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Credit Misallocation During the European Financial Crisis*

Fabiano Schivardi[†] Enrico Sette[‡] Guido Tabellini[§]

March 29, 2018

Abstract

Do banks with low capital extend excessive credit to weak firms, and does this matter for aggregate efficiency? Using a unique data set that covers almost all bank-firm relationships in Italy in the period 2008-2013, we find that, during the Eurozone financial crisis: (i) Under-capitalized banks cut credit to healthy firms (but not to zombie firms) and are more likely to prolong a credit relationship with a zombie firm, compared to stronger banks. (ii) In areas-sectors with more low-capital banks, zombie firms are more likely to survive and non-zombies are more likely to go bankrupt; (iii) Nevertheless, bank under-capitalization does not hurt the growth rate of healthy firms, while it allows zombie firms to grow faster. This goes against previous influential findings that, we argue, face serious identification problems. Thus, while banks with low capital can be an important source of aggregate inefficiency in the long run, their contribution to the severity of the great recession via capital misallocation was modest.

Keywords: Bank capitalization, zombie lending, capital misallocation

JEL classification number: D23, E24, G21

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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 et al. 2008) and, more recently, for the Euro area during the financial crisis (Acharya et al. 2016). 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 et al. 2015). Firms closures can also disrupt input-output relationships that, at least in the short run, can be difficult to substitute for (Barrot & Sauvagnat 2016). In this paper, we add to the literature by improving both in terms of data quality and of identification framework. As we show below, these modifications lead to conclusions that differ substantially from the received wisdom.

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 (see Figure 1). Moreover, unlike other Eurozone countries, Italy did not inject public funds to recapitalize its banking system (at least in our sample period) 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. The problem persists today, and it is one of the major policy challenges in Italy.

In short, these are our main findings. Under-capitalized banks are more likely to cut credit to healthy firms and are more likely to prolong a credit relationship with a zombie firm, compared to stronger banks. This affects firms survival and exit: in the areas-sectors where lending is predominantly done by weaker banks, zombie firms are more likely to survive while non zombies are more likely to go bankrupt, compared to area-sectors with stronger banks. 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, and contrary to previous findings, we do not find evidence that bank under-capitalization hurts the growth rate of healthy firms, while on the contrary zombie firms tend to grow faster in areas with under-capitalized banks. Our results suggest that this is because, during the crisis, all firms had low demand for investments and healthy firms were able to cover their working capital needs through other sources of finance (particularly liquidity and equity), mitigating the effects of banks' capitalization, while zombies needed lending even to cover their operating expenses. Thus, 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 that clearly are no longer viable – *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 (we experiment with alternative definitions to assess robustness). As shown in figure 2, credit to zombie firms dropped faster than credit to healthier firms during the first part of the crisis, but the opposite was true from 2011 onwards, when low capital became a pressing problem for several Italian banks. This suggests that credit was not reallocated away from zombie firms.

To study which bank characteristics are conducive to zombie lending, we regress the growth rate of granted credit at the firm-bank level on various indicators of banks' solidity, using the regulatory capital ratio as the preferred one. The identification challenge in this type of regressions is that the observed granted credit is the result of both demand and supply. To single out the supply effects, we exploit the fact that Italian firms typically borrow from more than one bank. This enables us to compare banks with different degrees of capitalization that lend to the same firm, controlling for firm-year fixed effects. As first argued by Khwaja & Mian (2008), this allows to control for any effect coming from firms' credit demand, such as a higher demand from zombie firms, and to interpret the coefficients as a credit supply effect.

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. More precisely, between 2008 and 2013 bank credit drops by almost 8% every year on average in our sample. But banks with a capital ratio below the median contract credit to healthy firms by 1.5 percentage points more than stronger banks (a 20% reduction relative to the average), while credit to zombie firms is not affected by the bank capital ratio. On the other hand, the probability of closing a credit relationship with a zombie firm is almost 1 percentage point lower if the bank capital ratio is below the median, while bank capital does not influence the survival rate of credit relationship with healthy firms. Thus, low-capital banks grant more credit to zombies than to healthy firms, relative to well capitalized banks, though the details of how this happens differ for the intensive and extensive margins. Low-capital banks are also less likely to classify their loans as bad, whether they are loans to zombie firms or to any firm. These results point to the conclusion that weak banks misallocate credit, since they are more likely to keep lending to non-viable rather than healthy firms. Why did this occur? Other evidence discussed in the paper suggests that 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 is located, 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: on average banks are active in about 48% of sector-provinces (the median is very similar). Thus, bank capitalization is unlikely to be correlated with shocks in the province-sector, and we can take it as exogenous with respect to shocks that shift the distribution of firms' performance.

We start by considering the intensive margin, namely how zombie lending affects the growth of existing non-zombie firms. Our central result here is that bank undercapitalization allows zombies to grow faster, while it has only negligible effects on the growth of healthy firms. This holds for the wage bill (a proxy for employment) and revenues, but not for capital, whose growth rate is not affected by bank capital for all types of firms. This finding may seem surprising, in light of the received wisdom from the previous literature and of our own results on credit misallocation. A priori, it is argued, weak banks that engage in zombie lending hurt healthy firms in two ways: first, by reducing bank credit available to the rest of the economy; second, given that lending to non-viable firms is equivalent to a subsidy, it hurts 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, due to the low investment propensity during a period of sharp GDP contraction. Moreover, zombie lending may also have positive economic effects during a recession: because it does not force inefficient firms to shrink or to exit, it could mitigate adverse aggregate demand and input/output externalities.

We then explore the extensive margin, namely the effect of bank capitalization on the survival rates of zombie and non zombie firms. In line with the results on credit allocation, we find that weak banks influence the composition of bankruptcies. Zombies are more likely to survive, and healthy firms are more likely 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 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. 2016). In a final section, we argue that this difference is due to the fact that previous literature faces a serious, and so far overlooked, identification issue. Indeed, the empirical framework first introduced by Caballero et al. (2008) and adopted by the subsequent literature rests on the implicit assumption that a negative sectoral shock affects the performance of zombies and healthy firms exactly in the same way. We show that this assumption is violated in very standard settings with

[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.

heterogeneous firm performance. As a consequence, this framework is likely to overstate the negative effects of zombies on healthy firms, something that we clearly see in our data.

Our findings contribute to the current policy debate on the importance of bank capital and on the consequences of a large stock of non-performing loans on credit supply and its allocation (IMF (2016)). They suggest that the main reason for injecting capital into a weak banking sector is not so much to alleviate the recession or shorten its duration, but rather to prevent productive inefficiencies and possibly to facilitate the recovery once it is in place.

The outline of the paper is as follows. Section 2 illustrates the related literature. Section 3 describes the data and how we define zombie firms. Section 4 asks which types of banks engage in zombie lending, while the real consequences of zombie lending are explored in Section 5. Section 6 concludes.

2 Related literature

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. In terms of policies, Giannetti & Simonov (2013) find that the effects of capital injections in Japanese banks have been non-linear: only large ones have improved the quality of lending.

Despite the centrality in the policy debate, surprisingly little evidence on zombie lending in Europe is available. Acharya et al. (2016) use syndicated loan data to study banks behavior after the "whatever it takes" announcement by Mario Draghi, showing that under-capitalized banks used the extra profits to lend 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 et al. (2017) for OECD countries. Blattner et al. (2017) show that in Portugal undercapitalized banks had a negative impact on firms' growth and productivity directly, through a reduction in the availability of credit, and indirectly, through spillover effects from zombies to non zombies. Other works consider in greater detail the link between weak banks and weak firms and its consequences in terms of access to credit and of firms' financial structure (Storz et al. 2017, Albertazzi & Marchetti 2010).

Following Hsieh & Klenow (2009), a growing literature assesses the effects of resource misallocation on aggregate productivity. The work that focusses on the effects of financial frictions reaches mixed results (Moll 2014, Yang 2011, Midrigan & Xu 2014). More directly related to our work, a growing literature studies the impact of misallocation in relation to financial crises (Barnett et al. 2014, Di Nola 2015). Gopinath et al. (2017) document a significant increase in productivity losses from capital misallocation in Southern Europe during the credit boom that proceeded the crisis, when capital was disproportionately directed toward firms with higher net worth but not necessarily more productive. They also find that credit frictions were not a key driver of misallocation during the financial crisis. These conclusions are confirmed by subsequent studies (Borio et al. 2016, Gamberoni et al. 2016, Calligaris et al. 2016, Linarello & Petrella 2016).

Our work contributes to this literature in several ways. First, we use a comprehensive dataset representative of the whole population of banks and firms, that includes both listed and unlisted firms. This is important when it comes to quantifying the relevance of zombie lending. Data covering only listed firms or syndicated loans do not provide a comprehensive picture to quantify the relevance of zombie lending and its impact on the real economy, particularly in countries such as Italy, where the presence of SMEs is preponderant. Second, thanks to the richness of our data set, we identify zombie lending exploiting firms that borrow from more than one bank. This allows us to quantify the extent of zombie lending after controlling for firm demand for credit and more generally for firm unobserved characteristics. Third, we propose a new and more reliable definition of zombie firm, that takes into account both efficiency (return on assets) and financial fragility (indebtedness before the crisis). Fourth, when assessing the consequences of bank under-capitalization on aggregate economic efficiency and growth, we can distinguish between the intensive margin (growth of existing firms) and the composition of bankruptcies, documenting how the most important aggregate effects of bank weakness operate through the latter channel. Last, and perhaps most important of all, we estimate the *absolute* effect of bank under-capitalization on the growth of healthy firms, and not just a relative effect on the growth of healthy vs zombie firms. This is a significant departure from the influential literature following Caballero et al. (2008), because we find that, while the relative effect is negative and highly significant, the absolute effect is negligible. We also show that the identification approach used in the literature to estimate the real effects of zombie firms is weak, because common shocks to firm performance that increase the share of zombie firms typically have differential effects on zombie and non-zombie firms, which violates the key (implicit) identification assumption of that approach.

3 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 *all* loans extended by banks to firms.[2] 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). The third data source is the Supervisory Reports collected by the Bank of Italy, that 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. The combined dataset offers a comprehensive description of corporate lending, covering almost the universe of banking relationships for firms and banks of all size.

In the reminder 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 5. We exclude mutual banks, as these are subject to highly specific regulations in their lending and governance.[3] Moreover, because of our identification strategy, we only retain firms that have credit relationships from at least two banks in a year. In our preferred specification, we aggregate all loans that a bank grants to a firm, independently of its nature (credit line, collateralized loan, etc). This leaves us with a sample of 2,287,690 firm-bank-year observations, corresponding to 210,904 firms and 143 banks. In a series of alternative specifications, we will also focus on specific types of loans (uncommitted credit lines). Our main sample spans the period 2008-2013, namely the years of the great recession (2008-2009) and the sovereign debt crisis (2011-2013). However, for some variables we use firm balance sheet data going back to 2002, and we also repeat the analysis for the period 2004-2007 to check for differences in the estimates compared to the crisis period.

[2]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).

[3]They can only lend in their geographic area and primarily to their shareholders (who also must be local residents). As a consequence, the exogeneity of their financial conditions with respect to local shocks is less likely to hold than for banks with a national scope.

3.1 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 return on assets, 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.[4] 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 a measure of the cost of capital for the safest borrowers in the sample. This is computed as the average interest rate charged on new term loans granted to the safest firms. To reduce time series fluctuations related to changes in the policy rates, here too we use a three years moving average. The safest firms are defined as those having an Altman Z-Score of either 1 or 2 - the Z-score varies from 1 (safest) to 9 (riskiest). This measure of the cost of capital is called *prime rate* (PRIME).

As a measure of default risk, we rely on leverage. Highly indebted firms are obviously more at risk of default, so that a lender should be less willing to extend them credit, controlling for expected returns. We define *leverage* as total financial debt over total assets. Total financial debt excludes debt towards shareholders, typically more akin to equity.

In our default definition, 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. Figure 3 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

[4] 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.

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 4 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.

We also experiment with a different measure of profitability, comparing EBIT to interest expenses to determine creditworthiness. Clearly, debt is unsustainable if interest expenses exceed EBIT for a prolonged period of time. Specifically, we define the variable $RATIO$ as the ratio between the three year moving average of EBIT and the three-year moving average of interest expenses. A firm is defined as a zombie in a given year if in that year the variable $RATIO$ is below 1 and if its leverage is above 40% (consistently with the previous definition of zombie). The dummy variable corresponding to this definition of zombie firm is called *Zombie 2*.

We also use a third definition, called *Zombie 3*, which is identical to *Zombie 1* except that we impose the additional condition that revenues do not increase for the next three consecutive years. This is to avoid defining firms currently investing in future growth, such as start-ups, as zombies.

The three definitions overlap significantly, although the second one is more stringent: in our sample about 19% of firms are classified as zombie in the first definition, 11% in the second one, and 17% in the third. The definition based on the ratio of EBIT to Interest Expenses (*Zombie 2*) is almost a strict subset of that based on the comparison between ROA and the prime rate. Only 0.2% of firms are classified as zombies according to definition 2 and non-zombie according to definition 1. The opposite occurs instead in 7.1% of the cases. Overall, we prefer definition 1 since it is based on an economic notion of credit misallocation, namely low returns on capital, but we check the robustness of our results to the other, more restrictive, definitions.

These definitions classify as zombies those firms that pass the established thresholds of low profitability and high leverage. While useful from a descriptive viewpoint and easy to interpret, there is some arbitrariness in the choice of the thresholds. Moreover, one could argue that the status of zombie would be better described by a continuous rather than a dichotomic variable. For this reason, we also construct two continuous indicators of zombie firms, by taking the first principal component of the two variables on which the dichotomic indicators are constructed. Specifically, *PC ROA-Leverage* is measured as the first principal component of leverage and ROA, while *PC EBIT/INT-Leverage* is measured by the first principal component of leverage and the ratio of EBIT over interest payments. For the continuous variables, the share of variance accounted for by *PC ROA Leverage* is 62%, while that accounted for by *PC EBIT/INT leverage* is 54%.

Finally, we also check the robustness of our results when we classify as zombies those firms with an Altman Z-score of 8 or 9, the two highest values. The Altman Z-score represents the likelihood of bankruptcy. About 9% of the bank-firm relationships in our sample concern firms classified as zombie according to the Z-score.

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.

3.2 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. 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 rebuilding bank capital during the crisis. Figure 5 illustrates how zombie firms are distributed between banks, according to their capital ratio. Banks with a capital ratio in the bottom quartile of the distribution have a substantially higher share of zombies out of total borrowers. Banks in the second quartile have a share that is lower than that in the first by still higher than that of last two quartiles, which have similar values. This suggests that the relationship between zombie lending and capital ratio is non-linear: weak banks are more likely to engage in zombie lending, but as the capital ratio increases substantially above the regulatory threshold, the relationship between capital ratio and zombie lending vanishes. To capture this non linearity, our preferred indicator of a weak bank is a dummy variable which equals 1 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). We call this variable *LowCap*. 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.

Table A2 in the Appendix shows that the variable *LowCap* is one in 24% of observations. This suggests that banks with fewer borrowers (smaller banks) suffered a more severe capital shortfall during the crisis. We experiment with alternative indicators based on the capital ratio. First, since the median (and mean) capital ratios increased somewhat overtime, reflecting the capital increases performed by banks, we also use a dummy equal to one if the capital ratio in year t is below the median of year t. Second, we define a dummy for banks with a capital ratio below 9%, and therefore very close to (or below) the regulatory ratio.

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 et al. 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 also 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.

4 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, not all banks meet these ideal conditions, however.

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. On the one hand, an economic recovery would reduce bank losses (on loans and other bank assets) and thus also the size of the necessary recapitalization, thanks to future retained earnings. On the other hand, 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 it is that credit extension was the preferred option.

This logic has a number of empirical implications:

- First, banks with low capital are more likely to contract credit than well capitalized banks, since deleveraging reduces their capital requirements. To avoid loss recognition, however, credit contraction by low-capital banks is less likely to affect zombie firms 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 zombie firms.

- 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 to zombie firms 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.

- Fifth, evergreening is more likely if the bank accounts for a large share of credit to zombie firms. The reason is that in this case the firm is less likely to find alternative sources of financing, and hence debt repayment is less likely.

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

4.1 Empirical strategy

We use the following regression framework:

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

where Δb_{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 time 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; *Dummies* are different sets of dummy variables used in different specifications. To test the predictions discussed above, we also replace Δb_{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 both of the bank and of the firm, standard errors are always double clustered at the bank and firm level.

To clarify the interpretation of the coefficients, define Δb_{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 β_2 could be due to matching between weak banks and weak firms for reasons other than the banks' capital ratio. For example, some banks could have 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). A well-known feature of the Italian lending market is that firms tend to borrow from different banks simultaneously (Detragiache et al. 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.[5] 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 β_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).

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 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.

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

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

same firm by different banks is uncorrelated with the regressors.

4.2 Basic results: 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. In column (1) we report a specification with separate year and firm fixed effects. First, $\beta_3 = -5.6$ and highly significant, meaning that healthy banks cut credit growth to zombies by 5.6% compared to healthy firms. Second, β_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, β_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 β_2 of 1.5 means that a bank with low capital allows credit to zombies to grow faster than credit to healthy firms by 1.5%, compared to banks with high capital. Given that well capitalized banks cut credit to zombie firms, relative to healthy firms, by about 5.6% 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=0.39, 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 affects, that account for unobserved heterogeneity at the firm level. 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 β_1 and β_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.[6]

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.

[6] When we include firm-year effects, the zombie dummy is absorbed by the firm-year fixed effects, and we can only estimate the relative effect of low vs high capital banks on each firm type.

In column (4) we introduce bank fixed effects and 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.

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 zombie firms are 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 more comprehensive specification corresponding to column (4) in Table 1. Results are similar for the other, more parsimonious, specifications.

4.3 Extensive margins

So far, we have focused on the intensive margin, that is, changes in the amount of credit granted, conditional on the continuation of the credit relationship. But 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. We thus also explore the extensive margins of the credit relationship.

Termination of the credit relationship. In columns (1) and (2) of Table 2 we re-estimate the same specifications as in column (4) of Table 1, except that the dependent variable is a dummy variable that equals 100 if the 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). Given the very large number of fixed effects, we cannot estimate logit or probit models, so that we run linear probability models (OLS). In column (1) the dependent variable refers to the overall credit relationship, while in column (2) it refers to credit lines, that can be closed at will by the bank. Only the interaction coefficient between the low capital dummy and the zombie dummy (β_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. The coefficient is larger for credit lines (column 2), that are easier to terminate. Unlike in Table 1, however, here $\beta_1 + \beta_2$ is negative and statistically significant at the 5% level or lower in both columns. Thus, low bank capital makes it more likely that a relationship or a credit line with zombie firms survives, while the effect on the survival of relationships with healthy firms is weaker and concentrated in credit lines. The sum of the two coefficients is about -1 or larger in absolute value, meaning that 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. To give a sense of the magnitude, note that on average 5.6% of all relationships 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. Both decisions entail a degree of discretion in credit evaluation, which is a natural part of the activities performed by banks.[7]

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 has a very negative effect on the firm's access to credit. The classification is reported to the Central Credit Register and all banks are notified of the event. As a result, 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

[7] In addition, non-performing loans (NPL) can also be classified as "past-due". This is the first entry into NPL status: a loan is past-due if its repayment is late by more than 180 days. Unlike bad loans and sub-standard loans, however, this classification involves little discretion by the bank, and for this reason we neglect it.

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.[8] Second, the benefit for a bank 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.[9]

In both columns (3) and (4), the interaction coefficient β_2 is negative and significant. Thus, low capital makes a bank less likely to classify a loan to a zombie firm as bad or substandard. 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 on loans to healthy firms. The point estimate of -0.55 means that having low bank capital reduces the probability of these classification 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.

4.4 Other predictions

We now explore the other possible consequences of low capitalization for banks' lending policies.

Collateralized loans. In Table 3 we further explore the mechanism behind the results. In the first two columns we report the results of the credit growth regression, splitting the sample according to whether the loan is collateralized (Column 1) or not (Column 2). 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, we find that low and high capital banks do not behave differently when loans are collateralized – neither β_1 nor β_2 is statistically significant in Column 1 –, while for uncollateralized loans the same pattern as in column (4) of Table 1 emerges, but the effects are stronger, as expected.

[8] For this paper we are using yearly data from the Credit Register. It is possible that a bank classifies a borrower as a bad loan, say, in June, and the other banks follow, say, in September, so that as of December, the borrower has been classified as a bad loan by all banks.

[9] 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%

Interest rates. The evidence so far suggests that low capital banks engage in zombie lending to hide losses. Do they also lend at subsidized rates, to increase the probability of survival of the weakest borrowers? Column 3 of Table 3 reports the usual most comprehensive specification, but now the dependent variable is the interest rate charged on the loan.[10] The estimates of β_1 and β_2 are not statistically significant and very small. Thus, this evidence provides no evidence of lending at subsidized rates to zombie firms by low-capital banks.

Evergreening. The incentive of a bank to roll over credit to a weak firm is stronger if it accounts for a large share of the firm's total debt. The reason is that in such a case, if the loan is not rolled over, the firm is more likely to default on its debt service obligations. Hence, we should observe zombie lending particularly when the bank is one of the main creditors of the firm. To test this hypothesis, we extend the specification in column (4) of Table 1 by adding all the interactions of $LowCap$ and Z with the variable $Share\ bank$ defined above. The dependent variable is yearly credit growth, as in Table 1. The results are displayed in column (4) of Table 3. The estimated coefficient on $LowCap*Z$ continues to be positive and statistically significant, and not much different from that in Table 1, confirming our previous finding that banks with low capital are more likely to cut credit growth if the firm is healthy than if it is a zombie, compared to better capitalized banks. The estimated coefficient on the interaction $Share\ bank * Z$ is positive and significant, while that on the triple interaction $Share\ bank * Z * LowCap$ is not statistically different from zero. Thus, as the share of the bank in the firm's total credit increases, all banks (and not just those with capital below the median) are more likely to roll over the loans if the firm is a zombie than if it is healthy. In other words, evergreening of zombie firms is not confined to banks with capital below the median. This can be understood by recalling that during this crisis period most Italian banks where under strong pressure to boost their capital.

Summary. All in all, this evidence is consistent with the hypothesis that low bank 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. Whether or not this behavior actually results in more lending to zombie firms by weaker banks, depends on the credit growth indicator. There is evidence that

[10] We use interest rates on uncommitted credit lines gross of fees and commissions. The reason is that these rates are more easily comparable across banks since uncommitted credit lines have the same (very short) maturity, which we observe very coarsely on longer term loans, and are not backed by real collateral. In any case, results are similar when we use interest rates on term loans and when we compute interest rates net of fees and commissions.

this happens at the extensive margin, where a relationship with a zombie firm is more likely to survive if the bank has low capital. On the intensive margin, on the other hand, a reduction in bank capital hurts healthy but not zombie firms. Stated differently, low capital banks deleverage (reduce assets that are costly in terms of capital requirements) by cutting credit to healthy firms relative to high capital banks. Finally, and consistently with our interpretation, banks with low capital are less likely to recognize a loan as substandard or bad if it is with a zombie rather than a healthy firm, compared to more capitalized banks. But there is no evidence that the interest rate on the loan is affected by bank capital and by the viability of the firm.

4.5 Robustness

We now assess the robustness of our results to various modifications of the basic setting. To save on space, unless otherwise noted, we only report regressions based on the most comprehensive specification that always includes firm-year and bank fixed effects plus the time varying bank controls and the variables *Share bank* and *Share credit line* defined above (i.e. column 4 of Table 1). Results are displayed in the Appendix.

Definition of zombies. One key issue relates to the definition of zombie firms. In Appendix Table A3 we repeat the estimations using alternative definitions of zombie firms, namely *Zombie 2* and *Zombie 3* in columns (1) and (2) respectively. As seen in Section 3, *Zombie 2* is a more restrictive definition of zombie firms. For example, in the crisis years 11% of firms are classified as zombies according to this definition, against 19% of the previous one. *Zombie 3* is similar to *Zombie 1*, with the further condition that revenues do not increase for the next 3 consecutive years. Notwithstanding this difference, the results are similar to those obtained with the basic definition of zombies, except that now the estimated coefficient β_3 is even larger.[11]

Another issue is the binary nature of our zombies indicators, that classify as zombies those firms that pass the established thresholds of profitability and leverage. Given the possible arbitrariness of the thresholds defining the zombies, columns (3)-(4) of Appendix Table A3 replace the variable *Zombie2* with the continuous indicators measured by the corresponding principal components (see Section 3). Higher values of $PC1$ and $PC2$ correspond to weaker firms. Again, we find that the estimated coefficient on $LowCap$ is negative although marginally not significant (p-values around 0.13), while the interaction coefficient is positive and significant. To give a sense of the magnitude, consider two firms with a difference in the value of *PC EBIT/INT leverage* of one standard deviation (about

[11] The coefficient of the dummy Lowcap is marginally not significant (p-value 0.106) when we use the definition Zombie 2.

1). Using the estimate of 1.03 in column (4), a reduction in bank capital from above to below the median implies a faster credit growth to the weaker firm (compared to the stronger one) of 1 percentage point. Results are similar when we use the other principal component, *PCROA leverage* (columns 3 and 4).

Finally, we also define zombie firms as those with an Altman Z-score in the worst two notches of the distribution. Estimates of the credit growth regressions are shown in column 5 of Appendix Table A3. Results indicate that high Z-score firms obtain relatively more credit from low capital banks, and that this is true also in absolute terms. The coefficient on *LowCap* is negative but marginally insignificant (p-value is 0.108).

Definition of bank capital structure. Next, we experiment with alternative definitions of bank under-capitalization. Above we defined a bank with low capital if its capital ratio is below the sample median in 2008 (about 10%). We experiment with other thresholds to check the sensitivity of the results to this choice. In column (1) of Appendix Table A4 we redefine the threshold for having low capital as being below the median year by year (rather than in 2008). Results are qualitatively similar to the baseline, but both coefficients of interest are larger in absoulte value.

Column (2) replaces the *LowCap* dummy with a continuous capital ratio indicator (thus higher values correspond to more capital). The estimated coefficient (β_1) is positive and significant, while β_2 (the coefficient of the interaction with the dummy zombie) is negative and significant, as expected. The numerical value of -0.27 on the interaction implies that an increase of one standard deviation in the capital ratio (2.4%) would imply a reduction in credit growth to zombie relative to healthy firms of about 0.65 percentage points.

Figure 5 shows that banks closer to the regulatory threshold are more likely to lend to zombies. To test if the intensity of the effect changes with a more stringent definition of weak bank, we construct a dummy variable equal to 1 if the bank capital ratio is below 9 ($Dcapratio < 9$), a value below which bank capitalization is particularly at risk. Banks in this danger zone are small: about 20% of all banks in our sample had a capital ratio below 9% in at least one year, but they only account for about 5.3% of all the bank-firm relationships in our sample, and the dummy variable is one for only 4% of observations. The behavior of these banks is not significantly different from that of others with regard to healthy firms (β_1 is negative but not significantly different from zero), but its interaction coefficient with Z, β_2, is highly significant and large. The point estimate in column (3) implies that the difference in credit growth between zombie and healthy firms is 2.7 percentage points higher if the bank capital ratio falls below 9. This confirms that the effects of capital requirements on lending policies are likely to be non-linear, and stronger closer to the regulatory threshold.

The remaining columns of Appendix Table A4 explore the effects of three other indicators of bank weakness in columns (4), (5) and (6) respectively: a dummy variable if the bank return on assets is below the median (*LowROA*), if the leverage ratio is above the median, (*high bank leverage*), and if the ratio of bad loans to assets is above the median (*high bad loans*). As before, all medians are computed using the distribution of 2008. Only the *high bad loans* dummy variable has a positive estimated coefficient when interacted with Z. Leverage is never statistically significant, on its own or interacted, and banks with low return on assets lend more to healthy firms, compared to banks with higher ROA, but there is no difference in their lending to zombie vs healthy firms. Thus, only regulatory indicators of bank strength predict a differential growth of credit to zombie vs healthy firms, while market-oriented measures of bank strength such as ROA or leverage do not. This too is consistent with our hypothesis that zombie lending by weak banks in this period reflects an attempt to hide losses from regulators, to avoid or delay requests to boost capital.

Finally, we also estimate similar regressions in the pre-crisis period, 2003-2007. We did not find any evidence that banks with low capital extended more credit to zombie firms than to healthy firms, compared to stronger banks (Appendix Table A5). Regulatory capital only mattered for credit growth during the crisis period, when both regulators and markets started paying much more attention to bank capital. This finding can be thought as a placebo test, that further reinforces our interpretation.

4.6 Firm level regressions

Table 4 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 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, that were excluded from the loan-level analysis. 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.[12] 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.

5 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. On the one hand, banks with low capital cut credit growth to healthy firms by about 1% or more, compared to well capitalized banks (cf. Table 1). On the other hand, combining the intensive and extensive margins, credit growth to zombie firms is about 2% higher if bank capital is below the median (cf. Table 4); this corresponds to a 25% increase relative to the average yearly contraction of credit of -8% during the crisis. We now ask how this misallocation of credit affected real economic activity.

Our strategy exploits arguably exogenous variation in the strength of banks operating in different sectors and geographic areas. In the closing subsection, we compare our results to those in the literature and point to a crucial pitfall in the analytical framework that

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

can give rise to an overestimation of the adverse effects of zombie lending. Incidentally, if we use the same (mis-specified) approach, we find results very similar to those of the previous literature.

We break the question in three parts. First, in subsection 5.1, we study how being exposed to under-capitalized banks affects the growth rate of healthy vs zombie firms. Second, low bank capital affects the composition of bankruptcies: more zombie firms are kept alive, and possibly more healthy firms are pushed into bankruptcy. We explore this issue in Subsection 5.2. Third, building on the literature on real misallocations (Hsieh & Klenow 2009), we consider the implications of low bank capital for the dispersion of productivity across firms. In a frictionless economy, factors of production would be allocated to firms so that the marginal value product of inputs – and thus revenue productivity – is equalized across firms. Zombie lending reduces the efficiency of the allocative process, both because inefficient firms are kept alive (or prevented from shrinking), and because healthy firms find it more difficult to grow. As a consequence, low bank capital is expected to increase the dispersion of productivity across firms. We address this implication in Subsection 5.3.

A key issue is how to define the group of firms 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. (2016) follow this approach and, given that they have a sample of firms from different European countries, they 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 geographically 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 et al. (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.[13] In terms of sector, we exclude agriculture and finance and divide the other firms in 18 sectors.[14]

[13]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. However, for our study the most relevant market is the banking one, so that we decided to keep the province as our preferred geographical unit.

[14]Specifically, the sectoral classification is: 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.

5.1 Firm growth

How does exposure to under-capitalized banks affect different growth indicators of individual firms operating in the same province-sector? 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 in agriculture, mining, coke, finance and public services and those 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 A6, Panel A. Panel B reports those for the sector-province-year variables.

5.1.1 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 Δy_{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. It is defined as 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 in year t. 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. The coefficient ϕ_1 captures its effect on the performance of healthy firms operating in the same province-sector, while ϕ_2 captures the effect of $\overline{LowCap}_{pt}$ 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 ϕ_1 is not identified, because the variable $\overline{LowCap}_{pt}$ is absorbed by the fixed effects. In such specifications, therefore, we can only estimate ϕ_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 4, 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. Note that credit flows affect firm growth not only directly, but also through spillover effects. If under-capitalized banks prevent zombie firms from shrinking (or from going bankrupt, as shown below), there are two contrasting effects. On the one hand, there is a positive aggregate demand and input-output externality in the area, because zombie lending may prevent layoffs or bankruptcies. On the other hand, zombie lending is like a subsidy to inefficient firms, that hurts competing firms in the same province-sector. Which of these two opposite externalities prevails is a priori uncertain, but the fact that the sample period is a deep recession increases the potential relevance of the positive externality. Overall, we expect $\phi_2 > 0$: zombies are expected to grow faster than healthy firms if banks are under-capitalized. 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). In any case, 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. Although the number of observations drops substantially in the two exercises, 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.

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. 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 A8 and A10 replicate the regressions using $\widehat{LowCap}_{pt}$ instead of $\overline{LowCap}_{pt}$ as regressor; the results are very similar.

5.1.2 Results

The results of estimating equation (2) are displayed in Table 5, for the growth rates of labor (expressed as log differences of the wage bill), capital (measured in book value) and sales.[15] For labor, we find no effect of bank capitalization on healthy firms: ϕ_1 is small and statistically insignificant. The coefficient ϕ_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 ϕ_2 is unaffected,

[15] We use nominal values but, given that we always include year dummies, regressions with deflated values produce exactly the same results.

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 ϕ_1 cannot be estimated.

The remaining columns of Table 5 repeat the same exercise for the growth rates of capital and sales. For capital, we find that neither ϕ_1, nor ϕ_2 or their sum are significantly different from zero: banks' capitalization does not affect capital accumulation. For sales we find effects that are similar to those for labor, although smaller in absolute value.

A plausible interpretation of the results for zombie firms is that they use the extra credit obtained from weak banks to pay for working capital to stay afloat, rather than for investments. Thus, changes in credit supplied induce corresponding changes in employment and production - regressions of intermediate expenditures (not shown for brevity) display the same pattern as for labor, supporting this interpretation. The absence of a negative estimated effect on the growth performance of healthy firms is more surprising, in light of the evidence in section 4 that healthy firms receive less credit from undercapitalized banks. This can be due to a number of reasons. On the one hand, healthy firms may have enough cash to cover their working capital, or they may be able to find alternative sources of finance. On the other hand, given the exceptionally negative cyclical conditions, they are unlikely to undertake investment projects, implying that they have a low demand for credit. Moreover, in such adverse circumstances, the spillover effects from keeping more zombie firms alive could be positive, rather than negative, because of aggregate demand and input-output externalities. Adding up all these reasons can explain why the performance of healthy firms is not hurt by low bank capitalization, despite the finding that healthy firms receive less credit if bank capital is low.

Partial support for this interpretation is provided in Table 6. 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: the estimate of ϕ_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.

We have performed some robustness checks. First, we have experimented with different sets of dummy variables. Our preferred specification controls for sector-province and year fixed effects. 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. Second, as explained above, we have used a measure of banks weakness based on the share of credit in the pre-crisis period (see equation 4). Results, reported in appendix Table A8, are very similar. We have experimented with the alternative definitions of zombies, using the more restrictive definition *Zombie 2*, the definition based on ROA computed gross of depreciation and amortization (EBITDA rather than EBIT, see footnote 4) and that based on the two highest classes of the Z-score. Again, the results are very similar to the basic ones.

In the regressions displayed so far, the measure of bank capital refers to the average in the local credit market (defined at the sector-province level). One could argue instead that what really matters is the strength of the banks from which the firm actually borrows. For instance, Blattner et al. (2017) use the firm-level share of borrowing from banks exposed to the EBA intervention of 2011 as a measure of bank weakness. We therefore also construct a firm-level measure of banks' weakness, defined as in the firm level credit regressions of subsection 4.6. Namely, $LowCap_{it} = \sum_j \frac{b_{ijt}}{b_{it}} LowCap_{jt}$, where b_{ijt} is the lending of bank j to firm i in year t, $b_{it} = \sum_j b_{ijt}$, and $LowCap_{jt}$ is a dummy variable that equals 1 if bank j has low capital in period t. We then run the regressions of Table 5 with this alternative measure. Note however that this firm level indicator of bank weakness is potentially more endogenous than the local credit market indicator used above, because it also reflects the firm choices of which banks to seek credit from. Table A9 in the appendix shows that, at least for labor, we find results comparable to those of our baseline specification (column 1). However, when we include in the regression both measures of banks' weakness, the one measured at the bank level ($LowCap_{it}$) and the one measured at the province-sector level ($\overline{LowCap}_{pt}$), the firm level indicator is not significant or changes sign for zombies in the sales regression, while the sector-province indicator delivers extremely robust estimates – if anything, the effects are stronger that in the baseline Table.[16] Thus, what matters for firm performance is the average strength of banks at the level of the local credit market, more than the strength of the specific banks that lend to the firm. This is consistent with the findings of Huber (2018) for Germany, confirming the importance of the indirect effects of lending, through aggregate demand and input/output externalities, and therefore of measuring lending conditions at the aggregate rather than at the individual level.

[16]Notice that these regressions are run on a smaller sample than the baseline one, as the credit shares can only be computed for firms actually borrowing from at least one bank. The fact that our results hold in this different sample further confirms their robustness. We have also experimented with the share of credit fixed at its pre-crisis period, $\frac{b_{ij04-07}}{b_{i04-07}}$, finding very similar results.

5.2 Firm failure

The previous regressions focus on the intensive margins, that is, firm's growth conditional on survival. But credit misallocations also affect the extensive margin, since the banks' financing decisions determines firms' survival.[17] 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, ie., paying out all liabilities. These are cases in which the entrepreneur decides to close the firm, rather than being forced to shut down due to lack of credit. Instead, we want to focus on episodes in which the closure event is related to financial distress, and therefore to access to credit. We use as year of failure the last year in which we observe the firm in the dataset, that is, the last year in which the firm compiles its balance sheets. One problem is that the effective failure often occurs in later years, as legal procedures take time to be implemented. For example, of the firms for which we last observe the balance sheets in 2008 and that exit through failure, 20% report as year of failure 2010, 10% 2011 and 7.6% 2012. This implies that, for the most recent years, we are underestimating the number of true failures, as we only have information up to 2013. To obtain a uniform definition of failure, independently from the year in which we last observe balance sheets, we only consider firms for which failure is within two years of the last year in which we observe the balance sheets and use data up to 2011. During the crisis years the overall failure rate is 2.9%; it decreases to 2% for non-zombies and increases to 7% for zombies. To analyze the effects on the survival probability, we estimate the following regression:

$$F_{ipt} = \gamma_0 + \gamma_1 \overline{LowCap}_{pt} + \gamma_2 Z_{it} * \overline{LowCap}_{pt} + \gamma_3 Z_{it} + Dummies + \nu_{ipt} \quad (5)$$

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-

[17] 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.

sector level. Table 7 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.[18] The relative effect on zombies is very similar (statistically identical) 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.

As before, we have performed the analysis replacing $\overline{LowCap}_{pt}$ with $\widehat{LowCap}_{pt}$ as defined in equation (4). Table A10 in the appendix shows that the results change only marginally.

5.3 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 et al. (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

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

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:

$$SD(TFPR)_{pt} = \lambda_0 + \lambda_1 \overline{LowCap}_{pt} + \lambda_2 \Delta TFPR_{pt} + Dummies + \mu_{pt} \tag{6}$$

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 8, yield no evidence that banks' capital had any impact on misallocation: the coefficient λ_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:

$$\begin{aligned} SD(TFPR)_{pt} = \lambda_0 + \lambda_1 \overline{LowCap}_{pt} + \lambda_2 \Delta TFPR_{pt} + \lambda_3 \overline{LowCap}_{pt} * ShZ_{pt} + \\ + \lambda_4 ShZ_{pt} + Dummies + \omega_{pt} \end{aligned} \tag{7}$$

where ShZ_{pt} is the share of zombies over the total number of firms in pt, and test the hypothesis that the interaction coefficient λ_3 is positive. The results are in the last two columns of Table 8. 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.[19] All in all, therefore, we 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. 2016, 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 A11).

5.4 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.[20]

Define Y^{NZ} as the average product of one unit of input in non-zombie firms. The units can be both firms (extensive margin) or workers/capital (intensive margin). Assume that a zombie's average product is $Y^Z = \theta Y^{NZ}, \theta \in [0, 1]$, where $\theta = 0$ is the case in which zombies are totally unproductive and $\theta = 1$ if zombies are as productive as non-zombies.

Consider first the case in which the unit is a firm, so that Y^{NZ} is the average output of non-zombies. Assume that there are n^{NZ} non-zombies and n^Z zombies. Total output is then

$$Y = Y^{NZ} * n^{NZ} + Y^Z * n^Z = Y^{NZ} * (n^{NZ} + \theta * n^Z). \tag{8}$$

Let δ^S, $S = Z, NZ$ be the effect of bank recapitalization on the failure rate of zombies and non-zombies respectively (so that $(1 - \delta^S)$ is the effect on their survival rate). Focusing on the extensive margin only, the effect of increasing bank capital is to bring output at

[19] 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.

[20] 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).

the counterfactual level:

$$Y^{CF} = Y^{NZ} * (n^{NZ}(1 - \delta^{NZ}) + \theta * n^{Z}(1 - \delta^{Z})) \tag{9}$$

Using the notation of equation (5) we have: $\delta^{NZ} = \hat{\gamma}_1 * \Delta\overline{LowCap}$ and $\delta^{Z} = (\hat{\gamma}_1 + \hat{\gamma}_2) * \Delta\overline{LowCap}$, and by the previous computations $\Delta\overline{LowCap} = -0.241$. When δ^{S} is negative, the number of surviving firms in the counterfactual scenario increases relative to the actual number, and vice versa if positive. We found that recapitalizing banks decreases the failure rate of non-zombies and increases that of zombies.

Define $sh^{NZ} = n^{NZ}/(n^{NZ} + n^{Z})$ as the share of non-zombies firms and symmetrically for sh^{Z}. The growth rate of output in the counterfactual scenario relative to actual output is:

$$\frac{Y^{CF} - Y}{Y} = \frac{-sh^{NZ}\delta^{NZ} - \theta * sh^{Z}\delta^{Z}}{sh^{NZ} + \theta * sh^{Z}} \tag{10}$$

The first term in the numerator is the percentage increase in output coming from the increase in the number of non-zombie firms (provided that δ^{NZ} is negative), while the second term is the decrease coming from the exit of zombie firms, weighted by their relative productivity. The increase is maximal, and equal to δ^{NZ} itself, when $\theta = 0$, i.e., when zombies are totally unproductive, and minimal when $\theta = 1$. Even in this case, however, the increase in the capital ratio of banks can have a positive effect as long as $-sh^{NZ}\delta^{NZ} > sh^{Z}\delta^{Z}$. In particular, the fact that the share of non-zombies is four times as large as that of zombies magnifies the effect: even when the treatment has perfectly symmetric effects ($\delta^{NZ} = -\delta^{Z}$), output increases because there are more non-zombies so that the contraction in output due to the exit of zombies is more than compensated by the expansion in non-zombies.

From the descriptive statistics in Table A2, we have that the share of zombies during the crisis is $sh^{Z} = 0.19$; regression results in the first column of Table 7 deliver $\hat{\gamma}_1 = 0.444$ and $\hat{\gamma}_1 + \hat{\gamma}_2 = -0.963$, so that $\delta^{NZ} = 0.0011$ and $\delta^{Z} = -0.0023$. The increase in output for $\theta = 0$ is 0.11% and basically zero for $\theta = 0.5$. So, according to these numbers, the lower failure rate of healthy firms and the higher failure rate of zombies that would result from the capital injection increases output growth by at best 0.1% during the crisis.

For the intensive margin, we have shown that the effects on the growth of non-zombies are rather modest. Consistently, if we take the estimates for employment growth in the first column of Table 5, we obtain $\delta^{Z} = 0.012$ and $\delta^{NZ} = 0.0004$, so the increase in output is negligible for $\theta = 0$ and slightly negative for positive values of θ. We obtain similar results, if not even more negative, when we use capital and sales growth. Overall, the effect coming from the intensive margin is, in the best of cases, rather limited.

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.

5.5 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. (2016), and McGowan et al. (2017) 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 led previous contributions to overestimate the adverse real 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 affect 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. (2016) and McGowan et al. (2017) 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 ϕ_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 issue. The standard approach neglects a second identification problem, due to firm heterogeneity. This problem is illustrated in Figure 6, where the lighter curve depicts an hypothetical distribution of firms in an area-sector. The horizontal axis is a measure of firm "quality", such as growth prospects, which translates in firm performance. Zombie firms are those below a given threshold, T_Z in the Figure. Healthy firms are those to the right of T_Z. We are interested in the difference between the average performance of healthy vs. zombie firms, namely $\mu^{NZ} - \mu^{Z}$, where $\mu^{NZ} \equiv E(x|x > T_Z)$ and $\mu_s^Z \equiv E(x|x \leq T_Z)$ denote the mean performance of healthy and zombie firms respectively. In particular, we want to know how exogenous changes in ShZ_{pt}, the share of zombies in area-sector p at t, affect $\mu^{NZ} - \mu^{Z}$ through possibile spillover effects, such as distortions of competition or lower credit supply to healthy firms. According to the prevalent interpretation in the literature, this can be assessed by the estimate of $\mu^{NZ} - \mu^{Z} = -\phi_2$ in equation (2).

The implicit identifying assumption behind this approach is that, *in the absence of spillover effects*, shocks that change the share of zombies have the same effect on the performance of zombies and healthy firms, that is, they do not affect $\mu^{NZ} - \mu^{Z}$. Under this assumption, observed variations in $\mu^{NZ} - \mu^{Z}$ associated with variations in the share of zombies can be entirely attributed to spillover effects. Unfortunately, this assumption is unlikely to hold in the data and, therefore, ϕ_2 cannot identify the effects of zombies on non-zombies even if one includes area-sector-year dummy variables in equation (2). To see this, suppose that the area-sector is hit by a negative shock that shifts the whole distribution of firms to the left, to the darker curve depicted in Figure 6. Three things happen. First, the share of zombie firms, ShZ_{pt}, increases (the area to the left of T_Z rises, as illustrated by the shaded area in Figure 6). Second, both conditional means μ^{NZ} and μ^{Z} change, and presumably drop.[21] This is the standard identification problem discussed above, addressed in the literature by the inclusion of area-sector-year dummy variables. Third, the difference between the conditional means $\mu^{NZ} - \mu^{Z}$ could also be affected, in a manner that depends on the shape of the distribution. This identification problem is neglected in the literature, but it is relevant for a large class of distributions.

Specifically, in the appendix we show that, under a simple condition on the distribution of performance, a shift to the left in the distribution induces a drop in the difference $\mu^{NZ} - \mu^{Z}$. We illustrate this with a numerical simulation. Consider the case of the normal distribution with unit variance and mean equal to 5 (the choice of the mean is

[21] Note that, for some distributions, a leftward shift might actually increase μ^{NZ}, the conditional mean above the threshold. However the mean surely decreases for log-concave distributions (Barlow & Proschan 1975), a family that includes many commonly used distributions, such as the normal, the Laplace and the logistic.

inconsequential for the results). Assume that a firm is classified as zombie if its quality is below 3. We perform the following experiment. We generate negative shocks $s = 0.01, 0.02, ..., 3$ that progressively shift the distribution to the left, $\mu(s) = 5 - s$, and compute $\mu^{NZ}(s) - \mu^{Z}(s)$, that is, the difference in the average quality of non-zombies and zombies, for each value of s. Panel A of figure 7 plots this difference and shows that it is decreasing for $s < 2$, that is, as long as the zombie threshold is to the left of the mean of the distribution (for $s = 2, \mu(s) = 3$, equal to the zombie threshold). Panel B of the figure plots $\mu^{NZ}(s) - \mu^{Z}(s)$ against the share of zombies (the latter obviously increases with s). Here too we find a negative relationship, as long as the share of zombies is below 50%. This condition is generally met in the papers on zombie lending. For example, in Acharya et al. (2016) the share of zombies varies between 3% in Germany and 20% in Italy, while in Caballero et al. (2008) it varies between sector and over time, but it exceeds 20% only in a few years in Services and Real Estate (see their Figure 3). In our case, we classify as zombies 19% of firms during the crisis years. Thus, in this very standard setting and without any negative spillovers occurring from zombies to non zombies, the estimation of equation 2 would deliver a positive coefficient ϕ_2, corresponding to a negative relative performance of healthy firms. But this simply reflects a property of the distribution of firms, and has nothing to do with the hypothesis that a larger share of zombies hurts healthy firms through spillovers in credit, product or input markets.[22]

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 A7 reports firm-level regressions of employment growth (measured by the growth rate of the wage bill), of capital growth and of sales growth 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 ϕ_1 and ϕ_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

[22]Note that in our simulation we are likely to underestimate the extent to which $\mu^{NZ}(s) - \mu^{Z}(s)$ decreases with s. The reason is that very low quality firms could exit the market. This would limit the drop in performance of (surviving) zombies (and hence the drop in $\mu^{Z}(s)$) when shocks hit. This can be seen again in Figure 6, where we also added an exit threshold T_D. When we shift the distribution to the left, the drop in the average quality of zombies is reduced by the fact that extremely low quality zombies drop out of the market. At the same time, as long as the density is higher at the zombie threshold T_Z than at the exit threshold T_D, we still obtain that a leftward shift in the distribution increases the mass of zombies.

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,[23] our estimates in Table A7 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.[24] Note that in this setting the share of zombies is also significantly and negatively correlated with the differential growth rate of capital of healthy vs zombie firms (in Table 5 instead, where we use $\overline{LowCap_{pt}}$ rather than ShZ_{pt}, the estimate of ϕ_2 is not significantly different from 0 in the capital growth regression). The results in Columns 1 and 2 of Appendix Table 5 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, given our discussion above, it is likely to be a mechanical consequence of the leftward shift in the distribution and cannot in itself be interpreted as evidence of negative spillovers from zombies to non-zombies.

6 Concluding remarks

This paper explores the consequences of under-capitalization of Italian banks during the Eurozone financial crisis, in the period 2008-13. 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

[23]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 $\tilde{\phi}_2 = -\phi_2$.

[24]Comparisons with Acharya et al. (2016) are less straightforward. In fact, they further split non-zombies into high and low quality firms and include firm fixed effects. They find no relative effect for low quality healthy firms, while a very large coefficient, of -0.5, for high quality healthy firms. But introducing a second threshold that distinguishes low and high quality healthy firms further exacerbates the identification problem for the interpretation of the relative coefficient. This can be seen in Figure 6 by adding another threshold to the right of T_z that distinguishes between high and low quality healthy firms. To a first order approximation, the average performance of low quality healthy firms does not change as the distribution shifts to the left, implying no correlation with the share of zombies, exactly in line with their findings.

transition of bank supervision from national to European authorities. Hence our results suggest that the misallocation 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 existing 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. There is also no evidence that bank weakness reduced the entry of new firms. As a consequence, we estimate that a counterfactual bank recapitalization would have had only negligible positive effects on aggregate growth during the crisis years. A possible interpretation of this finding, supported by our evidence, is 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. Moreover, in these circumstances, the negative spillover effect of zombies on healthy firms was probably modest, and on the contrary preventing zombie firms from shrinking or going bankrupt might have mitigated local adverse aggregate demand externalities.

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 cannot be blamed for aggravating the recession induced by the Eurozone financial crisis.

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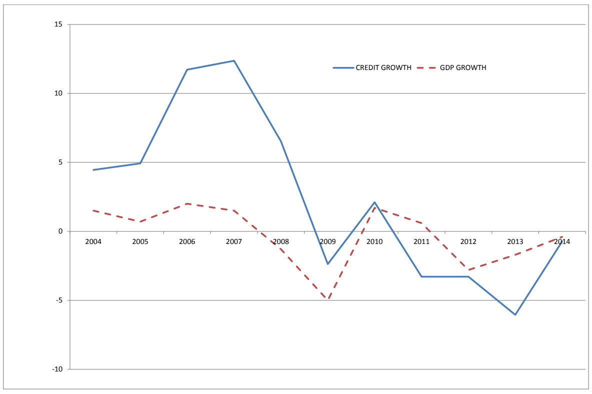
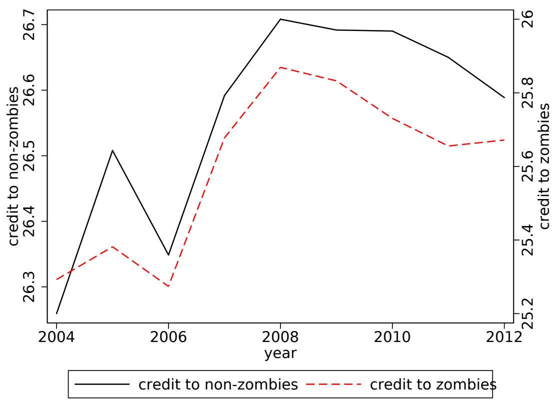
Figures and Tables

Figure 1: Credit Growth and GDP Growth in Italy



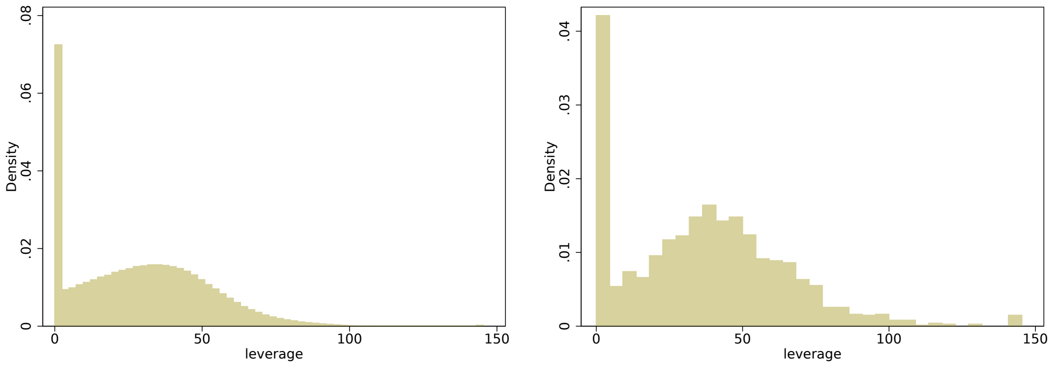
The figure shows the growth of credit by banks to non-financial firms and GDP growth in Italy between 2004 and 2014. Credit is from Supervisory reports, GDP growth is from National Statistics (ISTAT).

Figure 2: Credit to Zombie and to Non-Zombie Firms



The figure shows the log of granted credit to zombie and to non-zombie firms used in our sample. A firm is classified 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 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 sample includes non-financial firms borrowing from at least two Italian banks between 2004 and 2013. Data on credit are from the Credit Register. Data on firm characteristics are from the Firm Register.

Figure 3: Leverage of Firms



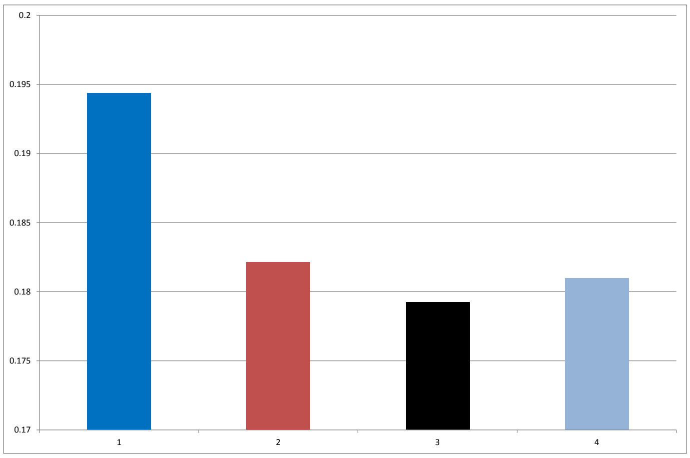
(a) Whole sample (b) Firms Exiting and with ROA<Prime Rate

Panel (a) shows the distribution of leverage (the ratio of debt from banks and from other financiers, excluding trade debt and debt towards shareholders, to total assets) for the whole sample of firms included in the firm register. Panel (b) shows the distribution of leverage of firms with the moving average of ROA below the prime rate in at least one year between 2004 and 2005 and that exited the market in 2006 or 2007 due to default or liquidation. The threshold on leverage used to define zombie firms is the median of this distribution. Data are from the year 2005.

Figure 4: Share of Zombie firms and GDP growth

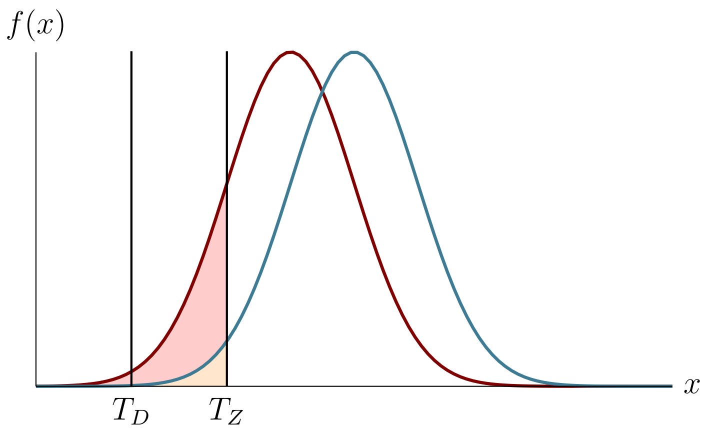
The figure plots the share of zombie firms (left scale) and GDP growth (right scale). Zombie firms are those with the three-year moving average of ROA below PRIME, and leverage above 40% (see the main text for the full denitition). Data on firms are from the firm register (CERVED), GDP growth is from National Statistics (ISTAT).

Figure 5: Share of zombie firms by quartiles of bank capital



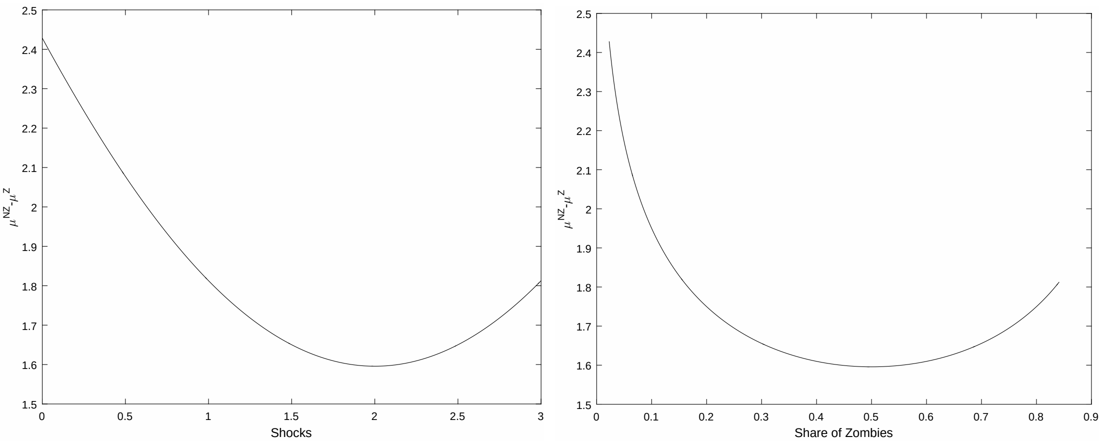
The figure shows the share of zombie firms by quartiles of bank capital. The share is computed using bank-firm relationships from the Italian Credit Register. Bank capital is the ratio of regulatory capital to risk weighted assets. Data cover the period 2004-2013.

Figure 6: The effect of a common shock on zombies and non zombies



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 zombie and T_D is the threshold for exit.

Figure 7: Difference in non-zombies vs. zombies average performance



(a) Relative performance and aggregate shocks (b) Relative performance and share of zombies

The graphs report the difference in the conditional mean of zombies and non-zombies, $\mu^{NZ} - \mu^{Z}$. In Panel (a) it is plotted against the aggregate shock $s = 0, 0.01..., 3$, which determines the leftward shift in the performance distribution, as illustrated in Figure 6. In Panel (b) it is plotted against the share of zombies implied by the leftward shift in the distribution shown in Panel (a).

Table 1: Growth of credit, baseline regressions

	(1)	(2)	(3)	(4)
LowCap	-0.7029	-1.6530**	-1.6590**	-1.2085*
	(0.6486)	(0.7228)	(0.7080)	(0.6768)
LowCap*Z	1.5228***	1.2530***	1.4010***	1.3918***
	(0.5625)	(0.4559)	(0.4778)	(0.4775)
Z	-5.5827***			
	(0.2064)			
Share bank			-0.2226***	-0.2224***
			(0.0130)	(0.0130)
Share credit line			0.1411***	0.1409***
			(0.0065)	(0.0065)
Liquidity ratio				0.2923***
				(0.0865)
Interbank ratio				0.1531**
				(0.0671)
Return on assets				-0.9757*
				(0.5682)
Bank size				-3.8506
				(2.7832)
H_0 : LowCap + LowCap*Z=0				
p-value	0.395	0.641	0.761	0.823
Firm FE	Y	N	N	N
Time FE	Y	N	N	N
Firm*year FE	N	Y	Y	Y
Bank FE	N	N	N	Y
Observations	2788833	2287690	2287690	2286282
R^2	0.149	0.360	0.376	0.376

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. 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; ROA is the ratio of profits to total assets. Bank size is the log of total assets. 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. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

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	-0.2467	0.5513**	0.1090*	-0.1318
	(0.3383)	(0.2463)	(0.0592)	(0.0856)
LowCap*Z	-0.8033***	-1.4302***	-0.5527**	-0.5989***
	(0.2827)	(0.3889)	(0.2220)	(0.1912)
Share bank	-0.2684***	-0.1713***	-0.0037***	0.0056**
	(0.0063)	(0.0052)	(0.0007)	(0.0026)
Share credit line	-0.0562***	0.0000	-0.0002	0.0072***
	(0.0041)	(0.0043)	(0.0007)	(0.0020)
Liquidity ratio	-0.1410***	-0.1058***	-0.0005	-0.0234
	(0.0390)	(0.0308)	(0.0087)	(0.0153)
Interbank ratio	0.1236	-0.0436	0.0206**	-0.0282*
	(0.1267)	(0.0305)	(0.0081)	(0.0148)
Return on assets	-0.3176	-0.1605	-0.0119	0.1195
	(0.2955)	(0.1218)	(0.0695)	(0.1381)
Bank size	4.7363**	1.2090	-0.2427	-1.6517**
	(2.2681)	(1.0289)	(0.2612)	(0.6822)
H_0 : LowCap + LowCap*Z=0				
p-value	0.00703	0.0556	0.0296	0.000687
Firm*year FE	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y
Observations	2636764	2095046	2698744	2698744
R^2	0.457	0.469	0.735	0.570

The table shows OLS regressions of different outcome variables on on the dummy for zombie firms (Z), the dummy for banks with capital ratio below the median (LowCap) and their interactions. 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 on the dummy for zombie firms (Z), the dummy for banks with capital ratio below the median (LowCap) and their interactions. 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. 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: Additional tests

	(1) collateral	(2) no collateral	(3) interest rates	(4) evergreening
LowCap	-1.1941	-1.2925**	0.0604	-1.0413
	(1.0122)	(0.6462)	(0.1018)	(0.7887)
LowCap*Z	0.4052	1.6195***	0.0090	1.6728**
	(0.7425)	(0.5206)	(0.0454)	(0.6827)
Share bank	-0.0402***	-0.3036***	-0.0196***	-0.2485***
	(0.0072)	(0.0131)	(0.0009)	(0.0129)
Share bank*LowCap				-0.0059
				(0.0093)
Share bank*Z				0.1329***
				(0.0098)
Share bank*LowCap*Z				-0.0162
				(0.0147)
Share credit line	0.0875***	0.1463***	-0.0190***	0.1425***
	(0.0073)	(0.0085)	(0.0015)	(0.0066)
Liquidity ratio	0.2855***	0.3033***	0.0020	0.2909***
	(0.1051)	(0.0880)	(0.0216)	(0.0862)
Interbank ratio	0.1614**	0.1612**	-0.0019	0.1529**
	(0.0681)	(0.0725)	(0.0218)	(0.0667)
Return on assets	-2.1998***	-0.7052	-0.1075	-0.9808*
	(0.5724)	(0.6219)	(0.1020)	(0.5683)
Bank size	-4.9106*	-4.1280	-0.1194	-3.8541
	(2.8314)	(3.0398)	(0.8563)	(2.7815)
H_0 : LowCap + LowCap*Z=0				
p-value	0.556	0.672	0.516	0.519
Firm*time FE	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y
Observations	144789	1878353	966838	2286282
R^2	0.470	0.389	0.654	0.376

Column 1 and 2 of 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. Column 1 includes firm*bank relationships in which some credit is collateralized (i.e. the share of collateralized credit is positive). Column 2 includes firm*bank relationships in which no credit is collateralized (i.e. the share of collateralized credit is zero). 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 $t+1$. Column 3 shows a regression of the level of the interest rate on revolving credit lines (inclusive of fees and commissions) on the dummy for zombie firms (Z), the dummy for banks with capital ratio below the median (LowCap) and their interactions. Column 4 shows a regression of the dummy low-capital bank and its interactions with the share of credit of the bank on the change in the log credit granted between year t and year $t+1$. These regressions represent a test of evergreening. All regressions include firm*year fixed effects and bank fixed effects (the same specification as in column (4) of Table 1), the share of total credit to the firm granted by the bank and the share of credit line out of total credit to the firm by the bank. Firm and bank level controls are measured as of year t, and are defined in the notes to Table 1. The sample includes yearly data between 2008 and 2013. Standard errors double clustered at the bank and firm level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Credit growth – Effect at the firm level

	(1)	(2)	(3)	(4)
LowCap	-0.9699***	-1.2161***	-0.8833***	-1.4187***
	(0.2335)	(0.2286)	(0.2313)	(0.1734)
LowCap*Z	3.0060***	3.3340***	3.2917***	3.8852***
	(0.4102)	(0.4078)	(0.4077)	(0.3414)
Z	-8.9887***	-8.6526***	-8.6391***	-10.3609***
	(0.2071)	(0.2042)	(0.2041)	(0.1927)
Share bank credit		0.2560***	0.2516***	0.6820***
		(0.0084)	(0.0085)	(0.0043)
Share credit lines		0.7595***	0.7575***	0.6832***
		(0.0083)	(0.0083)	(0.0056)
Liquidity Ratio			0.1519***	0.1337***
			(0.0300)	(0.0220)
Interbank ratio			-0.1945***	-0.0040
			(0.0263)	(0.0200)
Return on assets			-0.5682***	-0.2952***
			(0.1558)	(0.1116)
Bank size			0.2918**	-0.1821**
			(0.1395)	(0.0921)
H_0 : LowCap + LowCap*Z=0				
p-value	0	0	0	0
Firm FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Observations	662187	662187	662187	1223793
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. 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 5: Firms' growth and banks' capital ratio

	(1)	(2)	(3)	(4)	(5)	(6)
	ΔLabour		ΔCapital		ΔSales	
$\overline{\text{LowCap}}$	0.000		-0.008		-0.001	
	(0.007)		(0.006)		(0.008)	
$\overline{\text{LowCap}}$*Z	0.038***	0.037***	0.006	-0.002	0.019***	0.021***
	(0.004)	(0.004)	(0.007)	(0.006)	(0.005)	(0.005)
Z	-0.058***	-0.058***	-0.014***	-0.011***	-0.053***	-0.053***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
H_0 : LowCap + LowCap*Z=0						
p-value	0		0.782		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	916,693	916,440	966,039	965,762
R-squared	0.036	0.058	0.019	0.029	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 book value of the capital stock 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 6: Alternative sources of finance and banks' capital ratio

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ΔTrade debt		ΔNon-bank debt		ΔCash		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-squared	0.015	0.036	0.007	0.031	0.005	0.017	0.023	0.034

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 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 7: Firm failure and banks' capital ratio

	(1)	(2)	(3)
	Linear probability		Probit
$\overline{\text{LowCap}}$	0.444**		0.501**
	(0.208)		(0.220)
$\overline{\text{LowCap}}$*Z	-1.407***	-1.448***	-1.136***
	(0.346)	(0.355)	(0.195)
Z	5.659***	5.669***	4.318***
	(0.191)	(0.193)	(0.100)
H_0 : LowCap + LowCap*Z=0			
p-value	0.008		0.008
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-squared	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. $\overline{\text{LowCap}}$ is 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. Z is a dummy for zombie firms. 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. The first two columns are OLS estimates, while column (3) is a probit estimate, with marginal effects reported. $\gamma_1 + \gamma_2$ is the sum of the coefficients in the first two rows in the column. The sample includes yearly data between 2008 and 2011. Standard errors clustered at the province-sector level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: 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)
Observations	9,194	10,885	9,194	10,885
R-squared	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 $\overline{\text{LowCap}}$ which is 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. TFP growth is Delta log of the average TFP at the province-sector level. The dummy zombie firms (Z) is computed as described in Table 1. 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. Standard errors clustered at the province-sector level.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

A Appendixes

A.1 A general condition for the negative correlation between the relative performance of zombies and non zombies and the share of zombies

Consider the effect of a shift to the left in the distribution $F(X)$ depicted in Figure 6. We want to know how this shift affects the difference between conditional means, $\mu^{NZ} - \mu^{Z}$, where:

$$\mu^{NZ} = \frac{1}{1 - F(T_z)} \int_{T_z}^{\infty} x dF(x) \quad (11)$$

$$\mu^{Z} = \frac{1}{F(T_z)} \int_{-\infty}^{T_z} x dF(x)$$

Note that this question is equivalent to asking how $\mu^{NZ} - \mu^{Z}$ is affected by a change in the threshold T_z. By (11) we have:

$$\frac{\partial \mu^{NZ}}{\partial T_z} = \frac{f(T_z)}{1 - F(T_z)} (\mu^{NZ} - T_z)$$

$$\frac{\partial \mu^{Z}}{\partial T_z} = \frac{f(T_z)}{F(T_z)} (T_z - \mu^{Z})$$

so that

$$\text{Sign } \frac{\partial(\mu^{NZ} - \mu^{Z})}{\partial T_z} = \text{ Sign } \left\{ F(T_z)\mu^{NZ} + [1 - F(T_z)]\mu^{Z} - T_z \right\} \quad (12)$$

Let $\mu = F(T_z)\mu^{Z} + [1 - F(T_z)]\mu^{NZ}$ denote the unconditional mean of x. Equation (12) can then be rewritten as:

$$\text{Sign } \frac{\partial(\mu^{NZ} - \mu^{Z})}{\partial T_z} = \text{Sign } \left\{ (\mu^{NZ} - \mu) - (T_z - \mu^{Z}) \right\}$$

It is easy to verify that for a uniform distribution this implies $\frac{\partial(\mu^{NZ} - \mu^{Z})}{\partial T_z} = 0$. More generally, a necessary and sufficient condition for $\frac{\partial(\mu^{NZ} - \mu^{Z})}{\partial T_z} < 0$ is that

$$(\mu^{NZ} - \mu) < (T_z - \mu^{Z}) \quad (13)$$

A.2 Descriptive statistics and additional results

Table A1: Descriptive statistics of firms

	Mean	Median	25pct	75pct	S.D.	N
Non-Zombie Firms						
Leverage	23.92	23.05	6.71	36.36	19.09	582,406
ROA	5.54	5.26	1.77	9.46	8.50	582,406
EBIT/Int Exp	6.10	2.71	1.08	6.74	12.28	569,568
Cash Hold/Assets	6.96	2.71	0.62	8.85	10.27	551,970
Liquidity/Assets	13.18	6.07	2.33	14.14	62.10	582,265
Assets (000 Euros)	9,414	1,999	896	5,049	119,134	582,406
Zombie Firms						
Leverage	56.84	52.89	45.88	63.58	15.06	119,488
ROA	-1.34	1.09	-3.35	3.35	7.98	119,488
EBIT/Int Exp	-0.45	0.48	-1.36	1.44	4.16	118,875
Cash Hold/Assets	3.18	0.94	0.23	3.30	6.15	109,909
Liquidity/Assets	9.11	3.20	1.05	8.62	65.19	119,463
Assets (000 Euros)	12,896	3,156	1,245	8,653	79,031	119,488

The table shows descriptive statistics of firms according to zombie status. A firm is classified 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 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. Data are from the Firm Register (Cerved) available at annual frequency from firms' balance sheets. Leverage is total financial debt over total assets; ROA is profits to assets ratio; Ebit/Int Exp is the ratio of Earnings before interest taxes depreciation and amortization to interest expenses; Cash Holdings to Assets is the ratio of cash and cash equivalents to total assets; Liquidity to Assets is the share of liquidity and short term assets to total assets.

Table A2: Descriptive Statistics of the variables used in the credit regressions

	Mean	St.Dev.	Median	p25	p75	Obs.
Dependent variables:						
Delta Log Credit	-8.06	50.13	0	-15.771	0	2,287,690
D(Cut=1)	9.43	29.23	0.00	0.00	0.00	2,636,764
D(Cut Rev=1)	9.84	29.79	0.00	0.00	0.00	2,095,046
D(Bad loan=1)	1.78	13.22	0.00	0.00	0.00	2,698,744
D(Non-perf=1)	3.72	18.93	0.00	0.00	0.00	2,698,744
Interest rate on credit lines	10.00	4.26	9.46	6.61	12.87	1,273,014
Firm regressors:						
Zombie	0.19	0.39	0.00	0.00	0.00	2,287,690
Zombie 2	0.11	0.31	0.00	0.00	0.00	2,224,741
Zombie 3	0.17	0.37	0.00	0.00	0.00	2,287,690
PC ROA-leverage (PC 1)	0.07	0.84	0.11	-0.47	0.60	2,287,690
PC EBIT/Int.-leverage (PC 2)	0.09	0.99	0.28	-0.38	0.73	2,224,741
Score	0.06	0.23	0.00	0.00	0.00	2,281,296
Banks regressors:						
LowCap	0.24	0.43	0	0	0	2,287,690
Capital Ratio	11.32	2.36	11.09	10.17	12.09	2,287,690
LowCap9	0.04	0.00	0.00	0.00	0.20	2,287,690
LowCap yby	0.44	0.50	0	0	1	2,287,690
Liquidity ratio	9.04	4.33	9.21	5.64	11.09	2,287,690
Interbank ratio	7.92	8.14	5.94	3.56	9.06	2,286,616
Bank ROA	0.03	0.66	0.22	0.07	0.44	2,286,616
Bank Size	11.58	1.82	11.80	10.40	13.30	2,287,690
Bank-firm regressors:						
Share bank	29.39	21.45	23.94	12.28	42.35	2,287,690
Share credit line	24.16	30.50	11.11	3.50	30.71	2,287,690

See note to table on next page

The table shows descriptive statistics of the variables used in the regressions, relative to the estimating sample. The statistics are taken over the distribution of firm-bank-year observations. Data on credit and on bank-firm relationships are from the Italian Credit Register. Data on firm characteristics are from the Firm Register. Data on bank characteristics are from the Supervisory Reports. The sample period includes bank-firm relationships at the year frequency between 2008 and 2013. Delta log credit is the yearly difference in log credit granted; D(Cut= 1) is a dummy equal to one if a credit relationship is severed in the next year; D(Cut Rev= 1) is a dummy equal to one if a credit line is severed in the next year; D(Bad loan= 1) is a dummy equal to 1 if the bank classifies a loan as bad loan between year t and $t+1$; D(Non-perf= 1) if a dummy equal to 1 if the bank classifies a loan as non performing between year t and $t+1$; Interest rate on credit lines is the interest rate on revolving credit lines (inclusive of fees and commissions) by bank j to firm i; Zombie is a dummy equal to 1 if the firm's ROA (2 years moving average) is below the prime rate (2 years moving average) and the firm's leverage is above the median leverage, as of the end of 2005, computed on the sample of firms that had ROA below prime rate in at least 1 year between 2004 and 2005 and that exited the market in 2006 or 2007 due to default or liquidation. Zombie 2 is a dummy equal to 1 if the firm EBIT to interest expenses ratio (2 years moving average) is below 1 and the firm's leverage is above the median leverage, as of the end of 2005, computed on the sample of firms that the ebit to interest expenses ratio below 1 in at least 1 year between 2004 and 2005 and that exited the market in 2006 or 2007 due to default or liquidation; Zombie3 is the defined in the same way as zombie but it has the additional condition that revenues did not increase for the next consecutive years (this allows to define as non-zombies fast growing firms such as start-ups and the like; PC ROA-leverage (PC 1) is the principal components of the moving average of ROA and leverage; PC EBIT/Int-Leverage (PC 2) is the principal component of the moving average of the EBIT to interest expenses ratio and leverage; Score is a dummy variable equal to 1 if the firm has a Z-score in the bottom 2 notches of the distribution (which includes 9 notches) indicating high risk of default; LowCap is a dummy equal to 1 if the capital ratio is below the median capital ratio of the distribution as of 2008; Capital Ratio is the ratio of regulatory capital to risk weighted assets; LowCap9 is a dummy equal to 1 if the capital ratio is below 9 (the regulatory threshold is 8); LowCap yby is a dummy equal to 1 if the capital ratio is below the median capital ratio computed year by year; Liquidity ratio is the ratio of cash plus government securities to total assets; Interbank ratio is the ratio of interbank deposits to total assets; ROA is the ratio of bank profit to total assets; Bank size is the log of total 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.

Table A3: Credit Growth - Robustness to the definition of zombie firm

	(1) Zombie 2	(2) Zombie3	(3) PC 1	(4) PC 2	(5) Score
LowCap	-1.1356	-1.2252*	-1.0202	-1.0511	-1.1273
	(0.6981)	(0.6842)	(0.6803)	(0.6811)	(0.6960)
LowCap*Z	2.1040***	1.8121***	1.0972***	1.0188***	3.7804***
	(0.4978)	(0.4912)	(0.2688)	(0.2519)	(0.7995)
Share bank	-0.2217***	-0.2224***	-0.2225***	-0.2218***	-0.2231***
	(0.0133)	(0.0130)	(0.0130)	(0.0133)	(0.0130)
Share credit line	0.1417***	0.1408***	0.1408***	0.1416***	0.1410***
	(0.0065)	(0.0065)	(0.0065)	(0.0065)	(0.0066)
Liquidity ratio	0.2919***	0.2914***	0.2908***	0.2922***	0.2925***
	(0.0873)	(0.0866)	(0.0864)	(0.0871)	(0.0865)
Interbank ratio	0.1561**	0.1542**	0.1540**	0.1559**	0.1538**
	(0.0677)	(0.0669)	(0.0667)	(0.0676)	(0.0671)
Return on assets	-1.0127*	-0.9767*	-0.9788*	-1.0184*	-0.9707*
	(0.5716)	(0.5688)	(0.5694)	(0.5732)	(0.5680)
Bank size	-3.9083	-3.8472	-3.8226	-3.9182	-3.8800
	(2.7932)	(2.7638)	(2.7582)	(2.7892)	(2.7674)
H_0 : LowCap + LowCap*Z=0					
p-value	0.202	0.476	0.918	0.965	0.004
Firm*Year FE	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y
Observations	2,223,379	2,286,282	2,286,282	2,223,379	2,281,296
R^2	0.373	0.376	0.376	0.373	0.376

The table replicates the regressions in columns (4) (with firm*year and bank fixed effects) of Table 1 using alternative definitions of zombie firms. In column (1) the dummy for a zombie firm (Zombie 2) equals one if both a) the firm EBIT to interest coverage ratio (two-year moving average) is below 1; and b) the firm's leverage is above the median leverage, as of the end of 2005, computed on the sample of firms with EBIT to interest coverage ratio below 1 in at least one year between 2004 and 2005 and that exited the market in 2006 or 2007 due to default or liquidation; in column (2) the dummy for a zombie firm (Zombie 3) equals one if a) the firm's ROA (two-year moving average) is below the prime rate (two-year moving average) - b) the firm's leverage is above the median leverage, as of the end of 2005, computed on the sample of firms that had ROA below the prime rate in at least one year between 2004 and 2005 and that exited the market in 2006 or 2007 due to default or liquidation - c) revenues did not increase for the next consecutive years (this allows to define as non-zombies fast growing firms such as start-ups and the like); in column (3) the continuous indicator for zombie firms PC 1 is the principal component of the moving average of ROA and leverage; in column (4) PC 2 is the principal component of the moving average of the EBIT to interest coverage ratio and leverage; in column (5) Score is a dummy variable equal to 1 if the firm has a Z-score in the bottom 2 notches of the distribution (which includes 9 notches) indicating high risk of default. See the note to Table 1 for the definition of the other variables. Standard errors double clustered at the bank and firm level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A4: Credit Growth - Robustness on the definition of banks strength

	(1)	(2)	(3)	(4)	(5)	(6)
LowCap yby	-1.8463**					
	(0.7945)					
LowCap yby*Z	1.4287***					
	(0.4564)					
Capital ratio		0.6616**				
		(0.2600)				
Capital ratio*Z		-0.2729*				
		(0.1547)				
LowCap9			-0.9295			
			(0.6407)			
LowCap9*Z			2.6762***			
			(0.6309)			
LowROA				1.1890**		
				(0.4956)		
LowROA*Z				0.0457		
				(0.6844)		
HighLeverage					-0.0713	
					(0.8397)	
HighLeverage*Z					-0.3556	
					(0.6017)	
HighBadLoan						-0.0294
						(0.6206)
HighBadLoan*Z						1.7293***
						(0.5928)
H_0 : LowCap + LowCap*Z=0						
p-value	0.664		0.0638	0.157	0.668	0.0377
Observations	2286282	2286282	2286282	2286282	2286282	2285554
R^2	0.376	0.376	0.376	0.376	0.376	0.376

The table replicates the regression in column (5) (with firm*year and bank fixed effects) of Table 1 using alternative definitions of banks strength. In column (1) the indicator of banks strength is a dummy equal to one if the capital ratio in a year is below the median capital ratio in that year; in column (2) is the continuous capital ratio; in column (3) is a dummy equal to one if the capital ratio is below 9 (the minimum regulatory threshold is 8%); in column (4) a dummy for banks with ROA below the median of the distribution as of 2008; in column (5) a dummy equal to one if the bank has leverage (total assets to capital) above the median of the distribution as of 2008; in column (6) a dummy equal to one if the ratio of bad loans to assets is above the median of the distribution as of 2008. 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. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A5: Credit Growth – Pre-crisis

	(1)	(2)	(3)	(4)
LowCap	0.7997	-0.6807	-0.4763	0.6513
	(1.4099)	(1.6467)	(1.6100)	(1.6129)
LowCap*Z	-1.6304**	-0.4380	-0.2341	-0.1435
	(0.7185)	(0.5104)	(0.5420)	(0.5025)
Z	-4.7284***			
	(0.3785)			
Share bank			-0.4664***	-0.4653***
			(0.0239)	(0.0240)
Share credit line			0.1011***	0.1008***
			(0.0147)	(0.0143)
Liquidity ratio				0.5858
				(0.3586)
Interbank ratio				-0.0116
				(0.1600)
Bank ROA				1.7545
				(1.4537)
Bank size				-5.3750*
				(3.2112)
H_0 : LowCap + LowCap*Z=0				
p-value	0.552	0.569	0.717	0.790
Observations	1,622,863	1,368,511	1,368,511	1,368,511
R^2	0.149	0.336	0.364	0.364

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 2004. 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 a zombie firm (Z) is defined as in Table 1. The capital ratio is the ratio of bank regulatory capital and risk weighted assets. 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; ROA is the ratio of profits to total assets. Bank size is the log of total assets. The sample includes years between 2004 and 2007. Standard errors double clustered at the bank and firm level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A6: Summary Statistics for the Effects of Zombie Lending

	Mean	Median	25pct	75pct	S.D.	N
	Panel A: Firm level variables					
Non-zombie Firms						
Δ labor	0.002	0.012	-0.097	0.115	0.273	850,784
Δ capital	-0.016	-0.058	-0.206	0.079	0.391	805,464
Δ sales	-0.039	-0.023	-0.164	0.102	0.270	851,064
Δ Trade debit	-0.010	-0.004	-0.241	0.223	0.453	725,370
Δ Non-bank financial debt	-0.059	0.000	-0.318	0.135	0.803	297,929
Δ Cash holdings	-0.007	0.000	-0.651	0.632	1.242	772,595
Dummy capital injection	0.076	0.000	0.000	0.000	0.265	879,750
Failure	0.026	0.000	0.000	0.000	0.158	950,679
Zombie Firms						
Δ labor	-0.045	-0.020	-0.155	0.087	0.291	116,501
Δ capital	-0.023	-0.048	-0.149	0.035	0.339	111,272
Δ sales	-0.086	-0.058	-0.230	0.080	0.302	115,015
Δ Trade debit	-0.067	-0.049	-0.301	0.181	0.465	112,942
Δ Non-bank financial debt	0.026	0.000	-0.215	0.237	0.789	64,351
Δ Cash holdings	-0.101	0.000	-0.831	0.651	1.344	101,682
Dummy capital injection	0.130	0.000	0.000	0.000	0.336	122,817
Failure	0.077	0.000	0.000	0.000	0.266	199,982
	Panel B: Sector-province-year variables					
Capital ratio below median ($\overline{\text{LowCap}}$)	0.267	0.202	0.125	0.336	0.202	1,002,527
Share of zombies (ShZ)	0.200	0.197	0.148	0.243	0.083	1,002,527
Standard Deviation of TFP	0.596	0.563	0.484	0.656	0.203	10,900
TFP growth	-0.020	-0.017	-0.084	0.046	0.177	10,972

The table shows descriptive statistics of the variables used in regressions of the effects of zombie lending. Panel A reports growth rate of the wage bill, the capital stock, sales and TFP, all at constant prices, and a dummy equal to 1 if a firm fails. Panel B report indicators at the province-sector-year levels. CR below median is the share of credit extended by banks with a capital ratio below the median value of the banks' capital ratio; Share of zombies is the share of firms classified as zombies according to our preferred definition (see description in the paper and in Table 1). All statistics are computed at the firm-year level, except standard deviation of TFP and TFP growth, that are computed at the province-sector-year level (the unit of observation in the regressions). Variables refer to the years 2008-2013.

Table A7: Firms' growth and share of zombie firms

	(1)	(2)	(3)	(4)	(5)	(6)
	ΔLabour		ΔCapital		ΔSales	
ShZ	-0.110***		-0.039***		-0.112***	
	(0.014)		(0.013)		(0.017)	
ShZ*Z	0.067***	0.057***	0.041***	0.043***	0.079***	0.072***
	(0.013)	(0.013)	(0.013)	(0.014)	(0.013)	(0.013)
Z	-0.062***	-0.060***	-0.021***	-0.021***	-0.065***	-0.063***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
H_0 : ShZ + ShZ*Z=0						
p-value	0.018		0.880		0.110	
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	966,950	966,678	916,548	916,296	965,750	965,470
R-squared	0.036	0.058	0.019	0.029	0.083	0.122

The table shows regressions of different measures of firm growth on the share of zombies at the province-sector-year level ShZ. The dependent variable is the delta log of the wage bill in column (1)-(2), of the book value of the capital stock in columns (3)-(4), of sales in columns (5)-(6). The dummy for zombie firms (Z) is defined as 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 A8: Firms' growth and zombie lending with the alternative definition of banks' capital ratio

	(1)	(2)	(3)	(4)	(5)	(6)
	ΔLabour		ΔCapital		ΔSales	
$\widehat{\text{LowCap}}$	0.006		0.005		0.008	
	(0.006)		(0.006)		(0.008)	
$\widehat{\text{LowCap}}$*Z	0.035***	0.035***	0.007	-0.001	0.016***	0.019***
	(0.004)	(0.004)	(0.006)	(0.006)	(0.005)	(0.005)
Z	-0.057***	-0.056***	-0.014***	-0.011***	-0.052***	-0.052***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
H_0 : LowCap + LowCap*Z=0						
p-value	0		0.13		0.006	
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	967,280	967,004	916,731	916,472	966,075	965,791
R-squared	0.036	0.058	0.019	0.029	0.083	0.122

The table shows regressions of different measures of firm growth on banks' capital ratio, $\widehat{\text{LowCap}}$, computed 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 for the period 2004-2007 as weights. The dependent variable is the delta log of the wage bill in column (1)-(2), of the book value of the capital stock in columns (3)-(4), of sales in columns (5)-(6). The dummy for zombie firms (Z) is defined as 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 A9: Firms' growth and zombie lending with the firm-level measure of banks' capital ratio

	(1)	(2)	(3)	(4)	(5)	(6)
	ΔLabour		ΔCapital		ΔSales	
LowCap_i	-0.001	-0.000	0.002	0.002	-0.000	0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$\text{LowCap}_i * \text{Z}$	0.016***	-0.002	-0.000	0.001	0.003	-0.010**
	(0.003)	(0.005)	(0.005)	(0.006)	(0.004)	(0.005)
$\overline{\text{LowCap}}$		0.008		0.001		-0.000
		(0.008)		(0.008)		(0.010)
$\overline{\text{LowCap}} * \text{Z}$		0.043***		-0.003		0.032***
		(0.007)		(0.010)		(0.008)
Z	-0.048***	-0.055***	-0.012***	-0.012***	-0.045***	-0.050***
	(0.001)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)
Observations	571,172	571,171	521,723	521,722	569,044	569,043
R-squared	0.049	0.049	0.032	0.032	0.107	0.107

The table shows regressions of different measures of firm growth on two measures of capital ratio: LowCap_i, computed as the weighted average at the firm level of a dummy equal to one for banks with a capital ratio below the median capital ratio as of 2008, with the weights equal to the share of credit that firm i gets from each bank: $\text{LowCap}_i = \sum_j \frac{b_{ij}}{b_i} \text{LowCap}_j$, where b_{ij} is the credit from bank j to firm i and $b_i = \sum_j b_{ij}$; and $\overline{\text{LowCap}}$, computed 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 dependent variable is the delta log of the wage bill in column 1-2, of the book value of the capital stock in columns 3-4, of sales in columns 5-6. The dummy for zombie firms (Z) is defined as in Table 1. All regressions include province-sector and year fixed effects. 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 A10: Firms' failure and banks' alternative definition of capital ratio

	(1)	(2)	(3)
	Linear probability		Probit
$\widehat{\text{LowCap}}$	0.230		0.230
	(0.208)		(0.215)
$\widehat{\text{LowCap}}$*Z	-1.313***	-1.337***	-0.864***
	(0.322)	(0.331)	(0.183)
Z	5.602***	5.669***	4.209***
	(0.181)	(0.193)	(0.095)
$\gamma_1 + \gamma_2$	-1.083***		-0.634***
Test $\gamma_1 + \gamma_2 = 0$ (p-val)	0.003		0.009
Prov-Sect FE	Y	N	Y
Year FE	Y	N	Y
Prov-Sect-Year FE	N	Y	N
Observations	1,150,765	1,150,718	1,150,684
R-squared	0.016	0.020	0.038

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. $\widehat{\text{LowCap}}$ is 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 for the period 2004-2007 as weights. The dummy for zombie firms (Z) is defined as in Table 1. Odd columns include province-sector and year fixed effects, while even columns include province-sector-year fixed effects. The first two columns are OLS estimates, while column (3) is a probit estimate, with marginal effects reported. $LowCap + LowCap * Z$ is the sum of the coefficients in the first two rows in the column. The sample includes yearly data between 2008 and 2011. Standard errors clustered at the province-sector level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A11: TFP dispersion and banks' capitalization with the alternative definition of capital ratio

	(1)	(2)	(3)	(4)
$\widehat{\text{LowCap}}$	0.000	-0.003	-0.030***	-0.025***
	(0.008)	(0.006)	(0.011)	(0.008)
$\widehat{\text{LowCap}}$*ShZ			0.134***	0.106***
			(0.040)	(0.027)
ShZ			0.001	0.052***
			(0.021)	(0.017)
TFP growth	-0.054***	-0.076***	-0.054***	-0.074***
	(0.013)	(0.008)	(0.013)	(0.008)
Observations	9,194	10,885	9,194	10,885
R-squared	0.824	0.871	0.825	0.872

The table shows regressions of the standard deviation of TFP at the province-sector-year level on the share of zombies and banks' capital ratio. Specifically, ShZ is the share of firms that are classified as zombies in the province-sector-year and $\widehat{\text{LowCap}}$is 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 for the period 2004-2007 as weights. TFP growth is Delta log 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. Standard errors clustered at the province-sector level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.