# Credit Misallocation During the European Financial Crisis*

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February 16, 2021

**Abstract**

Using data on bank-firm relationships in Italy during the Eurozone financial crisis, we show that: (i) compared to healthy banks, under-capitalized banks cut credit to healthy but not to zombie firms and are more likely to prolong a credit relationship with a zombie; (ii) in areas-sectors with more low-capital banks, zombies are more likely to survive; (iii) nevertheless, bank under-capitalization does not hurt the growth rate of healthy firms. We provide evidence that extending credit to the weakest firms during the recession mitigated the disruption of supply chains and adverse local demand externalities.

**Keywords**: Bank capitalization, zombie lending, capital misallocation

**JEL classification number**: D23, E24, G21

*We are grateful to Nezih Guner, two anonymous referees, Matteo Bugamelli, Claudio Michelacci, Toshihiro Okubo, Marco Pagano, Edoardo Reviglio, Francesco Saita, Carlos Santos, Alexi Savov, Norman Schrhoff, Paolo Sestito, Neeltje Van Horen, Victoria Vanasco, and participants in seminars at the Bank of Italy, the BIS, Bocconi university, DIW, the ECB, the IMF, KU Leuven, UPF, the NBER Summer Institute 2018 Capital Markets and the Economy, the 19th CEPR Conference on Applied Industrial Organisation, the 4th CSEF Conference on Bank Performance, Financial Stability and the Real Economy, the ABFER conference on Financial Regulations: Intermediation, Stability and Productivity for helpful comments. We are also grateful to Valeria Zurla and David Kwon for excellent research assistance and to Centro Baffi-Carefin and the Italian Ministry of Research (MIUR - PRIN Bando 2015 - Prot. 2015RZWMMT) for financial support. Enrico Sette worked on this project while visiting the Bank for International Settlements under the Central Bank Research Fellowship programme. The views expressed in the paper are those of the authors and do not necessarily reflect those of the Bank of Italy.

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# 1 Introduction

An important dimension of financial crises is a weakened banking sector. It is often argued that under-capitalized banks can prolong depression by lending to weaker firms in the verge of bankruptcy and restraining credit to healthy borrowers ("zombie lending"). This concern is supported by evidence for Japan during the "lost decade" (Caballero, Hoshi & Kashyap 2008) and, more recently, for the Euro area during the financial crisis (Acharya, Eisert, Eufinger & Hirsch 2019). Due to data and methodological challenges, however, assessing the consequences of a weakened banking sector on credit allocation and real economic activity is difficult. Moreover, during a recession not all economic effects of zombie lending are necessarily bad for the healthy part of the economy. Extending credit to very weak firms keeps them alive and may prevent layoffs. This in turn can mitigate the adverse aggregate demand externalities that are so important during a recession (Mian, Sufi & Trebbi 2015). Firms closures can also disrupt input-output relationships that, at least in the short run, can be difficult to replace (Barrot & Sauvagnat 2016, Acemoglu & Tahbaz-Salehi 2020).

In this paper we explore the extent and consequences of credit misallocation in Italy during and after the Eurozone financial crisis. We ask two main questions. First, what bank characteristics are more conducive to zombie lending? Second, what is the cost of credit misallocation in terms of lost economic activity and misallocation of real resources? Italy is an ideal testing ground for these issues, because the financial crisis induced a very deep and long recession, that left a cumulative drop in GDP of almost 10%. This caused a very large increase in non-performing loans (from 5.8% of outstanding bank loans in December 2006 to 16% in December 2013), and a prolonged contraction in bank credit. Moreover, unlike other Eurozone countries, during this period Italy did not inject public funds to recapitalize its banking system, nor it created a bad bank to absorb the non-performing loans. As a result, Italian banks remained saddled with a large fraction of bad loans, and several banks struggled to meet the stricter capital requirements imposed by regulators in the aftermath of the crisis.

In short, these are our main findings. Under-capitalized banks are more likely to cut credit to healthy firms and to prolong a credit relationship with a zombie firm, compared to stronger banks. This affects the composition of bankruptcies, increasing the survival rate of zombies relative to non-zombies. Productivity dispersion is also larger in areas and sectors exposed to weaker banks, but only if the share of zombie firms is sufficiently large. Nevertheless, while zombie firms tend to grow faster in areas with under-capitalized banks, we do not find evidence that bank under-capitalization hurts the growth rate of healthy firms. Instead, preventing zombie firms from shrinking or going bankrupt mitigated disruptions of supply chains and aggregate demand externalities. Thus, by allocating credit to the most fragile firms, zombie lending may have shut down some channels of amplification of the recession. Overall, although weak banks distort the allocation of resources and this may matter for economic efficiency in the long run, zombie lending did not create relevant negative externalities on the performance of healthy firms, and cannot be blamed for aggravating the recession associated with the latest financial crisis.

We use a unique data set that covers almost all bank-firm relationships in Italy for the period 2008-2013. We observe all incorporated firms, including small ones. Most of the previous literature instead considered only listed firms. In addition to detailed information on firm-bank relationships, we also have access to firms and banks balance sheets. We focus on the most extreme form of credit misallocation, namely, loans granted to firms in bad economic and financial conditions – zombie firms. We define as zombie a firm that is highly indebted and for which the returns on assets have been systematically below the cost of capital of the safest firms.

To study which bank characteristics are conducive to zombie lending, we regress the growth of granted credit at the firm-bank level on an indicator of low regulatory bank capital. To identify a credit supply effect, we exploit firms borrowing from more than one bank, as in Khwaja & Mian (2008) and Amiti & Weinstein (2018). Thus, we compare banks with different capital ratios lending to the same firm, controlling for firm-year fixed effects and other determinants of credit demand. Our main finding is that low-capital banks significantly reduced credit growth to healthy firms, and were less likely to terminate a credit relationship with a zombie firm, compared to other banks. This occurred because weaker banks were seeking to hide losses from supervisors, in order to delay recapitalization until circumstances turned more favorable.

Next, we explore the economic consequences of this credit misallocation. Here we exploit time variation in bank capital within a local credit market. Since both bank lending and production are geographically concentrated, we take the relevant credit market to be the province-sector in which a firm operates, and study how the average capitalization of banks active in a given province-sector affects firms performance within the same province-sector. Banks are typically active in several province-sectors, and exposure to a single province-sector is very low. Thus, bank capital can be taken as exogenous with respect to shocks that shift the distribution of firms' performance in a given province-sector.

We start by considering the intensive margin, namely how zombie lending affects the growth of existing non zombie firms. Our central result is that bank under-capitalization allows zombies to grow faster, while it has only negligible effects on healthy firms. This finding contraddicts the received wisdom, which argues that zombie lending hurts healthy firms in two ways: first, by crowding out bank credit; second, by subsidizing non-viable firms and hence hurting their competitors in product and input markets. In our sample, however, healthy firms were able to sustain operations by depleting cash and injecting new equity in the firm, while the demand for new capital was arguably low for all types of firms, because of the sharp GDP contraction. Moreover, we provide evidence that zombie lending by low-capital banks had positive effects on firm growth in downstream sectors and in services, in line with the idea that extending credit to the weakest firms during a recession may mitigate the disruption of supply chains and adverse local demand externalities.

We then explore the extensive margin, namely the effect of bank capital on the composition of bankruptcies. Zombies are more likely to survive, and non zombie but weak firms to fail, in province-sectors where lending is predominantly done by low capital banks, compared to province-sectors with stronger banks. To assess the magnitude, consider an injection of capital in the weak banks so as to bring their capital ratio to the median level. This counterfactual exercise would increase the failure rate of zombies by 0.4% and reduce the failure rate of non-zombies by 0.2%. This represents a reduction of one tenth in the failure rate of healthy firms in the period.[1] Despite this, a simple evaluation scheme suggests that the contribution of credit misallocation on aggregate growth has been at best very modest. This is because, with stronger banks, more healthy firms would have survived the recession, but also more zombies would have gone bankrupt. Although potentially very important for economic efficiency in the long run, this compositional effect on the quality of firms going bankrupt would have reduced the severity of the recession only marginally.

We also ask whether bank under-capitalization is positively correlated with (revenue based) TFP dispersion in the province-sector. As shown by Hsieh & Klenow (2009), in the absence of frictions in the inputs market, revenue TFP should be equalized across firms. Thus TFP dispersion can be interpreted as revealing the presence of some frictions or misallocations in the input markets. The data show that there is a positive association

[1] Our finding that low bank capital has larger effects on the extensive than on the intensive margin is in line with the findings of Midrigan & Xu (2014), who study the impact of credit frictions on TFP through both margins.

between low bank capitalization and aggregate TFP dispersion, but only in the presence of a large fraction of zombie firms.

The conclusion that zombie lending had modest or no consequences on the overall economic performance stands in contrast to some well known findings in the literature (Caballero et al. 2008, Acharya et al. 2019).[2] In subsection 4.5, we argue that this difference is due to a serious, and so far overlooked, identification issue. The empirical framework first introduced by Caballero et al. (2008) and adopted by the subsequent literature typically finds that the *relative* performance of healthy vs zombie firms deteriorates as the share of zombie firms increases. This finding is interpreted as evidence of negative externalities emanating from zombies. But, as we explain in a companion paper (Schivardi, Sette & Tabellini 2020), this interpretation is unwarranted. If firms are heterogeneous, a higher share of zombies corresponds to a change in the composition of the groups of healthy and zombie firms. Under standard assumptions on the distribution of firms performance, this in turn mechanically leads to a reduction in the difference between the group means, absent any spillover. In this paper we exploit a different source of variation (low bank capital, rather than the share of zombies), and this explains why we get very different results. Moreover, our approach allows us to estimate the *absolute* effect of bank under-capitalization on the growth of healthy firms, and not just an effect relative to zombie firms. This is important because in our estimates, while the relative effect is negative and highly significant, the absolute effect is negligible.

Some recent papers have studied zombie lending in Europe. Acharya et al. (2019) use syndicated loan data and show that, in the exit from the latest financial crisis, undercapitalized banks have lent to industries with a higher share of zombie firms. Following Caballero et al. (2008), they also find that a larger share of zombies hurt the growth of healthy firms in the same industry and country. A similar conclusion is reached by McGowan, Andrews & Millot (2018) for OECD countries. Blattner, Farinha & Rebelo (2018) show that in Portugal undercapitalized banks had a negative impact on healthy firms' growth and productivity directly, through a reduction in the availability of credit, and indirectly, through spillover effects from zombies to non-zombies. Given that these results differ from ours, we discuss in greater details similarity and differences between

[2]Misallocation of credit and "zombie lending" have been proposed as an explanation for the prolonged stagnation of the Japanese economy after the real estate crisis of the early 90s (Hoshi 2000, Peek & Rosengren 2005, Caballero et al. 2008). Subsequent studies of the Japanese case have used different definitions of zombie firms and/or longer time spans (Ahearne & Shinada 2005, Fukao & Ug Kwon 2006, Fukuda & Nakamura 2011), suggesting that the impact of zombie lending on economic performance estimated by the early literature may have been overstated.

the two approaches in Subsection 4.5.[3]

Following Hsieh & Klenow (2009), a growing literature assesses the effects of resource misallocation on aggregate productivity. The work that focuses on the effects of financial frictions reaches mixed results (Moll 2014, Yang 2011, Midrigan & Xu 2014). Gopinath, Kalemli-Özcan, Karabarbounis & Villegas-Sanchez (2017) document a significant increase in productivity losses from capital misallocation in Southern Europe before the crisis, and argue that credit frictions were not a key driver of misallocation during the financial crisis. These conclusions are confirmed by subsequent studies (Borio, Kharroubi, Upper & Zampolli 2016, Gamberoni, Giordano & Lopez-Garcia 2016, Calligaris, Del Gatto, Hassan, Ottaviano & Schivardi 2018).

The outline of the paper is as follows. Section 2 describes the data and how we define zombie firms. Section 3 asks which types of banks engage in zombie lending, while the real consequences of zombie lending are explored in Section 4. Section 5 concludes.

# 2 The Data

Our data come from three sources. The first is the Firm Register (Cerved), that contains detailed balance sheet information of *all* incorporated businesses. We consider non-financial firms excluding agriculture. The data refer to more than 700,000 firms per year, accounting for approximately 70% of private sector value added. The second dataset is the Central Credit Register, which contains detailed information on loans extended by banks to firms. Banks must report data by borrower on the amount granted and effectively utilized for *all* loans with a breakdown by type of loan (credit lines, financial and commercial paper, collateralized loans, medium and long-term loans and personal guarantees).[4] The third data source is the Supervisory Reports collected by the Bank of Italy, which contain balance sheet data on all Italian banks. Combining the three data sources, we obtain loan-level information on almost all relationships between banks and firms, matched with balance sheet information of both firms and banks.

In the remainder of this section we describe the sample used to analyze lending, deferring the description of how we study the consequences of zombie lending to Section 4. We exclude mutual banks, as they are subject to highly specific regulations in their

[3] Other works consider in greater detail the link between alternative measures of banks and firms weakness and its consequences in terms of access to credit and firms outcomes (Albertazzi & Marchetti 2010, Storz, Koetter, Setzer & Westphal 2017, Balduzzi, Brancati & Schiantarelli 2018).

[4] The bank is exempted from this reporting obligation only for relationships for which the total amount granted to the firm is less than 30,000 euros (the reporting threshold was 75,000 euros until 2008).

lending and governance. In our preferred specification, we aggregate all loans that a bank grants to a firm, independently of its nature (credit line, collateralized loan, etc). We only include loans officially classified as performing.[5] This leaves us with a sample of 2,783,449 firm-bank-year observations. Because of our identification strategy, however, most of our regressions only exploit firms that have credit relationships from at least two banks in a year, corresponding to a sample of 2,287,690 firm-bank-year observations, consisting of 210,904 firms and 143 banks. Our main sample spans the period 2008-2013, namely the years of the great recession (2008-2009) and the sovereign debt crisis (2011-2013), although for some analyses we use data going back to 2002.

## 2.1 What is a zombie firm?

We define as zombie a firm for which the expected marginal return of capital is below the risk adjusted market cost of capital. Lending to zombie firms thus results in misallocation of capital, that could earn higher returns (and produce more output) elsewhere. Since we don't observe the expected marginal return of capital nor the risk of each firm, we rely on alternative measures of what is a zombie firm, and check that our results are robust to these alternative definitions. All these alternative measures combine indicators of low profitability and of high default risk. From a lender's perspective, both the debtor's expected profits conditional on surviving and default risk matter, since both determine the expected return on the loan.

Our preferred indicator of profitability is the returns on assets (ROA), defined as Earnings Before Interest and Taxes (EBIT) over total assets. EBIT is what is left of revenues after paying labor and intermediates, and deducting the replacement of capital so that its ratio to capital invested is the average gross return on capital.[6] Ideally, we would like to measure expected future profitability. Since this is not available, we define the variable *return on assets* (ROA) as the three-year moving average of EBIT over total assets. We compare ROA to the cost of capital for the safest borrowers, defined as the three years moving average interest rate charged on new loans to the safest firms (those having an Altman Z-Score of either 1 or 2 out of 9 possible ratings). This measure of the cost of capital is called *prime rate* (PRIME).

[5] This is important to avoid that weaker banks are just slower in writing-off non-performing loans, thus mechanically finding different credit growth across weak and stronger banks.

[6] For the Cobb-Douglas technology with constant returns to scale, this is exactly equal to the marginal product of capital. However, the depreciation and amortization of capital may be affected by tax incentives. For this reason we also used EBITDA, earning before interest, taxes, depreciation and amortization and results are qualitatively the same.

As a measure of default risk, we rely on *leverage,* defined as total financial debt (excluding debt towards shareholders) over total assets. Highly indebted firms are obviously more at risk of default, so that a lender should be less willing to extend them credit.

We classify a firm as zombie in any given year if, in that year, ROA is below PRIME, and if leverage exceeds 40%. This threshold corresponds to the median value of leverage in 2005 in the sample of firms that exited during 2006-2007 (i.e. just before the financial crisis), and that during the previous two years had ROA$<$ PRIME at least once. Appendix Figure A1 reports the distribution of leverage in 2005 for the whole sample and for this specific group of firms. The latter is clearly shifted to the right. We checked that the share of zombies varies little and continuously as we vary the leverage threshold between the 40-th and the 60-th percentile of the distribution, implying that our definition of zombie is not particularly sensitive to the numerical value of the selected threshold.

Figure 1 shows the time evolution of the share of zombies together with the evolution of GDP growth for the 2004-2013 period. The two series are clearly negatively related. The share of zombies reaches a maximum in 2009, when GDP contracted by almost 6%. It declines slightly in the following two recovery years and it increases again in 2012, when GDP growth turns negative again, dropping only slightly in 2013 as the contraction in GDP gets smaller. Table A1 in the Appendix provides summary statistics of balance sheet and economic variables for zombie and non zombie firms.

Observable outcomes associated with zombie firms are very different from those of healthy firms, confirming the plausibility of our definitions. First, the status of zombie firm is highly persistent. If a firm is classified as a zombie in period t, it has 73% probability of still being a zombie next period, and there is little difference between the pre-crisis and the crisis years. Second, credit to zombies is much more likely to be cut by the average bank: the proportion of terminated relationships with zombies is 11%, against 9% for non-zombies. Third, the share of zombie firms that exited because of default and bankruptcy is 12.8%, that of non-zombies 3.3%. Fourth, revenue growth is much slower for zombie firms than for non-zombies. The three-year average growth rate of revenues (weighted by firms' assets) is -4.1% for zombies, while it is -2.4% for healthy firms. This is important to reduce concerns that we may be classifying high-growth firms as zombies. For example, a start-up might have high leverage and negative profits because of high investment, but this might be due to high growth opportunities. It turns out that this is not the case in our data, indicating that our definition of zombie is effectively identifying firms with grim prospects.

## 2.2 Variables used in the credit regressions

In Table A2 in the Appendix we report descriptive statistics of the variables used in the credit regressions. Our outcome variables of interest are the yearly growth of credit, a dummy for the break-up of the credit relationship, the interest rate charged on the loan, and two indicators of the decision of the bank to classify a loan as problematic. Average credit growth is -8.06% in our 2008-13 sample (it was 5.3% in the previous four years).

Our key regressors are indicators of banks strength. The main measure of bank strength is the regulatory capital ratio. This is defined as the ratio of total capital (the sum of Tier 1 and Tier 2 capital) to risk-weighted assets, at the beginning of the period. The regulation in place in our sample period prescribed that banks maintain this ratio above 8%. Higher capital identifies financially stronger banks. Table A2 in the Appendix shows that average and median capital ratios are around 11%, reflecting the efforts at re-building bank capital during the crisis. We classify a bank as weak if in year $t$ the capital ratio is below 10.1%, corresponding to the median of the banks distribution in 2008 (the starting year of our sample). The corresponding dummy variable is called $LowCap$, and it takes a value of 1 in 24% of observations (cf. Appendix Table A2). We use the distribution in 2008 because it captures a pre-crisis situation not affected either by the capital erosion induced by losses occurred during the crisis, or by the subsequent recapitalization. Appendix Figure A2 illustrates how zombie firms are distributed between banks, according to their capital ratio. The distribution is non-monotonic, and banks with a capital ratio in the bottom quartile have a substantially higher share of zombies out of total borrowers. We will assess the robustness of our results to alternative indicators of bank strength.

Other bank characteristics may be relevant for lending. For this reason, in the regressions we include the set of standard controls used in the literature (Khwaja & Mian 2008, Iyer, Peydró, da Rocha-Lopes & Schoar 2014): the liquidity ratio, namely the ratio of cash plus government securities to total assets; the ratio of interbank deposits to total asset; bank profits divided by total assets; and bank size, measured by the log of total assets. Appendix Table A2 shows that the average firm borrows over one quarter of its bank credit from a single bank, and that approximately one quarter of total credit is granted through credit lines.

# 3 Who lends to zombie firms?

Why would any bank want to lend to a non-viable firm? A well capitalized bank should only grant loans with positive net present value, so it would never want to do that. In the period under consideration, however, not all banks met these ideal conditions. Capital requirements were raised repeatedly and several banks had capital shortfalls. But raising capital was very difficult and expensive in the midst of the financial and sovereign debt crisis. Delaying recapitalization until aggregate economic conditions improved may have been preferable for banks, for two reasons. First, an economic recovery would reduce bank losses and the size of the necessary recapitalization, thanks to future retained earnings. Second, raising fresh capital would be cheaper once the crisis was over. This created an incentive to hide losses for all banks, but particularly for those with less regulatory capital who faced more pressing recapitalization requirements.

Our main hypothesis, therefore, is that zombie lending reflects an attempt to hide losses by banks who sought to avoid or delay recapitalization imposed by regulators. Faced with a zombie firm, a bank had to choose between rolling over the credit ("evergreening"), or recognizing it as non-performing and writing off some capital. The more pressing was the capital requirement, the more likely that credit extension was the preferred option.

This logic has a number of empirical implications:

- First, since deleveraging reduces their capital requirements, banks with low capital are more likely to contract credit than well capitalized banks. To avoid loss recognition, however, credit contraction by low-capital banks is less likely to affect zombies than healthy firms. Thus, we should observe that a bank capital shortfall is associated with a contraction of credit to healthy firms, but not necessarily to zombies.

- Second, in order to avoid loss recognition, low-capital banks are less likely to terminate a credit relationship with a zombie firm and to classify loans as non-performing, compared to banks with adequate capital.

- Third, the relative effect of low bank capital on zombie vs healthy firms should be stronger if credit is not collateralized, because the default of an uncollateralized loan has a stronger impact on regulatory capital than that of a collateralized loan.

- Fourth, the relevant measure of capital is related to the nature of the capital requirements. If recapitalization is mainly imposed by regulators, then regulatory capital is the relevant measure of bank strength. If instead the pressure to recapitalize is mainly coming from financial markets, then other indicators of bank strength, like leverage, may be more strongly correlated with zombie lending.

In the remainder of this section we test these predictions, and explore which bank features and loan conditions are associated with zombie lending.

## 3.1 Empirical strategy

We use the following regression framework:

$$\Delta b_{ijt} = \beta_0 + \beta_1 LowCap_{jt} + \beta_2 (Z_{it} * LowCap_{jt}) + \beta_3 Z_{it} + \beta_4 \mathbf{X_{ijt}} + D_{ijt} + \eta_{ijt} \tag{1}$$

where $\Delta b_{ijt}$ is the log difference in total lending of bank $j$ to firm $i$ between year $t$ and $t+1$; $Z_{it}$ is the zombie 0/1 indicator; $LowCap_{jt}$ is a dummy equal to one if the capital ratio of bank $j$ at the beginning of period $t$ is below the median in 2008 (or alternative measures of weak bank capitalization); $\mathbf{X_{ijt}}$ are other controls at the firm and bank level; $D_{ijt}$ are different sets of dummy variables used in different specifications. To test the predictions discussed above, we also replace $\Delta b_{ijt}$ with other dependent variables, such as dummy variables for whether the credit relationship is severed and for whether the loan is classified as non-performing by the bank, and the interest rate charged on the loan. To account for potential correlation in the residuals at the level of both the bank and the firm, standard errors are always double clustered at the bank and firm level.

To clarify the interpretation of the coefficients, define $\Delta b_{ij}$ as the average growth of credit for firms $i = \{Z, N\}$ (zombies, non-zombies) when borrowing from banks $j = \{H, L\}$ (high and low capital). Then, $\beta_1 = \Delta b_{NL} - \Delta b_{NH}$ measures the difference in the credit growth of non-zombies when borrowing from low capital rather than high capital banks; $\beta_2 = (\Delta b_{ZL} - \Delta b_{NL}) - (\Delta b_{ZH} - \Delta b_{NH})$ measures the *relative* effect of a reduction in bank capital on zombie vs non zombie firms; and $\beta_3 = \Delta b_{ZH} - \Delta b_{NH}$ measures the difference in credit growth to zombie vs non zombie firms by a well capitalized bank. It is also useful to note that $\beta_1 + \beta_2 = \Delta b_{ZL} - \Delta b_{ZH}$ measures the effect of a reduction in bank capital on credit growth to zombie firms.

The main issue in identifying the effects of bank capital on credit supply is that observed credit also depends on credit demand by firms. Firms are not randomly matched to banks. The correlation measured by $\beta_2$ could be due to matching between weak banks and weak firms for reasons other than the banks capital ratio. For example, some banks may be specialized in lending to firms that were more severely hit by the crisis, which in turn led to a deterioration in the banks financial position. In this case, causality would go from firms to banks rather than the other way around. The richness of our data allows us to properly address this issue. First, we use *changes* in credit granted, rather then *levels*, so as to consider the dynamics of credit evolution rather than a stock measure of exposure. This does not eliminate all concerns, because zombie firms, possibly more likely to be matched to weak banks, might demand more credit during the crisis, compared to healthy firms. We thus follow the identification strategy proposed by Khwaja & Mian (2008) and Amiti & Weinstein (2018). A well-known feature of the Italian lending market is that firms tend to borrow from different banks simultaneously (Detragiache, Garella & Guiso 2000, Gobbi & Sette 2013). In our data, firms have 3.3 lending relationships on average. This allows us to include a full set of firm-year dummy variables. These dummy variables control for any potential effect coming from firm-level time varying shocks to credit demand, and therefore account for all the unobserved heterogeneity at the firm-year level.[7] Our estimates are only based on within firm-year variations in the growth of granted credit across banks with different degrees of financial strength. Thus, the inclusion of firm-year dummy variables rules out any demand-driven potential correlation between unobservable determinants of credit growth and measures of capital intensity of banks. This comes at the cost that we cannot identify $\beta_3$ anymore, as the zombie dummy is absorbed by the firm-year effects.

A second identification concern is that the bank capital ratio could be correlated with unobserved bank features that influence zombie lending, such as management practices or features of the banks balance sheet. For this reason, we include a full set of bank dummies, to account for all potential fixed unobserved heterogeneity at the level of the bank, as well as several observable and time varying banks' characteristics, potentially correlated with the capital ratio and with lending policies, such as bank profitability, liquidity and liability structure (more details are provided in context). In some specifications we replace these time varying bank covariates with bank*year fixed effects. These control for bank-time varying unobservables, but come at the cost that we can only identify the effect of low capitalization on zombie relative to healthy firms.

There remains a final concern. Although total credit demand by the firm is controlled by firm-year fixed effects, its partition across banks could reflect unobserved firm heterogeneity correlated with bank features. For instance, zombie firms could demand more credit from weaker banks because of stronger historical ties with such banks. Note that

[7] Firm-year dummies also account for all observed heterogeneity, making firm controls redundant.

our dependent variable is credit growth, rather than the stock of credit, which reduces the relevance of this issue. Nevertheless, to cope with this concern, we also control for some observable features of the bank-firm match, such as the importance of the individual bank in the total bank debt of the firm, and the share of credit granted through a credit line. For example, it might be easier to cut credit growth if it takes the form of a credit line, whose conditions can be modified unilaterally by the bank at any time, or if the bank accounts for only a small fraction of total firm credit. Thus, we define $share\ bank_{ijt} = credit_{ijt} / \sum_j credit_{ijt}$ where $credit_{ijt}$ is the total amount of credit granted by bank $j$ to firm $i$ in year $t$, and $share\ credit\ line_{ijt} = credit\ line_{ijt} / credit_{ijt}$, where *credit line* is the amount granted through the credit line. In addition, as a further robustness check, we also estimate the fully saturated specification with firm*time, bank*time and bank*firm fixed effects. In this demanding specification, the parameter of interest $\beta_2$ is estimated only exploiting changes over time in $Z_{it} * LowCap_{jt}$: either the firm or the bank must change status.

Our identification assumption is that, after controlling for all these variables, any remaining unobserved determinant of the *composition of changes* in credit granted to the same firm by different banks is uncorrelated with the regressors.

## 3.2 Results

### 3.2.1 Intensive margin

The results of estimating equation (1) are displayed in Table 1, where the dependent variable is the log difference of total credit granted by bank $j$ to firm $i$ between $t+1$ and $t$, expressed in percentage terms. Throughout, standard errors are double clustered at the bank and firm level, unless otherwise noted.[8]

In column (1) we report a specification with firm fixed effects and sector-province*year fixed effects. Here the sample also includes single-banking firms. First, $\beta_3 = -5.4$ and highly significant, meaning that healthy banks cut credit growth to zombies by 5.4% compared to healthy firms. Second, $\beta_1$ is negative but not significantly different from zero, implying that low capital banks' credit policy towards healthy firms does not differ from that of high capital banks. Third, $\beta_2$ is positive and significant at the 1% level: thus, banks with a capital ratio below the median extend relatively more credit to weak firms than to healthy firms, compared to banks with higher capital. The estimated $\beta_2$ of 1.6 means that a bank with low capital allows credit to zombies to grow faster than

[8] Clustering at sector-year or province-year level does not materially change the significance levels.

credit to healthy firms by 1.6%, compared to banks with high capital. Given that well capitalized banks cut credit to zombie firms, relative to healthy firms, by about 5.4% per year, this implies that the reduction in credit supplied to zombies is more than 25% lower for low capital banks. Also, note that $\beta_1 + \beta_2$, that measures the difference in credit supply to zombies between low and high capital banks, is not significantly different from 0 (p-value=0.48, see the last row of Table 1). Thus, bank capital influences the composition of credit growth in terms of firm quality, but not the overall amount of credit extended to zombie firms.

Column (2) adds the firm-year fixed effects, that account for unobserved heterogeneity at the firm level, and bank fixed effects. Thus, here by construction the sample is restricted to multiple-banking firms (estimating column 1 on this restricted sample produces similar estimates, indicating that excluding single bank firms does not affect the results). The interaction coefficient drops slightly and remains significant, but now the estimated coefficient on *LowCap* becomes more negative and significant at the 5% level. The point estimate implies that low-capital banks cut growth to healthy firms by about 1.6%, relative to well capitalized banks. This corresponds to about 20% of the average credit contraction during this period, a substantial effect. The sum of $\beta_1$ and $\beta_2$ remains insignificantly different from zero, implying that the only effect of low bank capital is to reduce credit growth for healthy firms, with no impact on credit to zombies.

In column (3) we add two variables that account for pre-existing bank-firm relationships, namely the share of the bank in total firm's credit and the composition of loans across different credit facilities. Credit growth is negatively related to the share of credit that a bank extends to a firm and positively related to the share extended through credit lines. But the coefficients of interest are not materially affected: if anything, they rise in absolute value. In column (4) we introduce time-varying bank controls, namely the *liquidity ratio* (the ratio of cash and government bonds to total assets), the *interbank ratio* (the ratio of interbank deposits and repos with banks–excluding those with central banks–and total assets), *ROA* (the ratio of bank profits to bank total assets), and *Bank size* (the log of bank total assets). These indicators are meant to capture other bank characteristics that might influence lending policies and possibly correlated with the capital ratio. They do influence credit growth, without however affecting our coefficients of interest. In column (5) we include bank*time fixed effects. We cannot identify $\beta_1$, but $\beta_2$ is broadly unchanged.

Finally, in column (6) we also include bank*firm fixed effects. Here, like in column

(5), standard errors are clustered at the bank-firm level, since this is the dimension of variation of the variable of interest. The estimate of $\beta_2$ drops in size and looses statistical significance at the margin (p-value 0.102), indicating that cross sectional variability is key to identify the effect. Nevertheless, the estimated coefficient of 0.39 is economically relevant, accounting for about 7% of the average credit growth in the period. Note that this is a very demanding specification, as it estimates $\beta_2$ only out of firm-bank relationships in which either the bank or the firm changes status (between low-high capital for banks and zombie-non zombie for firms). Since both dummies are constructed using thresholds, many of these changes are likely to be marginal, ie., occurring for small changes in the fundamentals for firms and banks close to the respective thresholds, reducing the power of the test. Indeed, as shown in Appendix Tables A4 and A5 below, when using continuous measures of either bank strength or zombie, the estimate of $\beta_2$ remains statistically significant also in this very demanding specification.[9]

Overall, Table 1 implies that the main difference between low vs high capital banks concerns credit extended to healthy firms. Relative to high capital banks, low-capital banks cut credit more aggressively to healthy firms than to zombie firms. This results in significantly lower credit growth for healthy firms who borrow from a low-capital bank, while credit to zombie firms is not significantly affected by bank capital. These effects are large, and correspond to about 20% of average credit contraction during the period.

Next, we consider the other predictions of the effects of low capital on bank lending behavior. Throughout, we only display the specification corresponding to column (4) in Table 1 as this allows us to estimate the coefficient of the dummy for low capital banks, which captures the effect of low bank capitalization on healthy firms.

### 3.2.2 Extensive margins

Credit can also be reduced by shutting down a credit relationship, something not captured by our credit growth indicator, or by classifying a loan as bad, which implies that the firm is essentially excluded from the credit market. In Table 2 we explore these extensive margins, using the same specifications as in column (4) of Table 1. Given the very large number of fixed effects, we cannot estimate logit or probit models, so we estimate linear

[9] Despite the inclusion of bank-firm fixed effects, one may wonder whether zombies may be more likely to increase their credit demand to weaker banks, in anticipation of being denied credit in the future. To check this, we have redefined the dependent variable as the faction of used to drawn credit in existing credit lines, and there is no evidence that zombies draw credit more intensively from low capital banks. We also focus on a specific form of credit, overdraft loans. These are a homogenous product across banks, so that they are robust with respect to the issue of bank specialization raised by Paravisini, Rappoport & Schnabl (2020).

probability models (OLS).

**Termination of the credit relationship** In column (1) the dependent variable is a dummy variable that equals 100 if the overall credit relationship is in place at $t$ but disappears at $t+1$ and zero otherwise (the value of 100 is chosen so that the coefficients can be interpreted as percentage points). Only the interaction coefficient between the low capital dummy and the zombie dummy ($\beta_2$ in equation 1) is statistically significant and has a negative value: low-capital banks are less likely to terminate a relationship or to cut a credit line with zombies than with healthy firms, compared to high-capital banks. In column (2) the dependent variable is similarly defined, but it refers to credit lines, which can be closed at will by the bank. Now the estimated coefficient $\beta_1$ is positive and significant, indicating that healthy firms are more likely have their credit line cut if the bank has low capital. The estimate of $\beta_2$ instead is negative and larger than in column (1), confirming that low capital banks are less likely to shut credit lines to zombies than to healthy firms. Unlike in Table 1, here $\beta_1 + \beta_2$ is close to -1 and statistically significant in both columns. Thus, on average the probability that a credit relationship or a credit line with a zombie firm is terminated is about 1 percentage point lower if bank capital is below the median. This is a large effect, given that on average 9.4% of the relationships in our sample are terminated every year.

**Non-Performing Loans** Next, we study how bank capital affects the decision of a bank to classify loans as non-performing. There are two classes of non-performing loans entailing some degrees of discretion by banks: "substandard loans" and "bad loans". A loan can be classified as substandard when the firm is "facing temporary difficulties - defined on the basis of objective factors - that are expected to be overcome within a reasonable period of time" (Banca d'Italia 2008). Bad loans are those for which banks expect to recover only a small fraction of the nominal value.

Classifying a loan as substandard or bad has two consequences. First, it forces the bank to set aside a provision for future losses, thus reducing current profits. Banks with a weak capital structure may be reluctant to do this. Second, a bad loan classification implies that the firm is basically excluded from the loan market. Therefore, if a bank wants to keep a zombie alive, it will refrain from classifying its loans as substandard or bad. For both reasons, we expect that under-capitalized banks are less likely to do so.

To test this hypothesis, in columns (3) and (4) of Table 2 we run a set of regressions in which the dependent variable is a dummy variable equal to 100 if a loan is classified as bad (column 3) or substandard (column 4) between $t$ and $t+1$. Note that this is a demanding test, for two reasons. First, our firm-year fixed effects specification identifies the estimated coefficient from differences in the bad loan classification across banks. Only about 4.7% of all bad loans in our sample are not classified as such by all banks. Second, for a bank the benefit of delaying a substandard or bad loan classification may not be long-lasting, as supervisors may require banks to do so anyway, or they may impose writedowns in order to increase coverage ratios, i.e., the ratio between write-downs and the overall stock of non-performing exposures.[10] In both columns (3) and (4), the interaction coefficient $\beta_2$ is negative and significant. The estimated coefficient on $LowCap$ is not statistically significant at the 5% level or it is positive, and the sum of the two coefficients is negative and significant. Thus, having low bank capital reduces the probability that a loan to a zombie is classified as bad or substandard, and has no effect or the opposite effect on loans to healthy firms. The point estimates imply that having low bank capital reduces the probability of these classifications by over half of a percentage point if the loan is with a zombie firm. In our sample, every year about 1.5% of loans are classified as bad. Hence, having low bank capital reduces such classifications by about one third if the firm is a zombie.

### 3.2.3 Other Predictions and Robustness

In the appendix, we explore other possible consequences of low capitalization for banks' lending policies. Consider first the presence of collateral. Loss provisions on non-performing loans are substantially smaller if credit is guaranteed by collateral. Thus, the bank has much stronger incentives to hide losses for non-collateralized loans. Consistently with this, in Appendix Table A3 we find that low and high capital banks do not behave differently when loans are collateralized (column 1), while for uncollateralized loans the same pattern as in column (4) of Table 1 emerges (column 2), but the effects are stronger, as expected.

If the main reason behind zombie lending is to hide losses, then we expect interest rates on the loan to be low. Subsidized credit is extended in order to keep the firm solvent, and raising interest rates could create difficulties for the borrower or attract the attention of regulators. If on the other hand a low-capital bank was gambling for resurrection, then the opposite should be observed: the bank charges very high interest rates on risky

[10]In 2012 and 2013 the Italian supervisor conducted targeted inspections on 20 major banks with the aim of verifying credit risk and increase coverage ratios. This resulted in banks increasing writedowns by 50%

loans, knowing that limited liability shields its shareholders from the downside risk. The evidence is consistent with the motive of hiding losses and does not support gambling for resurrection: low and high capital banks charge similar interest rates, irrespective of the identity of the borrower - column (3) of Table A3.

Finally, the main results are robust to alternative classifications of zombie firms and of low capital banks - Appendix Tables A4 and A5. Only regulatory indicators of bank strength predict a differential growth of credit to zombie vs healthy firms, however, while market-oriented measures of bank strength such as ROA or leverage do not. This is consistent with our hypothesis that zombie lending reflects an attempt to hide losses from regulators, to avoid or delay requests to boost capital. Note that, in the fully saturated specification that also includes bank*firm fixed effects (Panel B of Appendix Tables A4 and A5), the estimate of $\beta_2$ is statistically significant and with the expected sign when using a continuous measure of zombiness (columns 3 and 4 of Table A4, Panel B) or the continuous variable *Capital Ratio* (column 2 of Table A5, Panle B, where the expected sign of $\beta_2$ is now negative). This is in line with our previous observation that exploiting time variation in credit at the bank-firm level is very demanding when the treatment variables of interest are defined as binary variables. We also find no evidence that bank capital influenced the allocation of credit in the pre-crisis period, 2003-2007, when regulators did not pay much attention to bank capital - Appendix Table A6.

All in all, this evidence is consistent with the hypothesis that low capital induces banks to cut credit to healthy firms rather than to zombies, because low-capital banks try to hide losses and delay the moment in which they will be required to raise new capital.

#### 3.2.4 Firm level regressions

Table 3 aggregates total credit growth across banks and combines the intensive and extensive margins. The dependent variable is total credit granted at the level of the firm, therefore also accounting for credit changes deriving from credit relationships being severed or started (unless a firm enters or exists the credit market completely). For each firm, we compute the share of credit from low capital banks out of all banks from which a firm borrows, using the (beginning of period) share of credit from each bank as weights. All other bank-related variables are likewise computed as weighted averages of the banks from which the firm borrows. Compared to the basic regressions of Table 1, here an observation is a firm-year, so that we cannot include firm-year effects anymore (although we do include separate firm and year fixed effects). As such, these regressions might capture both credit demand and supply effects and should therefore be interpreted with care. Nevertheless, since they combine the intensive and the extensive margins, these estimates provide a summary picture of credit allocation across healthy and zombie firms. Columns (1-3) refer to firms that borrow from multiple banks only, whereas in column (4) we also include single-bank firms. Standard errors are clustered at the firm level.

As in the loan-level regressions, we find that healthy firms record a lower growth in credit granted the larger is the share of low-capital banks they borrow from. According to the estimates of the most saturated regression in column (3), a firm borrowing only from low capital banks would record a drop in the growth of credit of 0.9% compared to a firm borrowing from high capital banks only. This is somewhat below the estimates in the loan-level regressions, and it suggests that healthy firms may at least partly compensate the lower credit by low capital banks by opening new credit relationships. The effect is opposite but much larger for zombies: the same exercise delivers an increase in the growth of credit of over 3% or almost 4%, depending on the sample, and highly statistically significant. The estimated effect of low bank capital on overall credit growth of zombie (as opposed to healthy) firms is about twice as large as that estimated from the loan-level regressions in Table 1. This is because Table 1 only reflects the intensive margin, whereas here we also capture the effect of lower termination of credit relationships.[11] Now the sum of the estimated coefficients in the first two rows exceeds 2% and is significantly different from zero in all specifications, implying that zombie firms receive more credit if they borrow from banks with low capital, in absolute terms and not just compared to healthy firms. Overall, and with the caveat on the more restrictive identification, this suggests that banks' capitalization has substantial effects on the allocation of credit across firms.

# 4 The real effects of credit misallocation

In the previous section we have shown that, during the crisis, banks with low capital allocated relatively more credit to zombies than to healthy firms, compared to well capitalized banks. We now ask how this misallocation of credit affected real economic activity. Lending policies can affect firms growth in two ways. First, directly, as firm operations depend on credit availability. Second, indirectly, through spillovers. In particular, if under-capitalized banks prevent zombie firms from shrinking or exiting, there are two contrasting indirect effects. On the one hand, there is a positive aggregate demand (Huber

[11] Recall that for healthy firms we found that bank capital has no effect on the extensive margin (cf. Table 2).

2018) and input-output (Barrot & Sauvagnat 2016) externality, because zombie lending may prevent layoffs or bankruptcies. On the other hand, zombie lending is like a subsidy to inefficient firms, that hurts competing healthy firms.

We break the analysis in three parts. First, we study how being exposed to under-capitalized banks affects the growth rate of healthy vs zombie firms and which of the indirect effects mention above are at play. Second, we ask if low bank capital affects the composition of bankruptcies between zombies and healthy firms. Third, building on the literature on misallocation (Hsieh & Klenow 2009), we consider the implications of low bank capital for the dispersion of productivity across firms.

A key issue is how to define the reference group within which these effects take place. Caballero et al. (2008) study Japanese listed firms only, for which the relevant markets are national (or even international). Accordingly, they use the sector as the reference group. Acharya et al. (2019) follow this approach and, given that they have a sample of firms from different European countries, use the country-sector. Our sample instead consists of all incorporated firms, including very small ones. For this reason, we also consider geography. Many firms in our sample have access only to the local lending market. Since banks tend to be geographicallyi specialized, and often competing firms are also geographically concentrated, we define the credit market at the province-sector level. Provinces are administrative units roughly comparable to a US county. As argued by Guiso, Pistaferri & Schivardi (2013), they constitute an ideal geographical unit to define the credit market: in fact, according to the Italian Antitrust authority, the "relevant market" in banking for antitrust purposes is the province. Moreover, provinces are also a natural boundary to define a local labor market, within which firms compete for workers. In terms of sector, we exclude agriculture, mining, finance and public services and divide the other firms in 18 sectors.[12]

To capture the total effects of banks' capitalization, we consider local-sectoral indicators of banks' strength, rather than the firm level indicators used in the previous section. The reason is that firm-level indicators would only capture the direct credit effect. Our strategy exploits arguably exogenous variation in the strength of banks operating in different sectors and provinces.

[12] The National Institute for Statistics (ISTAT) defines local labor markets using census data on workers' commuting patterns. It turns out that local labor markets so defined are smaller than provinces. Given that we study the banking market, however, we keep the province as the geographic unit. The sectors are classified as: Food and tobacco; Textile and leather; Wood; Paper; Chemicals; Minerals; Metals; Machinery; Vehicles, Manufacturing n.e.c.; Electricity gas, water; Constructions; Wholesale and retail trade; Hotels and restaurants; Transport, storage, communication; Real estate, renting and business activities; Professional, scientific and technical services; Business services.

## 4.1 Firm growth

How does exposure to under-capitalized banks that are active in the province-sector affect firm growth? This is the question addressed in this subsection. We use the sample of all incorporated firms, including those that do not borrow from banks. From these, we exclude firms with non-positive values on capital, value added or labor costs and for which we cannot compute the zombie dummy. We are left with slightly less than a million firm-year observations. Descriptive statistics for the firm level variables are reported in Appendix Table A8, Panel A. Panel B reports those for the sector-province-year variables.

### 4.1.1 Empirical strategy

To assess the effects of low bank capital on firm growth, we estimate the following regression:

$$\Delta y_{ipt} = \phi_0 + \phi_1 \overline{LowCap}_{pt} + \phi_2 Z_{it} * \overline{LowCap}_{pt} + \phi_3 Z_{it} + Dummies + \epsilon_{ipt} \qquad (2)$$

where $i$ denotes the firm, $p$ the province-sector, and $t$ the year. The dependent variable $\Delta y_{ipt}$ is a measure of firm performance, such as the growth rate of inputs or output, $Z_{it}$ is a dummy variable that equals 1 if firm $i$ is a zombie, and $\overline{LowCap}_{pt}$ is a measure of under-capitalization of the banks that lend in the province-sector, defined similarly to the credit-weighted average of the variable $LowCap_{pt}$ used in the previous section:

$$\overline{LowCap}_{pt} = \frac{\sum_j LowCap_{jt} * Credit_{jpt}}{\sum_j Credit_{jpt}} \qquad (3)$$

where $Credit_{jpt}$ is the amount of credit granted by bank $j$ to province-sector $p$ during year $t$ and $LowCap_{jt}$ is a dummy variable that equals one if the capital ratio of bank $j$ in period $t$, as measured by end-of the period balance sheets, is below the 2008 median. Thus, $\overline{LowCap}_{pt}$ is the share of loans granted in each province-sector-year that originate from banks with a capital ratio below the median. We stress that we use a different timing convention than in the credit regression, where capital was measured at the beginning of period. The reason is that the credit regressions exploited variation at the firm-bank level, and used previous year matches to account for the endogeneity of matching formation. In the current setting, instead, we use a market level measure of capitalization. As we argue below, this can be taken as exogenous at the province-sector level. Using current bank capital (i.e. measured at the end of period) allows us to account for the fact that, during the crisis, events happened very quickly and banks' balance sheets where immediately affected by widening spreads on the domestic sovereign debt in their portfolio. In this formulation, bank losses can immediately affect the real economy through changes in credit availability to different kinds of firms (for the use of forward looking measures of banks health, see Balduzzi et al. (2018)). In fact, when we use previous period indicators of bank capital, we obtain even weaker results.

The coefficient $\phi_1$ on the RHS of (2) captures the effect of $\overline{LowCap}_{pt}$ on the performance of healthy firms operating in the same province-sector, while $\phi_2$ captures its effect on zombies, *in deviation from that on healthy firms.* We include either province-sector and year fixed effects, or province-sector-year fixed effects, depending on the specification. The province-sector-year fixed effects perfectly control for any aggregate shock, but have the disadvantage that the coefficient $\phi_1$ is not identified, because the variable $\overline{LowCap}_{pt}$ is absorbed by the fixed effects. In such specifications, therefore, we can only estimate $\phi_2$, the relative effect of $\overline{LowCap}_{pt}$ on zombie vs healthy firms. In each regression, we exclude the first and last percentile of the distribution of the dependent variable. Standard errors are clustered at the province-sector level.

As shown in Section 3, the variable $\overline{LowCap}_{pt}$ is at the heart of credit misallocation: if banks are weak, healthy firms receive less credit and zombies can more easily roll over their loans. This in turn should impact the growth rates of the two kind of firms, possibly in opposite directions. With more credit, zombies can expand operations (or contract less), while healthy firms have to find alternative sources of finance (internal or external) to sustain their growth at the margin. Moreover, as discussed above, subsidizing zombies can have both negative (competition) and positive (aggregate demand and input-output externalities) spillovers on healthy firms. Overall, we expect $\phi_2 > 0$: zombies grow faster the higher the degree of banks under-capitalization. Whether $\phi_1 \gtreqless 0$ is a priori uncertain, and depends on whether healthy firms can find alternative sources of finance, on how strong their demand for credit is and on which externality prevails.

The key identifying assumption is that bank capital is exogenous with respect to the conditions prevailing in a province-sector-year. There are two potential challenges to this assumption. First, there might be reverse causation: weakness in the province-sector-year may cause losses on the loan portfolio and erode bank capital. This is unlikely, however, because the banks in our sample are active in several province-sectors. The average bank is active in about 48% of sector-provinces (the median is very similar). Moreover, the share of lending in a given province-sector, as a fraction of the total loan portfolio of a single bank, remains very small even in the largest province-sectors. At the 95-th percentile of the distribution, the share of lending is 1.39%, and it reaches 6.46% only at the 99-th percentile. Shares of banks' loan portfolio above 5% are concentrated in a handful of sectors, such as construction or wholesale and retail trade, characterized by the presence of some very large firms, and in the provinces in which these large firms have their headquarter (the great majority of these are in Milan, Rome and Turin, the largest cities in the country). Large concentrations of a banks' portfolio also occur in the case of small banks whose operations are geographically concentrated. For banks with assets valued more than 50 billion euros, the share of the loan portfolio is above 5% in only 55 province-sector-year cells (out of 18,809 year-sector-province cells). To check that bank capital is not materially affected by local conditions, we constructed a measure of local shocks as the estimated year-province-sector-fixed effects in a regression where the dependent variable is sales growth at the firm level. Appendix Table A9 shows that a distributed lag of these shocks is not correlated with the banks' capital ratio.[13]

The second potential challenge to identification is that the shares of credit might be correlated with local-sectoral shocks. For example, when a negative shock hits a province-sector, low-capital banks might expand their credit shares (i.e. the weights in $Lowcap_{pt}$ change). To account for this possibility, we also construct an alternative measure of bank weakness based on the share of loans in the pre-crisis period. Specifically, we compute

$$\widehat{LowCap}_{pt} = \frac{\sum_j LowCap_{jt} * Credit_{jp04-07}}{\sum_j Credit_{jp04-07}}, \tag{4}$$

where $Credit_{jp04-07}$ is the total credit that bank $j$ extended to province-sector $p$ in the period 2004-2007, while $LowCap_{jt}$ is the end of period $t$ dummy variable. For this variable, credit shares are fixed at their pre-crisis average values, so that they are by construction exogenous with respect to shocks that occur during the crisis. It turns out that the shares are fairly stable: the correlation between $\widehat{LowCap}_{pt}$ and $\overline{LowCap}_{pt}$ is 0.83. In what follows, we use $\overline{LowCap}_{pt}$ as our main variable, as it represents a more accurate description of the credit condition at the sectoral-local level during the crisis. Appendix Tables A11 and A12 replicate the regressions using $\widehat{LowCap}_{pt}$ instead of $\overline{LowCap}_{pt}$ as regressor; the results are very similar.

[13] As a robustness check, we also run our tests excluding province-sector-year cells in which at least one bank has a share of its loan portfolio above 5%, as well as the whole province-sector in which at least one bank has a share of its loan portfolio above 5% in any year. The results are very similar to those based on the whole sample. We therefore maintain that the conditions prevailing in a province-sector-year are unlikely to be inducing significant variations in bank capital during the year.

### 4.1.2 Results

The results of estimating equation (2) are displayed in Table 4 for the growth rates of labor (expressed as log differences of the wage bill), capital (measured by the permanent inventory method) and sales.[14] For labor, we find no effect of bank capitalization on healthy firms: $\phi_1$ is small and statistically insignificant. The coefficient $\phi_2$ is instead positive and highly significant: under-capitalized banks increase labor expansion of zombie firms relative to healthy firms. Using the estimated coefficient of 0.038 on $\overline{LowCap}_{pt} * Z_{it}$ in column (1), increasing the capitalization of the weak banks so that they are all above the threshold used to define a weak bank (i.e. so that $\overline{LowCap}_{pt} = 0$) would imply that zombie firms would decrease the growth of their wage bill by 1.6% relative to healthy firms. Given that the coefficient of healthy firms is basically zero, these relative effects can be directly interpreted as absolute effects as well.

To assess if our estimates are robust to the presence of local-sectoral shocks, Column (2) also includes province-sector-year dummy variables. The estimate of $\phi_2$ is unaffected, suggesting that local shocks are not a major concern. Of course, we cannot infer anything about the size of the absolute effect, since $\overline{LowCap}_{pt}$ on its own is absorbed by the dummy and $\phi_1$ cannot be estimated.

The remaining columns of Table 4 repeat the same exercise for the growth rates of capital and sales. The results are basically the same, although the point estimates are a bit smaller: no effect of low bank capital on healthy firms, and a positive and significant effect on zombies.

One could argue that, although theoretically sound, our measure of bank capitalization at the industry-province level is an imperfect measure of banks strengths, for example because the province-sector is not the correct representation of the reference group. Moreover, it might also be that the direct credit effects dominate, and that they are better captured by the firm level indicators of banks weakness. To check for this possibility, we have run the credit regressions at the firm level described in Section 3.2.4 and reported in Table 3 using the aggregate indicator $\overline{LowCap}_{pt}$ instead of the firm level indicator. Table A7 in the Appendix shows that this is not a concern: the province-sector measure

[14] We use nominal values but, given that we always include year dummies, regressions with deflated values produce exactly the same results. The wage bill is the only measure of labor inputs directly available in firms' balance sheets. We have also used the number of employees, obtained by matching the Cerved data with those supplied by the Social Security Administration (INPS). Results, reported in Appendix Table A10, are similar, with slightly lower estimates, possibly because the match is not always perfect, as the notion of the firm from the legal and the social security point of view are not perfectly coincident.

of banks weakness has strong predictive power for firms' access to credit of both healthy and zombie firms. The effect is negative for the former and positive for the latter, in line with what obtained with the firm level indicator. This indicates that the lack of effects of bank capitalization at the sector-province level on firm real outcomes is not due to its weak correlation with firms' access to credit: rather, it occurs *despite* being correlated with credit flows. We now explore why this occurs.

We have performed several robustness checks. First, as explained above, we have redefined low-capital banks using the share of credit in the pre-crisis period, as in equation (4). Results, reported in appendix Table A11, are very similar. Second, we have experimented with different sets of dummy variables. Our preferred specification controls for sector-province and year fixed effects. Instead of sector-province fixed effects we included firm fixed effects. In addition, we have also experimented with sector-year and province-year fixed effects. In general, we confirm the overall results, with the only noticeable difference that, for employment growth, when we increase the set of dummies we find some evidence of a negative absolute effect on non-zombies. Third, we have experimented with the alternative definitions of zombies, using Zombie 2 and score, defined in Appendix Table A4. Again, the estimates are very similar. Fourth, to control for firm credit demand, we have added to the regression the firm fixed effects estimated in the bank-firm credit regressions, as in Bonaccorsi di Patti & Sette (2016) and Jiménez, Mian, Peydró & Saurina (2020). Despite losing more than half of the observations (many firms in the Cerved database are not present in the Credit Registry), the estimates remain very similar. All these results are available upon request.

These findings suggest that the extra credit obtained from weak banks allows zombie firms to contract less than they would have otherwise, during a deep aggregate recession. The positive estimated coefficient on sale growth, in particular, can be interpreted as saying that zombies are using bank credit to pay for working capital, and hence avoid a sharper contraction in production. Regressions of intermediate expenditures (not shown for brevity) display the same pattern, supporting this interpretation.

But why don't we see a negative effect of low bank capital on the growth performance of healthy firms, given that they receive less credit from under-capitalized banks? A first answer is that healthy firms may have enough cash to cover their working capital, or they may be able to find alternative sources of finance. Table 5 lends support to this explanation. Here the dependent variables are the growth rates of trade debt, non-bank debt, cash holdings and a dummy variable equal to one if the firm received an equity injection in the year. Healthy firms operating in an environment of low bank-capital use internal resources more intensely: the estimate of $\phi_1$ is negative and significant at 10% level in column 5, implying that they reduce their cash holdings. The use of sources of external finance different from bank borrowing does not differ between zombies and non-zombies, independently from banks capitalization (see columns 1-4 for trade debit and non bank debt). The noticeable exception is the equity dummy, where $\phi_1 > 0$, $\phi_2 < 0$ and we cannot reject that $\phi_1 + \phi_2 = 0$. This implies that healthy firms exposed to a weak banking sector are more likely to demand equity injections from their shareholders, but this does not occur for zombies.

A second, potentially more interesting, answer is that, in such a deep and prolonged recession, the spillover effects on healthy firms from keeping more zombie firms alive could be positive, rather than negative, because of aggregate demand and input-output externalities. We now present some evidence supporting this interpretation.

#### 4.1.3 Spillover effects

**Supply chains** A recent literature argues that, through input specificities and production complementarities, supply chains propagate economic shocks across firms and sectors (Barrot & Sauvagnat 2016, Acemoglu & Tahbaz-Salehi 2020). If so, zombie lending can exert positive externalities in upstream or downstream sectors, because it prevents or delays bankruptcies and it attenuates production cuts by weaker firms. To explore this mechanism, we construct a measure of propagation of zombie lending to the downstream sectors. Specifically, following Alfaro, García-Santana & Moral-Benito (2020), we define propagation to the downstream sector for firm $i$ in area (province) $a$ sector $s$ and year $t$ as:

$$DOWN_{isat} = \omega_{it} * \sum_k IO_{ks} * \overline{LowCap}_{kat} * ShZ_{kat} \tag{5}$$

where $\omega_{it}$ is total input intensity (defined as intermediates/(intermediates+wage bill)), $IO_{ks}$ is the (direct) coefficient of the IO matrix of inputs from sector $k$ to sector $s$, $\overline{LowCap}_{kat}$ is the share of credit in year $t$ from low capitalized banks in province-sector $a, k$ as defined above, and $ShZ_{kat}$ is the share of zombie firms in $k, a, t$. Thus, this indicator captures the exposure of firm $i$ to zombie lending to its suppliers. It equals 0 if all suppliers of sector $s$ consist of healthy firms or if they receive credit from strong banks, and it rises up to 1 if amongst suppliers of sector $s$ there are many zombie firms borrowing from under-capitalized banks. IO coefficients are obtained from the IO table of the national statistical institute (ISTAT) based on 63 sectors, aggregated to the sectoral classification we use in the paper. The procedure of sectoral aggregation is described in the Appendix.

We then add this variable as a covariate in the firm growth regressions (equation 2). The results are reported in Table 6. The variable $DOWN$ always has a positive and significant estimated coefficient, providing robust evidence that zombie lending has positive effects on downstream firms, presumably because it preserves the supply chain. The estimate of Column 2, which includes province-sector-year fixed effects, implies that one standard deviation increase in $DOWN$ (0.03) would rise employment growth by 0.6%. The effect is substantially stronger on sales. A possible explanation is that disruption of the supply chains reduces firm's output, but adjustment costs prevent a corresponding reduction in labor and capital. Another possibility is that, as upstream suppliers reduce their output, a downstream firm responds by partially substituting intermediates with capital and labor. Finally, once we account for these IO effects, the direct effect of low bank capitalization on healthy firms turns negative for capital and sales, providing further support for the relevance of this channel.

Unfortunately we don't have data on exports, and so we cannot follow Alfaro et al. (2020) and compute the equivalent measure of upstream propagation (i.e. of zombie lending amongst customers of firm $i$) that also varies at the firm level. We constructed a sectoral indicator of propagation to the upstream sector, defined as: $UP_{sat} = \sum_k IO_{ks} * \overline{LowCap}_{kat} * ShZ_{kat}$ where now the IO coefficients refer to purchases of sector $k$ from sector $s$. The coefficient on this sectoral variable can only be estimated if we do not include province-sector-year fixed effects, however. Doing so, and including both $DOWN$ and $UP$ in the regression, leaves the estimated coefficient on $DOWN$ unaffected, and results in a negative estimated coefficient on $UP$ (results available upon request). This might be due to the fact that we do not measure domestic sales and cannot compute the correct measure of upstream propagation of Alfaro et al. (2020), who, in any case, only find evidence of downward propagation, as we do.

**Local demand externalities** By keeping zombie firms alive or more active, lending by under-capitalized banks can exert positive aggregate demand externalities on other firms, dampening output contraction during a recession. These demand externalities are more relevant in non-tradable sectors, where demand is typically local. To assess the importance of this mechanism, we allow the effects of low bank capital to differ between manufacturing and services firms. Our prior is that manufacturing is less dependent on the local market than services. As a consequence, if aggregate demand externalities matter, we should find that services firms benefit more from undercapitalized banks lending in their province-sector. This is exactly what we find. Table 7 reports our basic regressions, having added an interaction between the variable $\overline{LowCap}$ and a dummy variable if the firm operates in services. Now the estimated coefficient of $\overline{LowCap}$ turns negative when the dependent variable is labor or sales, implying that manufacturing firms do suffer from low capitalized banks in their province-sector. The interaction between $\overline{LowCap}$ and services, on the other hand, has a positive and highly significant estimated coefficient: relative to manufacturing firms, firms in services benefit from an undercapitalized banking sector. When the dependent variable is capital, these signs are preserved but the estimated coefficients are no longer statistically significant.

Finally, Huber (2018) has shown that shocks to credit supply can have real effects also through agglomeration externalities. Since such externalities are more relevant in knowledge intensive sectors, we have allowed low bank capital to have different effects in sectors with high vs low innovation, using the technological classification of Huber (2018). Results (available upon request) do not support the hypothesis that the zombie lending preserves agglomeration externalities, possibly because of the limited span of our sample: in fact, the effects of agglomeration externalities on innovation should become visible on the medium run.

## 4.2 Firm failure

The previous regressions focus on the intensive margins, that is, firm's growth conditional on survival. But credit misallocation also affects the extensive margin, since banks financing decisions determines firms survival.[15] In fact, the term "zombie" is meant to indicate a non-viable firm that survives only thanks to bank lending. In this subsection we study how bank capital affects the bankruptcy rate of healthy and zombie firms in the same province-sector-year.

The Firm Register reports the status of firms, signaling those failed or undergoing a legal procedure due to financial distress, typically leading to failure. We focus on failure, rather than overall exit, because the latter also includes voluntary firm closures without financial distress. We define the year of failure as the last year in which the firm files

[15] An additional channel could occur through entry, if zombie lending depresses firms' entry. Differently from the exit analysis, that can be carried out at the firm level accounting for the zombie status, we do not observe potential entrants. In a series of unreported regressions, we have performed the analysis at the aggregate province-year-sector level, regressing observed entry rates on $\overline{LowCap}$. We did not find any robust correlation between entry and banks capital ratios.

its balance sheets. As legal failure is often reported with some delay, to avoid censoring towards the end of our sample period, we use data up to 2011 and only consider firms for which failure is reported within two years of observing the last balance sheet. During this period, the overall failure rate is 2.9% (2% for non-zombies and 7% for zombies).

To analyze the effects on the survival probability, we estimate the following regression:

$$F_{ipt} = \gamma_0 + \gamma_1 \overline{LowCap}_{pt} + \gamma_2 Z_{it} * \overline{LowCap}_{pt} + \gamma_3 Z_{it} + Dummies + \nu_{ipt} \tag{6}$$

where $F_{ipt}$ is a dummy variable equal to 1 if firm $i$ in sector-province $p$ exits through a bankruptcy procedure in year $t$. We expect that low capital banks reduce the failure rate of zombies ($\gamma_1 + \gamma_2 < 0$) at the expenses of healthy firms ($\gamma_1 > 0$).

We start with a linear probability model, as probit models are problematic to estimate with a large number of fixed effects. As before, we cluster standard errors at the province-sector level. Table 8 reports the results. In column (1) we use separate year and province-sector fixed effects. We find that $\gamma_1 = 0.444$ and significant at the 5% level, which implies that a larger share of undercapitalized banks increases the failure rate of healthy firms. The effect is opposite for zombies: $\gamma_2 = -1.407$. Moreover, we reject the null hypothesis that $\gamma_1 + \gamma_2 = 0$, meaning that low capital banks increases not only the relative but also the absolute survival probability of zombies.[16] The relative effect on zombies is very similar in column (2), where we control for province-sector-year fixed effects, signalling that reverse causality is not likely to be an issue. Finally, in column (3) we estimate a probit model using the more parsimonious dummy specification, that is, with separate year and province-sector dummies. The marginal effects fully confirm the results of the linear probability model. In terms of the magnitude of the effects, the estimates of column (1) imply that increasing the capital ratio of all banks above the median would increase the failure rate of zombies by 0.4% and decrease that of healthy firms by 0.2%. This represents a reduction of approximately one tenth in the failure rate of healthy firms in the period.[17]

As before, we have performed the analysis replacing $\overline{LowCap}_{pt}$ with $\widehat{LowCap}_{pt}$ as defined in equation (4). Table A12 in the appendix shows that the results change only

[16] Results are confirmed when we add sector-year and province-year fixed effects.

[17] As one would expect, the positive effect of low bank capital on the failure rate of "healthy" firms is due to weakest firms that are classified as "healthy". We have created a dummy variable that equals one if a non zombie firm has both leverage above and ROA below the median of all non zombie firms. If we include this dummy variable and its interaction in the failure regressions, the effect of bank capital on healthy firms is no longer significant, while it remains negative and significant for zombies. Moreover, the dummy variable and its interaction with low bank capital both have a positive and significant estimated coefficient, indicating that these weaker (but non zombie) firms are those most at risk of failure due to low bank capital.

marginally.

## 4.3 Productivity dispersion

We now turn to a third implication of credit misallocation: an increase in the dispersion of productivity across firms. TFP dispersion has become the standard measure of misallocation since the seminal contribution of Hsieh & Klenow (2009) who, following Foster, Haltiwanger & Syverson (2008), distinguish between physical TFP (computed on physical quantities) and revenue TFP (computed on revenues). In their model, monopolistic competition implies that, even if firms are heterogeneous in their physical TFP, revenue TFP should be equalized across firms, as more efficient firms expand their scale of operation, thus decreasing pricing and, through this, revenue TFP. This process is inhibited by frictions that prevent the efficient allocation of inputs of production: the larger are the frictions, the more dispersed is revenue TFP. In our case, the friction is an inefficient allocation of credit across firms that stems from low bank capital. We thus assess whether low bank capital is associated with an increase in (revenue) TFP dispersion.

We compute revenue TFP (TFPR from now on) at the firm level assuming a constant return to scale Cobb-Douglas production function of the form $Y = TFPR * L^{\alpha} * K^{1-\alpha}$ where Y is value added, L labor and K the capital stock. We estimate the labor coefficient as the labor share at the sectoral level: $\alpha = \frac{wL}{Y}$, which varies between a maximum of 0.66 in Vehicles to a minimum of 0.35 in Electricity, gas and water. The labor input is measured as the wage bill and the capital input is computed using the permanent inventory method. We first compare the TFPR of zombies and non-zombies. As expected, we find that the average log TFPR is substantially higher in healthy firms, with a log difference of almost 0.5. There is also evidence that the dispersion is higher among zombies firms: 0.71 against 0.61 for non-zombies. Reallocating inputs from zombies to non-zombies, therefore, should reduce the dispersion.

We turn to testing whether the extent of misallocation due to banks' lending choices affects the dispersion of TFPR, using the following model:

$$SD(TFPR)_{pt} = \lambda_0 + \lambda_1 \overline{LowCap}_{pt} + \lambda_2 \Delta TFPR_{pt} + Dummies + \mu_{pt} \tag{7}$$

Again, we use the share of credit originated by banks with capital ratio below the median, $\overline{LowCap}_{pt}$ to proxy for the intensity of the misallocation of credit. As argued above, this variable is likely to be exogenous with respect to local conditions, and directly captures the health of the banking sector at the local-sectoral level. We include province-sector and year dummies, as well as the change in average TFPR at the province-sector level, $\Delta TFPR_{pt}$, to control for local shocks (results are similar if we exclude this control). The estimates, reported in column (1) and (2) of Table 9, yield no evidence that banks' capital had any impact on misallocation: the coefficient $\lambda_1$ is always negative, but very small in absolute value and statistically insignificant.

Nevertheless, one can argue that what really matters is the interaction between the banks' capital ratio and the presence of zombies. That is, weak banks misallocate credit only if a market is populated by zombies: in sector-province with only strong firms, there is no scope for diverting credit to unhealthy firms. To test this implication, we run the following regression:

$$\begin{aligned} SD(TFPR)_{pt} = \lambda_0 + \lambda_1 \overline{LowCap}_{pt} + \lambda_2 \Delta TFPR_{pt} + \lambda_3 \overline{LowCap}_{pt} * ShZ_{pt} + \\ + \lambda_4 ShZ_{pt} + Dummies + \omega_{pt} \end{aligned} \tag{8}$$

where $ShZ_{pt}$ is the share of zombies over the total number of firms in $pt$, and test the hypothesis that the interaction coefficient $\lambda_3$ is positive. The results are in the last two columns of Table 9. First, the share of zombies itself is not significant while that of $\overline{LowCap}_{pt}$ is negative and significant, implying that, in the absence of zombies, low capitalization decreases TFPR dispersion. The interaction between $\overline{LowCap}_{pt}$ and the share of zombies always has a positive and significant impact on the dispersion of TFPR, as expected. This means that, during the crisis, the combination of a larger population of zombies and of weaker banks was positively related to the dispersion of TFPR. Given that $\partial SD(TFPR)_{pt}/\partial \overline{LowCap}_{pt} = \lambda_1 + \lambda_3 ShZ_{pt}$, using the estimate of the last column we find that an increase in $\overline{LowCap}$ increases dispersion if the share of zombie firms is above 22%, which happens in around 44% of the province-sector-years. This indicates that low bank capitalization increases TFPR dispersion only in the presence of a fairly large population of zombies.[18] All in all, we therefore conclude that low capitalization of banks is responsible for only a modest misallocation of resources, measured in terms of TFPR dispersion. This is in line with some recent analyses of the evolution of misallocation in Italy at the aggregate level, which find that, if anything, it has slightly decreased during the crisis (Calligaris et al. 2018, Linarello & Petrella 2016). Again, all results are confirmed when using the indicator of banks weakness based on the pre-crisis credit shares (see appendix Table A13).

[18]The weak correlation between bank capitalization and TFPR dispersion is confirmed by the fact that, when we increase the set of dummies including sector-year and province-year fixed effects, we tend to loose statistical significance.

## 4.4 The Aggregate Effects of Low Bank Capital

Putting all the pieces together, what would be the aggregate effects of recapitalizing the banking system so as to reduce the extent of zombie lending? In this section we propose a simple stylized framework that allows us to determine some bounds on the answer to this question. We compute the counterfactual GDP growth that would have occurred during the crisis if all banks had a capital ratio above the median. This correspond to a decrease of $\overline{LowCap}$ from its average value of 0.241 to zero.[19] The details of the computations are in Appendix A.

This quantitative exercise suggests that recapitalizing the weaker banks so as to eliminate zombie lending would have increased yearly output growth by at most 0.1% during the crisis period 2008-2013. During this same period, yearly output growth was on average -3.7% in our sample of firms. Even under the most extreme assumption of zero productivity of zombies, therefore, zombie lending can explain only a very small fraction of this drop. Thus, taken at face value, these results suggest that the credit misallocation induced by zombie lending was not a key factor in aggravating the deep GDP contraction recorded by the Italian economy during the great recession. Other developments, such as the drop in aggregate demand and the overall contraction of credit –rather than its misallocation to weak firms– are likely to be at the heart of the recession.

## 4.5 Why do our results differ from those of the previous literature?

Our main result, that credit misallocation and zombie lending have at most a modest real effect, in absolute terms and more specifically on the relative performance of healthy firms, runs counter the received wisdom in some of the existing literature. In particular, Caballero et al. (2008), Acharya et al. (2019), and McGowan et al. (2018) argue that keeping zombie firms alive (or preventing them from shrinking) imposes substantial costs on healthy firms, because it reduces credit availability and it amounts to a subsidy to inefficient firms (see our previous discussion on the spillover effects). These different conclusions could reflect estimates based on a different sample - in Japan in particular, zombie lending occurred during a prolonged period of slow recovery, rather than in the midst of a severe recession. But the different findings are also due to a different empirical approach, that might have led previous contributions to overestimate the adverse real

[19] To bring all banks at the median in all years of our baseline sample, it would be necessary to inject 9.2 billion euros in the system (this is computed considering the largest capital short-fall for a bank if the bank has capital below the pre-crisis median in more than one year).

effects of zombie lending.

Consider again the analysis of growth at the intensive margin in subsection 5.1. Rather than estimating equation (2) above, the previous literature estimates a similar regression, except that the variable $\overline{LowCap_{pt}}$ is replaced by the share of zombies in area-sector $p$ at $t$, say $ShZ_{pt}$. The key identification problem in estimating such a regression is that the share of zombies is correlated with shocks affecting the performance of both zombies and non-zombies, such as demand shocks. An adverse demand shock in area-sector $p$ is bound to increase the share of zombies and also negatively affects the performance of firms operating in the same area-sector. This problem is well understood by the literature, and Caballero et al. (2008), Acharya et al. (2019) and McGowan et al. (2018) specify the vector of dummy variables as a full set of country-sector-year dummies (in our setting this is a set of province-sector-year dummies). As explained above, such specification takes care of demand shocks, but can only estimate the coefficient $\phi_2$ that refers to the *relative* performance of zombies and non-zombies. Thus, unlike in our framework, nothing can be said about the absolute performance of healthy or zombie firms.

There is also another, more fundamental identification issue that makes this framework problematic to identify the spillover effects of zombies on healthy firms. As shown by Schivardi et al. (2020), even if zombies exert no negative spillover effect on healthy firms, an aggregate adverse shock typically deteriorates the average performance of non-zombies relative to zombies. Thus, a negative estimated coefficient $\phi_2$ cannot be interpreted as evidence of negative externalities emanating from zombie firms. To see the intuition, consider a population of firms with heterogeneous performance, where firms below a certain performance level $T_Z$ are classified as zombies. When a negative shock hits, the distribution of performance shifts to the left, as in Figure 2. In Schivardi et al. (2020) we show that, for a large class of distributions typically used to model heterogeneous firms performance, this shift to the left also reduces the gap in average performance of zombie vs healthy firms. This is a mechanical effect that occurs if the performance threshold $T_Z$ defining zombie firms is to the left of the mode of the distribution of firm performances. Intuitively, the composition of the groups of healthy and of zombie firms is altered, and this results in a reduction in the difference between the group means. Thus, a negative correlation between the share of zombies and the relative performance of healthy vs zombie firms, that is, a negative estimate of $\phi_2$ in Equation 2 - cannot be interpreted as evidence that a larger share of zombies hurts healthy firms. It is simply a mechanical consequence of the fact that, under general conditions, an aggregate shock affects the performance of all firms, but with different intensity along the performance distribution.

To confirm the relevance of this point in our sample, we have replicated the regressions run by the previous literature of firm performance on the share of zombies at the province-sector-year levels. The results are in line with those in the literature. Appendix Table A14 reports firm-level regressions of the growth in labor, capital and sales on the share of zombie firms at the province-sector-year level, by itself and interacted with a dummy for zombie firms. In odd columns we control for province-sector and year fixed effects, so we can estimate both $\phi_1$ and $\phi_2$ in equation (2). We find that, as the share of zombies increases, all performance measures deteriorate more for non zombie firms than for zombies. This result survives the inclusion of a full set of province–sector-year dummies (even columns), in which case we can only identify the relative effects between zombies and non-zombies. As in the previous literature, we also find that the relative performance of non-zombies gets worse as the share of zombies increases.

Despite the substantial differences in the settings, particularly in terms of firms included in the exercise (listed firms for the other papers, all firms in our case) and definition of reference group (country-sector-year vs. province-sector-year), the magnitudes are also comparable to those in the literature, particularly with Caballero et al. (2008), who find a coefficient on the share of zombies in the employment growth regression of -0.045 and on the interaction between the share of zombies and the non zombie dummy of -0.023 (see their Table 3, Column 2). Mapping our specifications in theirs,[20] our estimates in Table A14 imply corresponding values of -0.043, very close, and of -0.06, larger in absolute value. This might be due to the much finer geographical definition of our analysis. The results in Columns 1 and 2 of Appendix Table A14 are clear cut: the negative relationship between the share of zombies and the relative performance of non-zombies is a very robust empirical finding also in our setting. Unfortunately, it cannot be interpreted as evidence of negative spillovers from zombies to non-zombies. Our approach in this paper exploits a different source of variation unrelated to local shocks (low bank capital, rather than the share of zombies), and this explains why we get very different results.

Another paper that finds negative effects of troubled banks on firms growth is Blattner et al. (2018) for Portugal. There are however important differences between their approach and ours that limit comparability. First, they use different definitions of weak banks (banks that were subject to the 2012 EBA capital increase requirement) and weak firms

[20]Caballero et al. (2008) use the specification $\Delta y_{ipt} = \tilde{\phi}_0 + \tilde{\phi}_1 \overline{ShZ}_{pt} + \tilde{\phi}_2 NZ_{ipt} * \overline{ShZ}_{pt} + ...$, while we use $\Delta y_{ipt} = \phi_0 + \phi_1 \overline{ShZ}_{pt} + \phi_2 Z_{ipt} * \overline{ShZ}_{pt} + ...$, so that $\tilde{\phi}_1 = \phi_1 + \phi_2$ and $\tilde{\phi}_2 = -\phi_2$.

(firms on which banks were underreporting delays in payments). Second, they use a different approach to assess the real effects of banks undercapitalization. Specifically, in a first exercise they regress firm performance on credit growth, instrumenting the latter with the quality of the pool of banks the firm is borrowing from. This specification only focuses on the direct effects of credit, rather than factoring in also potential spillover effects, as we do.[21] Moreover, they do not allow the effects of banks strength to differ for weak and healthy firms, something that we show to be important in our context. In a second exercise, they run a separate regression of performance of healthy firms on the sectoral share of underreported firms (which correspond to our zombies). Acknowledging our critique to this analytical framework, they instrument such share with the sectoral average borrowing share from EBA banks (which corresponds to $\overline{LowCap}$ in our framework). While an important step forward compared to the traditional approach, using only sectoral variability can still be problematic if exposure to the EBA shock is correlated with the sectoral specialization of bank lending (e.g. banks more exposed to construction or real estate firms may be more likely to be required to increase capital). Moreover, for the small and medium enterprises in our sample, spillover effects are likely to have an important geographical component. As explained in Section 4.1.1, our approach of using the sector-province as the relevant market addresses both concerns. Further work will be needed to understand if the different results reflect differences between the two economies (Italy vs. Portugal), in the period under consideration (we only focus on the crisis years), or in the empirical strategy.

# 5 Concluding remarks

This paper explores the consequences of under-capitalization of Italian banks during the Eurozone financial crisis. We find that banks with low capital cut credit more aggressively to healthy firms (but not to zombie firms), and are more likely to prolong a credit relationship with zombie firms, compared to well capitalized banks. The effect is only present during the crisis years and its aftermath, and it only concerns regulatory capital (and not other indicators of bank weakness). Capital requirements became more demanding during and after the crisis years, also in association with the transition of bank supervision from national to European authorities. Hence our results suggest that the misallocation

[21] As shown above, when we use firm level indicators of banks healthiness we find that they are dominated by the market level ones. We have also tried some IV regressions similar to theirs, finding qualitatively similar but statistically weak results.

of credit towards non-viable firms by under-capitalized banks may have been a reaction to the tighter regulatory environment, as weaker banks attempted to hide losses in order to delay recapitalization to more favorable circumstances.

This misallocation of credit has effects on the real economy. Bank capitalization affects the composition of bankruptcies. In province-sectors where lending is predominantly done by weaker banks, zombie firms are more likely to survive, and healthy firms are more likely to fail, compared to province sectors with stronger banks. We also observe a greater dispersion of TFP if banks are weaker, although this effect is present only if the share of zombie firms in the province-sector-year is sufficiently large.

Nevertheless, and contrary to previous results in the literature, we find no evidence that the growth of healthy firms is hurt by bank weakness. We do find that bank weakness induces a lower growth rate of healthy firms relative to zombies, in line with the previous literature. But this happens because weak banks allow zombies to grow faster (or more precisely to contract less), whereas the effect of bank under-capitalization on the growth rate of healthy firms is close to zero. As a consequence, we estimate that a counterfactual bank recapitalization would have had only negligible positive effects on aggregate growth during the crisis years. We also provide evidence of the mechanisms behind this finding. Preventing zombie firms from shrinking or going bankrupt during the recession mitigated negative externalities due to the disruption of supply chains and to reductions in local aggregate demand. Moreover, the evidence also suggests that healthy firms exposed to under-capitalized banks were nevertheless able to finance ongoing operations with their cash and injecting new equity, while their demand for new capital was very low due to the severity of the recession.

All in all, this suggests that bank-undercapitalization may be costly in terms of misallocation of capital and productive efficiency in the medium term, but this credit misallocation cannot be blamed for aggravating the recession induced by the Eurozone financial crisis.

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# References


Acemoglu, D. & Tahbaz-Salehi, A. (2020), Firms, failures, and fluctuations: the macroeconomics of supply chain disruptions. NBER Working Paper No. 27565.

Acharya, V. V., Eisert, T., Eufinger, C. & Hirsch, C. W. (2019), 'Whatever it takes: The real effects of unconventional monetary policy', *The Review of Financial Studies* **32**, 3366–3411.

Ahearne, A. G. & Shinada, N. (2005), 'Zombie firms and economic stagnation in Japan', *International Economics and Economic Policy* **2**, 363–381.

Albertazzi, U. & Marchetti, D. J. (2010), 'Credit supply, flight to quality and evergreening: An analysis of bank-firm relationships after Lehman', *Bank of Italy Temi di Discussione (Working Paper) No* **756**.

Alfaro, L., García-Santana, M. & Moral-Benito, E. (2020), 'On the direct and indirect real effects of credit supply shocks', *Journal of Financial Economics* .

Amiti, M. & Weinstein, D. E. (2018), 'How much do idiosyncratic bank shocks affect investment? Evidence from matched bank-firm loan data', *Journal of Political Economy* **126**(2), 525–587.

Balduzzi, P., Brancati, E. & Schiantarelli, F. (2018), 'Financial markets, banks' cost of funding, and firms' decisions: Lessons from two crises', *Journal of Financial Intermediation* **36**, 1–15.

Banca d'Italia (2008), Circolare 272.

Barrot, J.-N. & Sauvagnat, J. (2016), 'Input specificity and the propagation of idiosyncratic shocks in production networks', *The Quarterly Journal of Economics* **131**(3), 1543–1592.

Blattner, L., Farinha, L. & Rebelo, F. (2018), When losses turn into loans: The cost of undercapitalized banks. Mimeo. Stanford GSB.

Bonaccorsi di Patti, E. & Sette, E. (2016), 'Did the securitization market freeze affect bank lending during the financial crisis? Evidence from a credit register', *Journal of Financial Intermediation* **25**, 54–76.

Borio, C. E., Kharroubi, E., Upper, C. & Zampolli, F. (2016), Labour reallocation and productivity dynamics: Financial causes, real consequences. BIS Working Paper.

Caballero, R. J., Hoshi, T. & Kashyap, A. K. (2008), 'Zombie lending and depressed restructuring in Japan', *American Economic Review* **98**, 1943–77.

Calligaris, S., Del Gatto, M., Hassan, F., Ottaviano, G. I. & Schivardi, F. (2018), 'The productivity puzzle and misallocation: an italian perspective', *Economic Policy* **33**(96), 635–684.

Detragiache, E., Garella, P. & Guiso, L. (2000), 'Multiple versus single banking relationships: Theory and evidence', *Journal of Finance* **55**(3), 1133–1161.

Foster, L., Haltiwanger, J. & Syverson, C. (2008), 'Reallocation, firm turnover, and efficiency: Selection on productivity or profitability?', *American Economic Review* **98**, 394–425.

Fukao, K. & Ug Kwon, H. (2006), 'Why did Japan's TFP growth slow down in the lost decade? An empirical analysis based on firm-level data of manufacturing firms', *Japanese Economic Review* **57**, 195–228.

Fukuda, S. & Nakamura, J. (2011), 'Why did zombie firms recover in Japan?', *The world economy* **34**(7), 1124–1137.

Gamberoni, E., Giordano, C. & Lopez-Garcia, P. (2016), Capital and labour (mis) allocation in the Euro area: Some stylized facts and determinants. ECB working paper series No. 1981.

Gobbi, G. & Sette, E. (2013), 'Do firms benefit from concentrating their borrowing? Evidence from the great recession', *Review of Finance* **18**(2), 527–560.

Gopinath, G., Kalemli-Özcan, Ş., Karabarbounis, L. & Villegas-Sanchez, C. (2017), 'Capital allocation and productivity in south europe', *The Quarterly Journal of Economics* **132**(4), 1915–1967.

Guiso, L., Pistaferri, L. & Schivardi, F. (2013), 'Credit within the firm', *The Review of Economic Studies* **80**(1), 211–247.

Hoshi, T. (2000), Naze nihon wa ryudosei no wana kara nogarerarenainoka?(Why is the Japanese economy unable to get out of a liquidity trap?), *in* M. Fukao & H. Yoshikawa, eds, 'Zero Kinri to Nihon Keizai (Zero Interest Rate and the Japanese Economy)', Tokyo: Nihon Keizai Shimbunsha, pp. 233–266.

Hsieh, C.-T. & Klenow, P. J. (2009), 'Misallocation and manufacturing TFP in China and India', *The Quarterly Journal of Economics* **124**(4), 1403.

Huber, K. (2018), 'Disentangling the effects of a banking crisis: Evidence from German firms and counties', *American Economic Review* **108**(3), 868–98.

Iyer, R., Peydró, J.-L., da Rocha-Lopes, S. & Schoar, A. (2014), 'Interbank liquidity crunch and the firm credit crunch: Evidence from the 2007–2009 crisis', *Review of Financial studies* **27**(1), 347–372.

Jiménez, G., Mian, A., Peydró, J.-L. & Saurina, J. (2020), 'The real effects of the bank lending channel', *Journal of Monetary Economics* **115**, 162–179.

Khwaja, A. I. & Mian, A. (2008), 'Tracing the impact of bank liquidity shocks: Evidence from an emerging market', *The American Economic Review* **98**(4), 1413–1442.

Linarello, A. & Petrella, A. (2016), Productivity and reallocation. Evidence from the universe of Italian firms. Questioni di Economia e Finanza No. 353.

McGowan, M. A., Andrews, D. & Millot, V. (2018), 'The walking dead? Zombie firms and productivity performance in OECD countries', *Economic Policy* **33**.

Mian, A., Sufi, A. & Trebbi, F. (2015), 'Foreclosures, house prices, and the real economy', *The Journal of Finance* **70**(6), 2587–2634.

Midrigan, V. & Xu, D. Y. (2014), 'Finance and misallocation: Evidence from plant-level data', *The American Economic Review* **104**(2), 422–458.

Moll, B. (2014), 'Productivity losses from financial frictions: Can self-financing undo capital misallocation?', *The American Economic Review* **104**(10), 3186–3221.

Paravisini, D., Rappoport, V. & Schnabl, P. (2020), Specialization in bank lending: Evidence from exporting firms. Mimeo, LSE.

Peek, J. & Rosengren, E. S. (2005), 'Unnatural selection: Perverse incentives and the misallocation of credit in Japan', *The American Economic Review* **95**(4), 1144–1166.

Schivardi, F., Sette, E. & Tabellini, G. (2020), ‘Identifying the real effects of zombie lending’, *The Review of Corporate Finance Studies* **9**(3), 569–592.

Storz, M., Koetter, M., Setzer, R. & Westphal, A. (2017), Do we want these two to tango? On zombie firms and stressed banks in Europe.

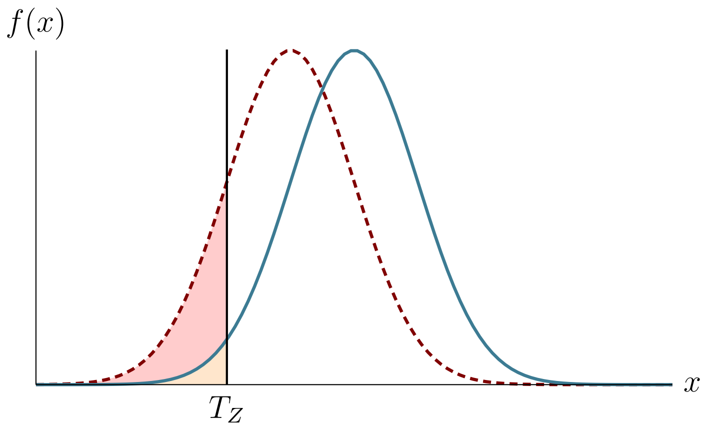
Yang, M.-J. (2011), Micro-level misallocation and selection: Estimation and aggregate implications. Mimeo. UC Berkeley.

# Figures and Tables

Figure 1: Credit to zombies firms and GDP growth


The figure plots the share of zombie firms (left scale) and GDP growth (right scale). Data on credit are from the Credit Register, data on firms are from the firm register (CERVED), GDP growth is from National Statistics (ISTAT). Data cover the period 2004-2013.

Figure 2: The effect of a common shock on zombies and nonzombies




The figure plots two normal distributions with unit variance and mean $\mu_L = 4$ and $\mu_H = 5$, respectively. $T_Z$ is the threshold to be classified as a zombie. Source: Schivardi et al. (2020), pg. 578. By permission of Oxford University Press.

Table 1: Growth of credit, baseline regressions

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Low Cap | -0.880 | -1.653** | -1.659** | -1.208* | | |
| | (0.637) | (0.722) | (0.706) | (0.675) | | |
| Low Cap*Z | 1.553*** | 1.253*** | 1.401*** | 1.392*** | 1.306*** | 0.390 |
| | (0.567) | (0.470) | (0.495) | (0.495) | (0.199) | (0.239) |
| Z | -5.356*** | | | | | |
| | (0.202) | | | | | |
| Share bank | -0.128*** | | -0.223*** | -0.222*** | -0.221*** | -1.914*** |
| | (0.012) | | (0.013) | (0.013) | (0.002) | (0.006) |
| Share credit line | 0.252*** | | 0.141*** | 0.141*** | 0.141*** | 0.284*** |
| | (0.010) | | (0.006) | (0.007) | (0.002) | (0.005) |
| Liquidity ratio | 0.194** | | | 0.292*** | | |
| | (0.086) | | | (0.086) | | |
| Interbank ratio | -0.005 | | | 0.153** | | |
| | (0.056) | | | (0.067) | | |
| Bank Roa | -0.201 | | | -0.976* | | |
| | (0.598) | | | (0.568) | | |
| Bank size | 0.273** | | | -3.851 | | |
| | (0.108) | | | (2.759) | | |
| $H_0$ : Low Cap + Low Cap*Z=0 | | | | | | |
| p-value | 0.478 | 0.645 | 0.765 | 0.826 | - | - |
| Firm FE | Y | N | N | N | N | N |
| Sector*Province*Year FE | Y | N | N | N | N | N |
| Firm*year FE | N | Y | Y | Y | Y | Y |
| Bank FE | N | Y | Y | Y | N | N |
| Bank*Year FE | N | N | N | N | Y | Y |
| Firm*Bank FE | N | N | N | N | N | Y |
| Observations | 2,783,449 | 2,287,690 | 2,287,690 | 2,286,282 | 2,287,683 | 2,107,882 |
| $R^2$ | 0.178 | 0.360 | 0.376 | 0.376 | 0.379 | 0.629 |

The table shows regressions of the change in the log of credit granted (credit commitments) on the dummy for zombie firms (Z), the dummy for banks with capital ratio below the median (LowCap) and their interactions. The median capital ratio is computed on the distribution as of 2008. The change in the log of credit granted is computed as the difference between total credit granted to the firm by the bank in period $t$ and period $t+1$. Firm and bank level controls are measured as of year $t$. The dummy for zombie firm equals one in any given year if, in that year, ROA is below PRIME, and if leverage exceeds 40%. This threshold corresponds to the median value of leverage in 2005 in the sample of firms that exited the market during 2006-2007 (i.e. just before the financial crisis) due to default or liquidation, and that during the previous two years had ROA$<$ PRIME at least once. The capital ratio is the ratio of bank regulatory capital and risk weighted assets. Share bank is the share of total credit to the firm by the bank; Share credit line is the share of overdraft loans out of total loans within the bank-firm relationship. Liquidity ratio is the ratio of cash and government bonds to total assets; Interbank ratio is the ratio of interbank deposits and repos with banks (excluding those with central banks) and total assets; Bank Roa is the ratio of profits to total assets. Bank size is the log of total assets. The first column includes firm and sector*year fixed effects. Columns (2) to (4) include firm*year and bank fixed effects. Column (5) includes firm*year and bank*year fixed effects. The last column includes firm*year, bank*year and firm*bank fixed effects. $LowCap + LowCap * Z$ is the sum of the coefficients in the first two rows in the column. The sample includes years between 2008 and 2013 (the change in log credit in the last year is computed between 2012 and 2013). Standard errors double clustered at the bank and firm level in parentheses in specification shown in columns 1 to 4. They are clustered at the bank-firm level in columns 5 to 6 as this is the dimensions at which the main variable of interest (the interaction Low Cap*Z) varies. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2: Extensive Margin - Interrupting credit relationships and classifying loans as bad or non-performing

| | (1) D(Cut=1) | (2) D(Cut Rev=1) | (3) D(Bad loan=1) | (4) D(Non-perf=1) |
|---|---|---|---|---|
| LowCap | -0.247 | 0.551** | 0.109* | -0.132 |
| | (0.340) | (0.246) | (0.059) | (0.086) |
| LowCap*Z | -0.803*** | -1.430*** | -0.553** | -0.599*** |
| | (0.286) | (0.389) | (0.225) | (0.190) |
| Share bank | -0.268*** | -0.173*** | -0.004*** | 0.006** |
| | (0.006) | (0.005) | (0.001) | (0.003) |
| Share credit line | -0.056*** | 0.000 | -0.000 | 0.007*** |
| | (0.004) | (0.004) | (0.001) | (0.002) |
| Liquidity ratio | -0.141*** | -0.106*** | -0.001 | -0.023 |
| | (0.039) | (0.031) | (0.009) | (0.015) |
| Interbank ratio | 0.124 | -0.044 | 0.021** | -0.028* |
| | (0.127) | (0.030) | (0.008) | (0.015) |
| Bank Roa | -0.318 | -0.161 | -0.012 | 0.119 |
| | (0.295) | (0.122) | (0.070) | (0.138) |
| Bank size | 4.736** | 1.209 | -0.243 | -1.652** |
| | (2.267) | (1.029) | (0.261) | (0.682) |
| $H_0$ : LowCap + LowCap*Z=0 | | | | |
| p-value | 0.007 | 0.056 | 0.030 | 0.001 |
| Firm*year FE | Y | Y | Y | Y |
| Bank FE | Y | Y | Y | Y |
| Observations | 2,636,764 | 2,095,046 | 2,698,744 | 2,698,744 |
| $R^2$ | 0.457 | 0.469 | 0.735 | 0.570 |

The table shows OLS regressions of different outcome variables on the dummy for banks with capital ratio below the median (LowCap) and its interaction with the dummy for zombie firms (Z). The dependent variable in column 1 (D(Cut=1)) is a dummy equal to 100 if a firm has credit from a bank in period t and has no credit from the same bank in period t+1 (i.e. the credit relationship has been severed). The dependent variable in column 2 (D(Cut rev=1)) is a dummy equal to 100 if a firm has a credit line from a bank in period t and has no credit lines from the same bank in period t+1. The dependent variable in column 3 (D(Bad loan=1)) is a dummy equal to 100 if the bank classifies the loan as a bad loan, and zero otherwise, between year t and year t+1. The dependent variable in column 4 (D(Non-perf=1)) is a dummy equal to 100 if the bank classifies the loan as non-performing and zero otherwise, between year t and year t+1. The regressors are defined in the note to Table 1. All columns include firm*year and bank fixed effects. $LowCap + LowCap * Z$ is the sum of the coefficients in the first two rows in the column. The sample includes yearly data between 2008 and 2013 (the change in log credit in the last year is computed between 2012 and 2013). Standard errors double clustered at the bank and firm level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Credit growth – Effect at the firm level

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| LowCap | -0.970*** | -1.216*** | -0.883*** | -1.419*** |
| | (0.234) | (0.229) | (0.231) | (0.173) |
| LowCap*Z | 3.006*** | 3.334*** | 3.292*** | 3.885*** |
| | (0.410) | (0.408) | (0.408) | (0.341) |
| Z | -8.989*** | -8.653*** | -8.639*** | -10.361*** |
| | (0.207) | (0.204) | (0.204) | (0.193) |
| Share bank | | 0.256*** | 0.252*** | 0.682*** |
| | | (0.008) | (0.008) | (0.004) |
| Share credit line | | 0.759*** | 0.758*** | 0.683*** |
| | | (0.008) | (0.008) | (0.006) |
| Liquidity ratio | | | 0.152*** | 0.134*** |
| | | | (0.030) | (0.022) |
| Interbank ratio | | | -0.195*** | -0.004 |
| | | | (0.026) | (0.020) |
| Bank Roa | | | -0.568*** | -0.295*** |
| | | | (0.156) | (0.112) |
| Bank size | | | 0.292** | -0.182** |
| | | | (0.139) | (0.092) |
| $H_0$ : LowCap + LowCap*Z=0 | | | | |
| p-value | 0.000 | 0 | 0 | 0 |
| Firm FE | Y | Y | Y | Y |
| Year FE | Y | Y | Y | Y |
| Observations | 662,187 | 662,187 | 662,187 | 1,223,793 |
| $R^2$ | 0.318 | 0.349 | 0.349 | 0.368 |

The table shows regressions of the change in the log of credit granted (credit commitments) on the dummy for zombie firms (Z), the dummy for banks with capital ratio below the median (LowCap) and their interactions. The median capital ratio is computed on the distribution as of 2008. The change in the log of credit granted is computed as the difference between total credit granted to the firm by all banks in period $t$ and period $t+1$. Firm and bank level controls are measured as of year $t$ and are defined in the notes to Table 1. Bank level and relationship-level controls are averaged at the firm level using the share of credit of the bank as weight. Columns 1 to 3 include the same firms as those included in Table 1 (firms borrowing from at least two banks in both period t and t+1). Column 4 also includes single bank firms. All columns include firm and year fixed effects. $LowCap + LowCap * Z$ is the sum of the coefficients in the first two rows in the column. The sample includes yearly data between 2008 and 2013 (the change in log credit in the last year is computed between 2012 and 2013). Standard errors clustered at the firm level in parentheses.
$p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Firms growth and banks capital ratio

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | ΔLabour | | ΔCapital | | ΔSales | |
| $\overline{\text{LowCap}}$ | 0.000 | | 0.002 | | -0.001 | |
| | (0.007) | | (0.003) | | (0.008) | |
| $\overline{\text{LowCap}}$∗Z | 0.038*** | 0.037*** | 0.028*** | 0.028*** | 0.019*** | 0.021*** |
| | (0.004) | (0.004) | (0.004) | (0.004) | (0.005) | (0.005) |
| Z | -0.058*** | -0.058*** | -0.022*** | -0.022*** | -0.053*** | -0.053*** |
| | (0.002) | (0.002) | (0.001) | (0.001) | (0.002) | (0.002) |
| $H_0$ : LowCap + LowCap*Z=0 | | | | | | |
| p-value | 0 | | 0 | | 0.044 | |
| Prov-Sect FE | Y | N | Y | N | Y | N |
| Year FE | Y | N | Y | N | Y | N |
| Prov-Sect-Year FE | N | Y | N | Y | N | Y |
| Observations | 967,243 | 966,973 | 972,358 | 972,078 | 966,039 | 965,762 |
| $R^2$ | 0.036 | 0.058 | 0.024 | 0.034 | 0.083 | 0.122 |

The table shows regressions of different measures of firm growth on banks capital ratio $\overline{\text{LowCap}}$, defined as the average at the province-sector-year of a dummy equal to one for banks with a capital ratio below the median capital ratio as of 2008. The average is computed using the share of credit in the province-sector-year as weights. The dependent variable is the delta log of the wage bill in column 1-2, of the capital stock computed using the permanent inventory method in columns 3-4, of sales in columns 5-6. The dummy zombie firms (Z) is computed as described in Table 1. Odd columns include province-sector and year fixed effects, while even columns include province-sector-year fixed effects. $LowCap + LowCap * Z$ is the sum of the coefficients in the first two rows in the column. The sample includes yearly data between 2008 and 2013. Standard errors clustered at the province-sector level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Alternative sources of finance and banks capital ratio

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | $\Delta$Trade debt | | $\Delta$Non-bank debt | | $\Delta$Cash | | Dummy Equity Injection | |
| $\overline{\text{LowCap}}$ | -0.006 | | 0.015 | | -0.032* | | 0.012*** | |
| | (0.009) | | (0.017) | | (0.018) | | (0.003) | |
| $\overline{\text{LowCap}}$*Z | -0.004 | -0.005 | -0.007 | -0.005 | -0.006 | 0.003 | -0.016*** | -0.014*** |
| | (0.008) | (0.008) | (0.017) | (0.018) | (0.020) | (0.021) | (0.005) | (0.005) |
| Z | -0.054*** | -0.054*** | 0.086*** | 0.085*** | -0.093*** | -0.095*** | 0.057*** | 0.056*** |
| | (0.003) | (0.003) | (0.006) | (0.006) | (0.006) | (0.006) | (0.002) | (0.002) |
| $H_0$ : LowCap + LowCap*Z=0 | | | | | | | | |
| p-value | 0.328 | | 0.672 | | 0.118 | | 0.458 | |
| Prov-Sect FE | Y | N | Y | N | Y | N | Y | N |
| Year FE | Y | N | Y | N | Y | N | Y | N |
| Prov-Sect-Year FE | N | Y | N | Y | N | Y | N | Y |
| Observations | 838,270 | 837,982 | 362,252 | 361,520 | 874,236 | 873,937 | 1,002,523 | 1,002,266 |
| $R^2$ | 0.015 | 0.036 | 0.007 | 0.031 | 0.005 | 0.017 | 0.023 | 0.034 |

The table shows regressions of different measures of firms' sources of financing on banks capital ratio $\overline{\text{LowCap}}$, defined as the average at the province-sector-year of a dummy equal to one for banks with a capital ratio below the median capital ratio as of 2008. The average is computed using the share of credit in the province-sector-year as weights. The dependent variable is the delta log of trade debit in column 1-2, of non-bank debt in columns 3-4, of cash holdings in columns 5-6 and a dummy for firms that recorded an increase in the book value of equity in columns 7-8. The dummy zombie firms (Z) is computed as described in Table 1. Odd columns include province-sector and year fixed effects, while even columns include province-sector-year fixed effects. $LowCap + LowCap * Z$ is the sum of the coefficients in the first two rows in the column. The sample includes yearly data between 2008 and 2013. Standard errors clustered at the province-sector level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Firms growth and banks capital ratio: Controlling for effects on the supply chain

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | ΔLabour | | ΔCapital | | ΔSales | |
| $\overline{\text{LowCap}}$ | -0.003 | | -0.013*** | | -0.070*** | |
| | (0.007) | | (0.004) | | (0.010) | |
| $\overline{\text{LowCap}}$*Z | 0.034*** | 0.035*** | 0.024*** | 0.026*** | 0.005 | 0.016*** |
| | (0.004) | (0.004) | (0.004) | (0.004) | (0.005) | (0.005) |
| Z | -0.057*** | -0.057*** | -0.021*** | -0.021*** | -0.049*** | -0.052*** |
| | (0.002) | (0.002) | (0.001) | (0.001) | (0.002) | (0.002) |
| Down | 0.054** | 0.195*** | 0.197*** | 0.371*** | 0.903*** | 1.692*** |
| | (0.025) | (0.032) | (0.019) | (0.028) | (0.051) | (0.056) |
| $H_0$ : LowCap + LowCap*Z=0 | | | | | | |
| p-value | 0 | | 0.02 | | 0 | |
| Prov-Sect FE | Y | N | Y | N | Y | N |
| Year FE | Y | N | Y | N | Y | N |
| Prov-Sect-Year FE | N | Y | N | Y | N | Y |
| Observations | 921,640 | 921,345 | 925,826 | 925,519 | 920,506 | 920,194 |
| $R^2$ | 0.037 | 0.060 | 0.024 | 0.035 | 0.090 | 0.133 |

The table shows regressions of different measures of firm growth on banks capital ratio $\overline{\text{LowCap}}$ as defined in Table 4, and on Down, defined in equation 5 which captures the effect of zombies and bank capital along the supply chain at the sectoral-local level. The dependent variable is the delta log of the wage bill in column 1-2, of the capital stock computed using the permanent inventory method in columns 3-4, of sales in columns 5-6. The dummy zombie firms (Z) is computed as described in Table 1. Odd columns include province-sector and year fixed effects, while even columns include province-sector-year fixed effects. $LowCap + LowCap * Z$ is the sum of the coefficients in the first two rows in the column. The sample includes yearly data between 2008 and 2013. Standard errors clustered at the province-sector level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Firms growth and banks capital ratio: Manufacturing vs. services firms

| | (1) | (2) | (3) |
|---|---|---|---|
| | ΔLabour | ΔCapital | ΔSales |
| $\overline{\text{LowCap}}$ | -0.018** | -0.000 | -0.025** |
| | (0.007) | (0.004) | (0.010) |
| $\overline{\text{LowCap}}$*Z | 0.038*** | 0.028*** | 0.019*** |
| | (0.004) | (0.004) | (0.005) |
| Z | -0.058*** | -0.022*** | -0.053*** |
| | (0.002) | (0.001) | (0.002) |
| $\overline{\text{LowCap}}$*Services | 0.026*** | 0.003 | 0.034*** |
| | (0.005) | (0.003) | (0.007) |
| $H_0$ : LowCap + LowCap*Z=0 | | | |
| p-value | 0.016 | 0 | 0.56 |
| Prov-Sect FE | Y | Y | Y |
| Year FE | Y | Y | Y |
| Observations | 967,243 | 972,358 | 966,039 |
| $R^2$ | 0.036 | 0.024 | 0.083 |

The table shows regressions of different measures of firm growth on banks capital ratio $\overline{\text{LowCap}}$ as defined in Table 4. Compared to the basic specification of Equation 2, the regressions also include an interaction between $\overline{\text{LowCap}}$ and a dummy for services firms. The dependent variable is the delta log of the wage bill in column (1), of the capital stock computed using the permanent inventory method in column (2), of sales in column (3). The dummy zombie firms (Z) is computed as described in Table 1. All columns include province-sector and year fixed effects. $LowCap + LowCap * Z$ is the sum of the coefficients in the first two rows in the column. The sample includes yearly data between 2008 and 2013. Standard errors clustered at the province-sector level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Firm failure and banks capital ratio

| | (1) | (2) | (3) |
|---|---|---|---|
| | Linear probability | | Probit |
| $\overline{\text{LowCap}}$ | 0.443** | | 0.501** |
| | (0.208) | | (0.220) |
| $\overline{\text{LowCap}}$*Z | -1.405*** | -1.445*** | -1.135*** |
| | (0.346) | (0.355) | (0.195) |
| Z | 5.657*** | 5.667*** | 4.318*** |
| | (0.191) | (0.193) | (0.100) |
| $H_0$ : LowCap + LowCap*Z=0 | | | |
| p-value | 0.008 | | 0.009 |
| Prov-Sect FE | Y | N | Y |
| Year FE | Y | N | Y |
| Prov-Sect-Year FE | N | Y | N |
| Observations | 1,150,659 | 1,150,623 | 1,150,661 |
| $R^2$ | 0.016 | 0.020 | 0.0381 |

The table shows regressions of a dummy equal to 100 for firms that go bankrupt on banks capital ratio, so that all coefficients can be read as percentages. See the notes to Table 4 for the definition of $\overline{\text{LowCap}}$. *Z* is a dummy for zombie firms and it is computed as described in Table 1. Columns (1) and (3) include province-sector and year fixed effects, while column (2) includes province-sector-year fixed effects. The first two columns are OLS estimates, while column (3) is a probit estimate, with marginal effects reported. The sample includes yearly data between 2008 and 2011. Std. errors clustered at the province-sector level.

Table 9: TFP dispersion and banks capitalization

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| $\overline{\text{LowCap}}$ | -0.002 | -0.001 | -0.038*** | -0.027*** |
| | (0.008) | (0.006) | (0.011) | (0.008) |
| $\overline{\text{LowCap}}$∗ShZ | | | 0.152*** | 0.121*** |
| | | | (0.038) | (0.029) |
| ShZ | | | -0.008 | 0.045 |
| | | | (0.020) | (0.018) |
| Tfp growth | -0.054*** | -0.076*** | -0.054*** | -0.074*** |
| | (0.013) | (0.008) | (0.013) | (0.008) |
| Prov-Sect FE | Y | Y | Y | Y |
| Year FE | Y | Y | Y | Y |
| Observations | 9,194 | 10,885 | 9,194 | 10,885 |
| $R^2$ | 0.824 | 0.871 | 0.826 | 0.872 |

The table shows regressions of the standard deviation of TFP at the province-sector-year level on $\overline{\text{LowCap}}$ (see the notes to Table 4 for its definition). ShZ is the share of firms that are classified as zombies in the province-sector-year. TFP growth is the log change of the average TFP at the province-sector level. Odd columns exclude province-sector-years with less than 10 firms. Even columns include all province-sector-years but weigh them according to the number of firms. All regressions include year and province-sector fixed effects. The sample includes yearly data between 2008 and 2013. Std. errors clustered at the province-sector level.