an increase in the zombie prevalence experience a reduction in their firms' average productivity.

The evidence presented in Panels B-D of Table Table 4 suggests that the effect of the zombie credit channel on inflation presented in Panel A of Table 2 constitutes a lower bound. In particular, since markets that experienced a zombie firm increase have lower average productivity and higher average input costs, their production cost level is pushed upwards. Hence, without a change in markups, this costs push would increase prices. The observed inflation

[13] To measure the firms' labor costs, we use the annual change in the Eurostat's Labour Cost Index, which is designed to capture the labor cost pressure. For the job vacancy rate, we rely on Eurostat's job vacancy statistics, which calculates the rate as the number of job vacancies as a percentage of the sum of the number of occupied posts and job vacancies.

reduction for zombie industries thus implies that the excess production capacity induced the firms in these markets to lower markups to such an extent that it overcompensated the production costs increase.

5.2.3 Tradeability

A unique feature of the zombie credit channel is that it is competition related, that is, it predicts that the excess capacity created by the higher number of firms (due to low exit rate) and, in turn, the fiercer competition has a disinflationary effect. Hence, if the zombie credit channel is indeed an important driver for the depressed inflation levels, we expect that the effects are stronger in non-tradable than tradable industries. For tradable industries, markets are across country lines (or even global) and are thus not so much affected by local conditions in a specific market. In contrast, local conditions should matter significantly more for non-tradable industries where sold goods need to be produced locally.

To test this prediction, we split industries into tradable and non-tradable sectors and redo our analysis. To classify industries, we rely on the UN Comtrade database, which reports imports and exports for each country at the four digit NACE level. Any industry included in the UN Comtrade database is classified as tradable.

Table 5 presents the results of this sample split. Panel A shows that the negative effect of the rise in the zombie share on inflation primarily occurs in non-tradable industries. A 10pp increase in the zombie share implies a 0.37pp lower inflation level in these industries, corresponding to 15% of the standard deviation of CPI growth. Panel B confirms that the markup reduction is also primarily occurring in non-tradable industries, where a 10pp increase in the zombie share leads to 0.83pp larger decrease in markups, corresponding to 16.6% of the standard deviation.

This evidence reinforces the notion that the zombie credit channel was responsible for the markup and, in turn, inflation reduction in markets that experienced a strong increase in the prevalence of zombie firms.

Panel A	CapEx	CapEx	CapEx	CapEx	CapEx
Δ Share Zombie	-0.144***	-0.143***	-0.130***	-0.128**	-0.130**
	(0.048)	(0.051)	(0.050)	(0.052)	(0.052)
Industry Sales Growth					-0.011
					(0.017)
Observations	2,658	2,658	2,658	2,658	2,658
R-squared	0.377	0.467	0.398	0.488	0.489

Panel B	Material Cost	Material Cost	Material Cost	Material Cost	Material Cost
Δ Share Zombie	0.065***	0.070***	0.066***	0.072***	0.075***
	(0.023)	(0.024)	(0.023)	(0.024)	(0.024)
Industry Sales Growth					0.013*
					(0.008)
Observations	3,084	3,084	3,084	3,084	3,084
R-squared	0.936	0.936	0.938	0.938	0.938

Panel C	Labor Cost	Labor Cost	Labor Cost	Labor Cost	Labor Cost
Δ Share Zombie	-0.027	-0.030	-0.025	-0.031	-0.024
	(0.031)	(0.030)	(0.027)	(0.025)	(0.026)
High Vacancy	-0.002	0.001	-0.005	-0.002	-0.003
	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)
Δ Share Zombie × High Vacancy	0.078*	0.079**	0.106***	0.110***	0.100***
	(0.041)	(0.037)	(0.036)	(0.032)	(0.032)
Industry Sales Growth					0.005
					(0.005)
Observations	861	876	876	861	786
R-squared	0.228	0.317	0.406	0.491	0.514

Panel D	Productivity	Productivity	Productivity	Productivity	Productivity
Δ Share Zombie	-0.191**	-0.195*	-0.205**	-0.211*	-0.208*
	(0.089)	(0.109)	(0.093)	(0.114)	(0.123)
Industry Sales Growth					0.101**
					(0.044)
Observations	3,161	3,161	3,161	3,161	3,161
R-squared	0.869	0.887	0.873	0.891	0.892
Country-Industry FE	✓	✓	✓	✓	✓
Year FE	✓				
Industry-Year FE		✓		✓	✓
Country-Year FE			✓	✓	✓

Table 4: Investment, Input Costs, and Productivity: Industry-Country Evidence. This table presents industry-country-year level regressions. The dependent variables are asset-weighted investment (capex/fixed assets measured in $t+1$, Panel A), the industry material cost (material input cost/turnover, Panel B), the industry labor cost (Eurostat's labor cost index, Panel C), and asset-weighted productivity (*log(sales)–2/3*log(employment)–1/3*log(fixed assets)*, Panel D). Δ*Share Zombie* measures the increase in the asset-weighted share of zombie firms in a particular market from $t-1$ to t. *Industry Sales Growth* measures the growth in aggregate sales at the industry-country level from $t-1$ to t. 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 clustered at the industry-country level. *** p<0.01, ** p<0.05, * p<0.1

	Tradable	Non-Tradable
Panel A	ΔCPI	ΔCPI
Δ Share Zombie	-0.007	-0.037***
	(0.007)	(0.010)
Observations	1,434	1,776
R-squared	0.860	0.705
Panel B	ΔMarkup	ΔMarkup
Δ Share Zombie	-0.027	-0.083***
	(0.036)	(0.029)
Observations	1,249	1,466
R-squared	0.361	0.408
Industry-Year FE	✓	✓
Country-Year FE	✓	✓
Country-Industry FE	✓	✓

Table 5: Tradable vs Non-Tradable Industries: Industry-Country Evidence. This table presents industry-country-year level regressions, separately for tradable and non-tradable industries. The dependent variable is the annual CPI growth rate (inflation) from period t to $t+1$ (Panel A) and the turnover-weighted change in markups from t to $t+1$ (Panel B). Δ*Share Zombie* measures the increase in the asset-weighted share of zombie firms in a particular market from $t-1$ to t. 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 clustered at the industry-country level. *** p<0.01, ** p<0.05, * p<0.1

6 Firm-Level Analysis

In this section, we take advantage of our detailed firm-level data. In particular, we exploit the fact that the zombie credit channel predicts spillover effects on non-zombie firms active in markets with an increase in the zombie prevalence.

According to the zombie credit channel, a rise of zombie credit leads to a higher number of competing firms and excess production capacity in the respective market. This market congestion leads to a sales decrease for individual non-zombie firms as more firms have to share a given demand level.[14] In turn, the affected non-zombie firms try to limit their drop in market share and capacity utilization by pricing more aggressively. At the same time, these firms face higher input prices due to a decreased bargaining power vis-a-vis their suppliers as more firms compete for a limited amount of resources.

In sum, the zombie credit channel thus predicts for individual non-zombie firms in zombie industries: lower sales growth, lower markups, and higher input costs (i.e., material and labor costs) compared to individual non-zombie firms in non-zombie industries.

Following Caballero et al., 2008, we run the following regression at the firm-year level to test for these spillovers on non-zombie firms:

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

where our dependent variables are markup, sales growth, material cost, labor cost, and investment. We include industry-country-year fixed effects to absorb any country-industry specific shocks. Our key 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.

[14] Recall that, at the industry-country level, the zombie credit channel predicts a slight increase in aggregate sales for zombie industries due to the downward adjusted output prices and the resulting slightly higher aggregate demand. Table 2, Panel C confirms this prediction.

	Markup	Sales Growth	Material Cost	Labor Cost	CapEx
Non-Zombie	0.060***	0.061***	-0.022***	0.020***	0.014***
	(0.006)	(0.007)	(0.002)	(0.005)	(0.002)
Non-Zombie	-0.226***	-0.176***	0.064***	0.108***	-0.049**
× Industry Share Zombies	(0.043)	(0.034)	(0.019)	(0.036)	(0.020)
Observations	3,768,543	5,290,486	4,252,590	3,756,312	3,306,336
R-squared	0.584	0.032	0.521	0.484	0.065
Industry-Country-Year FE	✓	✓	✓	✓	✓
Firm-Level Controls	✓	✓	✓	✓	✓

Table 6: Markup, Sales Growth, Input Costs, Investment: Firm-Level Evidence. This table presents firm-year level regressions. The dependent variables are a firm's markup, sales growth, material cost (material input cost/turnover), labor costs (wage bill/# employees), or investment (capex/fixed assets). *Non-Zombie* is an indicator variable equal to one if a firm is classified as non-zombie in year t. *Industry Share Zombies* measures the asset weighted share of zombie 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 zombie if it is low-quality and paid advantageous interest rates (see Section 4.2 for more details). Standard errors clustered at the industry-country level. *** p<0.01, ** p<0.05, * p<0.1.

The first column of Table 6 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. Moreover, we indeed see a drop in sales growth for individual non-zombie firms active in a market with a large zombie share increase (see Column 2 of Table 6).

The results in Columns (3) and (4) of Table 6 confirm that non-zombie firms that have to compete against a higher number of zombie firms (relative to non-zombie firms in non-zombie industries) indeed pay higher input costs. Finally, the results in Column (5) of Table 6 show that non-zombie firms that are active in a market with a high zombie prevalence invested less, which reinforces the notion that these markets suffer from an excess production capacity and thus a lack of profitable investment opportunities.

7 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 effect theory and lowered interest rates, as well as, implemented massive quantitative easing programs to encourage more investment and consumption, hoping that this leads 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 have a disinflationary side effect, thereby providing an explanation for the persistent low inflation rates in Europe. As argued by Borio and Hofmann (2017), Borio (2018), and Banerjee and Hofmann (2018) 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 then puts downwards 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 11 European countries across 65 industries. We show that industries that experienced a stronger rise of zombie firms subsequently experienced fewer firm defaults, lower average firm markups, product prices, investment, and productivity, an increase in aggregate sales, as well as, material and labor costs, and a lower inflation level.

Our results suggest that a more expansive fiscal policy could be an effective tool to raise inflation, since the resulting positive demand shock would absorb at least part of the zombie-induced excess capacity. At the same time, significantly expanding fiscal spending allows to normalize interest rates, since a fiscal expansion would attenuate the negative economic effects resulting from an interest rate raise and a subsequent increase in default rates of unproductive firms.

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Appendix A Model Appendix

A.1 Derivations and Proofs

Lemma 1. 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. $\square$

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

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

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. $\square$

A.2 A Temporary Demand Shock

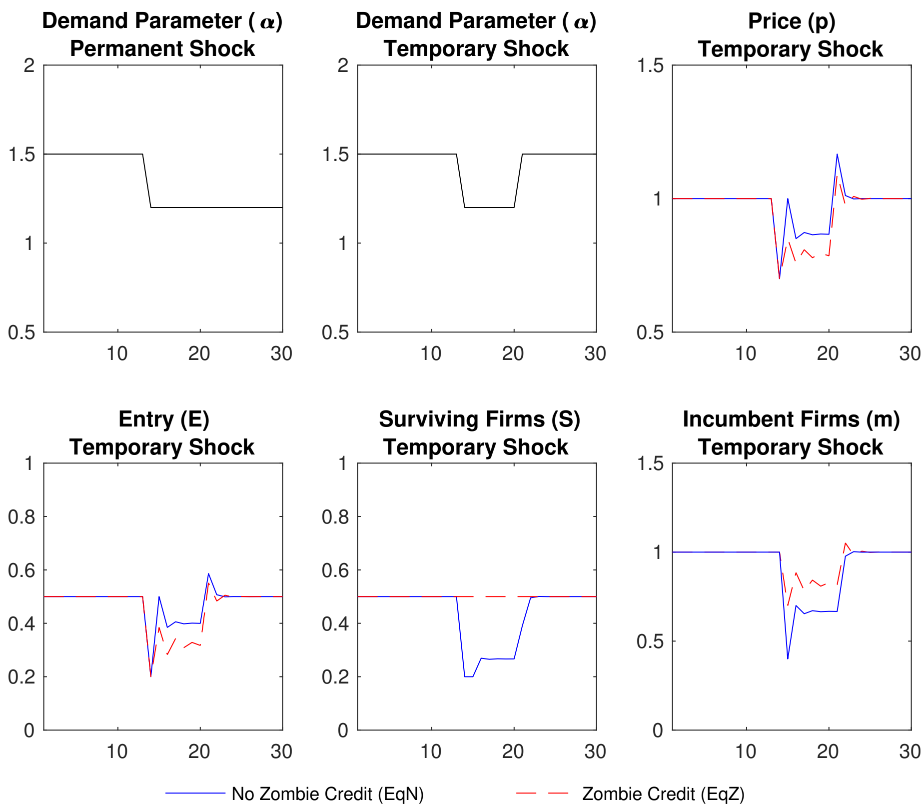

Figure A.1: Temporary Negative Demand Shock. This figure shows how equilibrium quantities and prices respond to a temporary decrease in α in EqN (solid lines) and in EqZ (dashed lines).

Appendix B Markup Estimation

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

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

To correct the markup estimates for unobserved productivity shocks, De Loecker and Warzynski (2012) follow the control function or proxy approach, developed by Ackerberg et al. (2006), 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:

$$Q_{it} = Q_{it}(\Omega_{it}, V_{it}, K_{it}), \tag{A1}$$

where Q_{it} is the output quantity produced by technology $Qit(\cdot)$, 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 and Eeckhout (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 are thus are left with the following

Lagrangian function:

$$\mathcal{L}(V_{it}, K_{it}, \lambda_{it}) = P_{it}^{V} + V_{it} + r_{it}K_{it} + F_{it} - \lambda_{it}(Q(\cdot) - \overline{Q}_{it}), \tag{A2}$$

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:

$$\frac{\partial \mathcal{L}_{it}}{\partial V_{it}} = P_{it}^{V} - \lambda_{it}\frac{\partial Q(\cdot)}{\partial V_{it}} = 0. \tag{A3}$$

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

$$\theta_{it}^{v} \equiv \frac{\partial Q(\cdot)}{\partial V_{it}}\frac{V_{it}}{Q_{it}} = \frac{1}{\lambda_{it}}\frac{P_{it}^{V}V_{it}}{Q_{it}}. \tag{A4}$$

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:

$$\mu_{it} = \theta_{it}^{v}\frac{P_{it}Q_{it}}{P_{it}^{V}V_{it}}. \tag{A5}$$

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):[15]

$$q_{it} = \beta_{v1} v_{it} + \beta_{k1} k_{it} + \beta_{v2} v_{it}^2 + \beta_{k2} k_{it}^2 + \omega_{it} + \epsilon_{it}. \tag{A6}$$

where lower cases denote logs.[16] 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. (A6), 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:

$$q_{it} = \phi_{it}(v_{it}, k_{it}) + \epsilon_{it}. \tag{A7}$$

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

$$\omega_{it} = g_t(\omega_{it-1}) + \varepsilon_{it}. \tag{A8}$$

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

[15] 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).

[16] We follow De Loecker and Eeckhout (2019) and 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.

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:

$$E\left(\varepsilon_{it}(\beta)\begin{pmatrix} v_{it-1} \\ k_{it} \\ v_{it-1}^2 \\ k_{it}^2 \end{pmatrix}\right) = 0, \tag{A9}$$

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

$$\theta_{it}^{v} = \widehat{\beta}_{v1} + 2\widehat{\beta}_{v2}v_{it}, \tag{A10}$$

which allows us to calculate the markup of firm i.

Appendix C Additional Figures

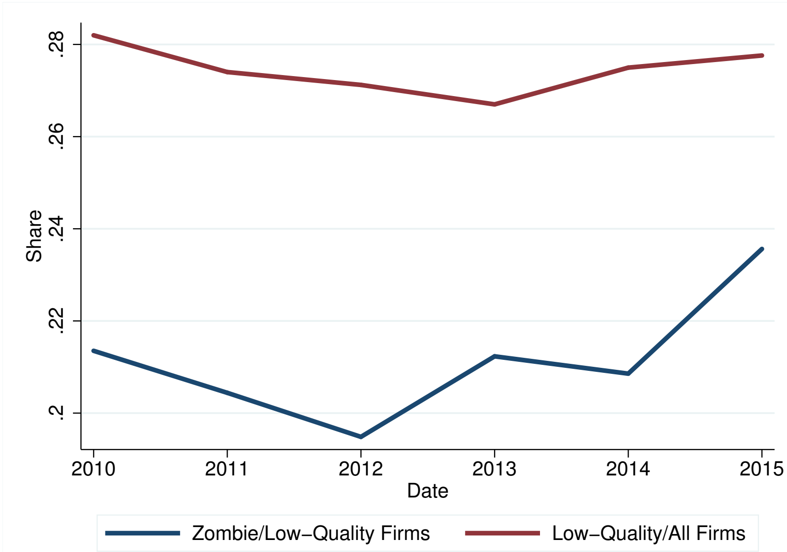

Figure C.1: Share of Low-Quality and Zombie Firms. This figure shows the share of zombie firms relative to all low-quality firms (blue line) and the share of low-quality firms relative to all firms (red line). A firm is classified as zombie if it is low-quality (i.e., above median leverage and below median interest coverage ratio) and receives subsidized credit (interest expenses/debt smaller than that of the highest quality firms in a given year).

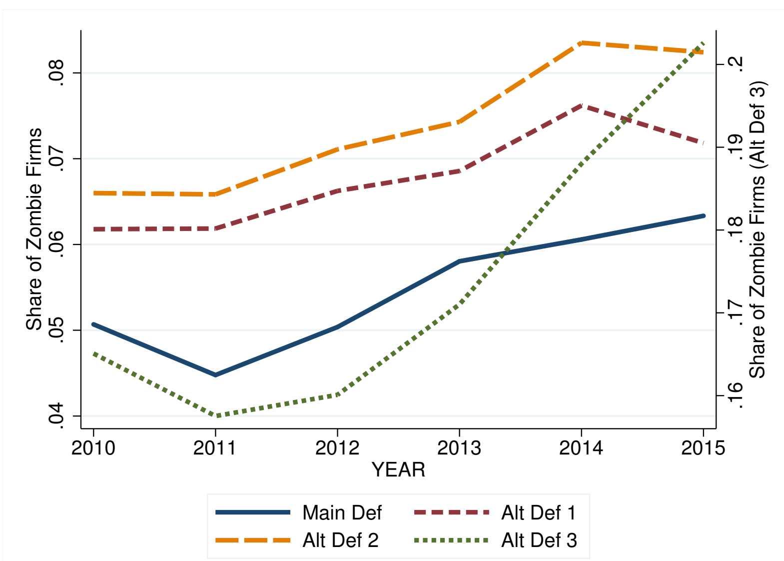

Figure C.2: Alternative Zombie Definitions. This figure shows the evolution of the share of zombie firms for alternative zombie definitions. The blue solid line replicates our main measure of the share of zombie firms. Alt Def 1 (red dashed line) calculates median values for leverage and IC ratio at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

Figure C.3: Growth in Bank and Bond Financing. This figure shows the growth rate in bank and bond financing as a fraction of total debt relative to 2009 for zombie firms, low-quality non-zombie firms, and high-quality firms.

Appendix D Additional Tables

Panel A	EBITDA	EBITDA	EBITDA	EBITDA	EBITDA
Δ Share Zombie	-0.093***	-0.101***	-0.094***	-0.102***	-0.105***
	(0.018)	(0.021)	(0.018)	(0.021)	(0.021)
Industry Sales Growth					-0.012***
					(0.003)
Observations	3,171	3,171	3,171	3,171	3,171
R-squared	0.864	0.883	0.873	0.892	0.894

Panel B	Markup	Markup	Markup	Markup	Markup
Δ Share Zombie	-0.099***	-0.108***	-0.106***	-0.114***	-0.114***
	(0.026)	(0.027)	(0.025)	(0.026)	(0.026)
Industry Sales Growth					0.006
					(0.008)
Observations	2,801	2,801	2,801	2,801	2,801
R-squared	0.971	0.977	0.973	0.978	0.978
Country-Industry FE	✓	✓	✓	✓	✓
Year FE	✓				
Industry-Year FE		✓		✓	✓
Country-Year FE			✓	✓	✓

Table C.1: EBITDA Margin and Markups: Industry-Country Evidence. This table presents industry-country-year level regressions. In Panel A, the dependent variable is the turnover-weighted EBITDA Margin at time t. In Panel B, the dependent variable is the turnover-weighted average markup at time t. Δ Share Zombie measures the increase in the asset-weighted share of zombie firms in a particular market from $t-1$ to t. *Industry Sales Growth* represents measures the growth in aggregate sales at the industry-country level from $t-1$ to t. 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 clustered at the industry-country level. *** p<0.01, ** p<0.05, * p<0.1

	Δ CPI	Δ CPI	Δ Markup	Δ Markup
$\Delta ShareZombie_{t+2,t+1}$	0.007			0.007
	(0.010)			(0.016)
$\Delta ShareZombie_{t+1,t}$	0.002	-0.003	-0.036	-0.034
	(0.010)	(0.008)	(0.029)	(0.032)
$\Delta ShareZombie_{t,t-1}$	-0.025**	-0.026**	-0.061**	-0.085***
	(0.012)	(0.011)	(0.030)	(0.027)
$\Delta ShareZombie_{t-1,t-2}$		0.007	-0.010	
		(0.013)	(0.024)	
Observations	2,173	2,170	1,920	1,924
R-squared	0.837	0.836	0.366	0.412

Table C.2: Alternative Timing. This table presents industry-country-year level regressions. The dependent variables are the growth in CPI from t to $t+1$ (Columns 1 and 2 and the change in markups from t to $t+1$ (Columns 3 and 4). $\Delta ShareZombie$ measures the increase in the asset-weighted share of zombie firms for different periods relative to the dependent variable. 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 clustered at the industry-country level. *** p<0.01, ** p<0.05, * p<0.1

	Default	Default	Default	Default	Default
Δ Share Zombie	-0.012***	-0.016***	-0.009**	-0.013***	-0.013***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Industry Sales Growth					-0.001
					(0.001)
Country-Industry FE	✓	✓	✓	✓	✓
Year FE	✓				
Industry-Year FE		✓		✓	✓
Country-Year FE			✓	✓	✓
Observations	2,595	2,595	2,595	2,595	2,595
R-squared	0.821	0.845	0.860	0.885	0.885

Table C.3: Firm Defaults: Industry-Country Evidence. This table presents industry-country-year level regressions. The dependent variable is the share of firm defaults at time t. Δ*Share Zombie* measures the increase in the asset-weighted share of zombie firms in a particular market from $t-1$ to t. *Industry Sales Growth* is the growth in aggregate sales at the industry-country level from $t-1$ to t. 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 clustered at the industry-country level. *** p<0.01, ** p<0.05, * p<0.1

	Tradable	Non-Tradable
	Markup	Markup
Non-Zombie	0.048***	0.063***
	(0.001)	(0.008)
Non-Zombie	-0.111***	-0.258***
×Industry Share Zombies	(0.014)	(0.057)
Observations	899,967	2,868,576
R-squared	0.687	0.570
Industry-Country-Year FE	✓	✓
Firm-Level Controls	✓	✓

Table C.4: Tradable vs Non-Tradable Industries: Firm-Level Evidence. This table presents firm-year level regressions, separately for firms operating in tradable and non-tradable industries. The dependent variables are a firm's markup. *Non-Zombie* is an indicator variable equal to one if a firm is classified as non-zombie in year t. *Industry Share Zombies* measures the asset weighted share of zombie 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 zombie if it is low-quality and paid advantageous interest rates (see Section 4.2 for more details). Standard errors clustered at the industry-country level. *** p<0.01, ** p<0.05, * p<0.1.