Discussion Paper

Contagious zombies

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Non-technical summary

Research question

What effect does non-standard monetary policy have on bank lending to the real economy? Does it help poorly capitalised banks to expand their lending to non-viable firms as a way of averting the otherwise imminent risk of forfeiting existing liabilities? This behaviour, also known as zombie lending, has the potential to delay market restructuring, leading to disruptions in the real economy. To cite an example, the real economy might suffer contagion effects if the firms concerned also step up their accumulation of trade credits from suppliers. We investigate whether, following the long-term refinancing operations of the European Central Bank (ECB) at the end of 2011 and the beginning of 2012, poorly capitalised German banks actually granted more loans to non-viable firms, and whether these firms were subsequently awarded more trade credits.

Contribution

We use detailed information on lending, linking it to balance sheet data encompassing all German banks. This dataset is in turn linked to firms' detailed annual balance sheet data so as to identify any non-viable firms. Firms exhibiting a negative interest coverage ratio over the past three years are deemed to be non-viable. This dataset enables us to examine the impact of the ECB's long-term refinancing operations on bank lending to non-viable firms, as well as the take-up and granting of trade credits at firm level.

Results

Poorly capitalised banks that took advantage of the ECB's long-term refinancing operations were found to be particularly prone to granting loans to non-viable firms. These firms constitute an above-average credit risk. Moreover, non-viable firms receiving additional credit from banks more heavily reliant on central bank financing were able not just to expand their granting of trade loans but also to heighten their take-up of trade credits. Non-viable firms that garnered additional bank loans along with other trade credits on the back of the ECB's long-term refinancing operations are more likely to default than the average non-viable firm.

Nichttechnische Zusammenfassung

Fragestellung

Welchen Effekt hat unkonventionelle Geldpolitik auf die Kreditvergabe durch Banken an die Realwirtschaft? Trägt sie dazu bei, dass niedrig kapitalisierte Banken ihre Kreditvergabe an nicht lebensfähige Firmen ausweiten, um den sonst drohenden Verlust bestehender Verbindlichkeiten zu vermeiden? Dieses Verhalten, auch „Zombie Kreditvergabe" genannt, kann Marktbereinigungen verzögern und so Störungen in der Realwirtschaft verursachen. Beispielsweise kann es zu Ansteckungseffekten in der Realwirtschaft führen, wenn diese Firmen verstärkt auch Handelskredite von Zulieferbetrieben akkumulieren. Wir untersuchen, ob schwach kapitalisierte deutsche Banken nach den langfristigen Refinanzierungsgeschäften der Europäischen Zentralbank (EZB) Ende 2011 und Anfang 2012 tatsächlich mehr Kredit an nicht lebensfähige Firmen vergaben und ob diese Firmen in der Folge auch mehr Handelskredite erhalten haben.

Beitrag

Wir nutzen detaillierte Informationen zur Kreditvergabe und verknüpfen diese mit Bilanzdaten aller deutschen Banken. Diesen Datensatz verknüpfen wir wiederum mit ausführlichen jährlichen Firmenbilanzdaten, um nicht lebensfähige Firmen zu identifizieren. Als nicht lebensfähig gelten dabei Firmen mit einem negativen Zinsdeckungsgrad in den vergangenen drei Jahren. Mit Hilfe dieses Datensatzes können wir sowohl den Effekt der langfristigen Refinanzierungsgeschäfte der EZB auf die Kreditvergabe von Banken an nicht lebensfähige Firmen, als auch die Aufnahme und Vergabe von Handelskrediten auf Unternehmensebene untersuchen.

Ergebnisse

Insbesondere schwach kapitalisierte Banken, welche die langfristigen Refinanzierungsgeschäfte der EZB nutzten, haben Kredite an nicht lebensfähige Firmen vergeben. Diese Firmen stellen ein überdurchschnittliches Kreditrisiko dar. Zudem konnten nicht lebensfähige Firmen, die zusätzlichen Kredit von Banken mit einer höheren Abhängigkeit von Zentralbankfinanzierung erhalten haben, nicht nur die Vergabe, sondern auch die Aufnahme von Handelskrediten ausweiten. Nicht lebensfähige Firmen, die im Zuge der langfristigen Refinanzierungsgeschäfte zusätzlichen Bankkredit und weitere Handelskredite erhielten, haben eine höhere Ausfallwahrscheinlichkeit als die durchschnittliche nicht lebensfähige Firma.

Contagious Zombies [*]

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Abstract

Does banks' zombie lending induced by unconventional monetary policy also allow zombie firms to leverage their trade credit borrowing? We first provide evidence suggesting that—even in Germany—particularly weak banks used the European Central Bank's very long-term refinancing operations (VLTROs) to evergreen exposures to zombie firms, which in turn elevated credit risk. Second, we show that zombie firms, which obtained additional funding from banks relying to a larger extent on VLTRO funding, also increased their accounts payable and advance payments received from downstream and upstream firms. And third, zombie firms that obtained further bank funding and such trade credit after the VLTROs had an elevated expected default probability even compared to average zombie firms. This suggests that suppliers relying on banks' lending decisions as a signal about borrowers' credit quality might be misled by banks' zombie lending to extend more trade credit to zombie firms exposing suppliers to elevated contagion risk.

Keywords: unconventional monetary policy, zombie lending, trade credit

JEL Classification: G1, G20, E58

1 Introduction

Zombie lending is widely perceived as undermining market discipline: Rather than making efficient use of their private information and restricting the supply of credit to unproductive firms forcing those firms to downscale or even leave the market, banks implicitly subsidize unproductive borrowers and delay their market exit. There is evidence that this evergreening of loans impairs competitors of zombie firms.[1] In addition, zombie lending might also affect upstream and downstream firms in the supply chain of the zombie firm. A supplier of a bank's non-financial borrower might interpret the extension of bank credit to the borrower as a positive signal about the borrower's solvency, which in turn also increases the supplier's willingness to provide trade credit to that borrower (Biais and Gollier (1997)).[2] At the same time, being less cash constrained, zombie firms might need less trade credit from upstream and grant more trade credit to downstream firms (Petersen and Rajan (1997)). In any case, zombie lending has an impact on trade credit provision within the corporate sector, which is one of the main sources of finance for non-financial firms (Demirgüç-Kunt and Maksimovic (2001)), and on the systemic risks inherent in the network of trade credit relations (Boissay and Gropp, 2013; Jacobson and von Schedvin, 2015). In this paper, we assess how zombie lending induced by the European Central Bank's (ECB) unconventional monetary policy in the form of very long-term refinancing operations (VLTROs)—i.e. with a maturity of more than one year—affects trade credit in the corporate sector in Germany.

In crisis countries, expansionary (unconventional) monetary policy fostered particularly weakly capitalized banks' evergreening of outstanding loans (Acharya et al. (2019)). In other words, banks extend new loans to borrowers that are seemingly not able to service their outstanding credit in order to avoid the firm's bankruptcy, which would require the bank to write-off the outstanding loans. However, identifying zombie firms properly in an ailing macroeconomic environment with depressed aggregate demand is extremely chal-

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[1]For Japan Caballero et al. (2008) show that this impaired the profitability and productivity of competing healthy firms, while Schivardi et al. (2017) do not find such an effect for Italy in the aftermath of the financial crisis.

[2]Actually, the continuation of operations (i.e. the fact that the borrower is not filing for bankruptcy) might already serve as a positive signal for the supplier.

lenging. Operating income and return on assets might only be low because of depressed aggregate demand (see Albertazzi and Marchetti (2010) and Schivardi et al. (2017)). Without a macro shock—or after effective monetary policy intervention—firms characterized as zombies might in fact be perfectly viable. Moreover, unconventional monetary policy measures, particularly those aimed at revitalizing lending, ease credit in order to stimulate the macroeconomy, which reduces the interest burden for heavily indebted firms.

In this paper, we focus on the effect of unconventional monetary policy measures on *German* banks' corporate lending during the sovereign debt crisis. Undoubtedly, German macroeconomic conditions were not severely impaired by the sovereign debt crisis. On the contrary. Due to the weak euro and the ECB's low main refinancing rates, Germany's gross domestic product grew by 3.7% in 2011, far outstripping the ten-year average of 1.2%.[3] We use data from the German credit register that allow us to precisely identify credit relations between all German banks and firms.[4] We match these data to comprehensive data on 1) bank characteristics, including the liquidity banks obtained in the ECB's VLTROs and 2) firm balance sheets and their profit and loss information, which also comprises trade credit granted and received. As a first step, we try to identify whether unconventional monetary policy measures indeed induced German banks to engage in zombie lending. Specifically, we focus on the ECB's VLTROs as unconventional monetary policy tool and use the extent to which a bank borrowed in these VLTROs as a proxy for how much it benefited from this unconventional policy measure. We assess whether a bank that benefited more from the VLTROs changed its subsequent lending policies to a greater degree. We face three key challenges in our identification. First, we need to ensure that the policy intervention is exogenous, i.e. not specifically aimed at alleviating credit constraints in Germany. As we argue above, this is the case. Second, changes in the observed amount of bank lending to a zombie firm could be driven by firm demand rather than bank supply. We explicitly control for this by including firm-time fixed effects, effectively restricting our sample to firms that bor-

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[3]See Deutsche Bundesbank (2012*b*) and Deutsche Bundesbank (2012*a*) for a discussion of the overall positive stance and outlook of German banks and German non-financial firms in 2011.

[4]These data include all end-of-quarter bank-firm relations that are at least €1.5 million at some point during the quarter.

row from at least two banks at any given date. And third, weaker banks might have a higher propensity to be matched with zombie firms. To account for this, we explicitly include the interaction of our main zombie variable with various variables of bank strength.

Using a panel approach, fully saturated with fixed effects, we find that banks that particularly increased their ECB borrowing after the VLTROs in 2011Q4 and 2012Q1 (announced beginning December 2011) are indeed more likely to extend a new loan and will provide larger new loans to zombie firms (defined as firms with an interest coverage ratio of below one over the previous three years). This result is robust to using alternative definitions of zombie firms.

In line with the view that banks evergreen these exposures in order to avoid writing them off, we find that those banks obtaining more funding in the ECB's VLTROs engage more extensively in zombie lending with a particular firm the larger the concentration risk of that bank's loan portfolio on that firm. We also find monetary policy-induced zombie lending to be particularly pronounced at banks with a relatively low raw- as well as risk-weighted equity ratio and large, internationally active banks, whose equity ratio is presumably more closely monitored by investors. We are furthermore able to show that banks are more inclined to use ECB funding to engage in zombie lending with smaller, non-listed firms, which do not issue debt claims but rather are dependent on bank funding. This supports the notion that evergreening is only worthwhile if free riding of other creditors is limited. These findings highlight how essential it is to also consider small firms that are fairly dependent on a main bank (Acharya et al. (2019)) and the precise exposure to the respective bank as well as accounting for exposures to other banks (Storz et al. (2017)).

What is particularly striking is that, prior to the ECB's VLTROs, banks extend new and more credit to those zombie firms that subsequently had a relatively low default probability. In stark contrast, after the introduction of the VLTROs, zombie firms obtaining new and larger loans from banks using VLTRO funding subsequently had a higher expected default probability even compared to average zombie firms. They also experienced a larger increase in their average expected default probability after the loan was granted. Thus, while in nor-

mal times banks might have used private information to cherry pick those zombie firms that might eventually recover, with unconventional monetary policy measures in place, banks no longer engaged in zombie lending based on such private information. This finding is in direct contrast to Schivardi et al. (2017). Using loan level data for Italy, they find that evergreening reduces the failure rate of zombie firms, which could be driven by their focus on a crisis country in which firms identified as zombies might be viable were it not for the prevailing macroeconomic conditions. Like in other previous studies, they also do not consider that banks might manage the resulting credit risk from zombie lending by adapting the required collateral. Using our rich credit register data which also report the collateralization ratio at the exposure level, we find that banks using VLTRO funding to grant more and new loans to zombie firms did not increase the collateral they required from those borrowers. Thus, the zombie lending induced by unconventional monetary policy not only increased the likelihood of a subsequent loss of the credit exposure, but was probably also associated with a higher loss given default. In sum, these findings lead us to conclude that banks that made more extensive use of the ECB's unconventional monetary policy measure did indeed also offer more credit to zombie firms that carried a particularly high credit risk.

In a second step, we turn to the implications that zombie lending induced by the ECB's VLTROs has for trade credit and the credit risk exposures of suppliers to zombie firms. We find that zombie firms obtain less trade credit compared to other firms. However, with the introduction of the VLTROs, zombie firms received more trade credit then their peers. This is due, in particular, to those zombie firms that obtained more credit from their main bank after the VLTROs. They also subsequently received more trade credit. Similarly, zombie firms that maintained credit relationships with banks that drew on the VLTROs and zombie firms that obtained more credit from banks that were borrowing from the ECB's VLTROs also leveraged both their accounts payable and advance payments received compared to other zombie firms.[5]

However, following the argument of Biais and Gollier (1997), suppliers might have

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[5]See Mateut (2014) for evidence on the similarities of regular forms of trade credit, i.e. accounts payable, and advance payments received.

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private information on borrowers credit risk complementary to banks' signals. Thus, they might be able to cherry pick and extend only additional trade credit to those zombie firms that were likely to recover. In other words, only zombie firms for which suppliers had a positive credit risk assessment might be able to obtain more trade credit. However, our results show that after the ECB's unconventional monetary policy, zombie firms that simultaneously obtained more trade credit and larger new loans from a main bank borrowing under the VLTROs displayed a faster subsequent increase in expected default probability than the average zombie firm, and a higher expected default probability at the end of the sample. This suggests that suppliers might have falsely interpreted the bank's decision to roll over a zombie loan as a positive signal about the bank's credit risk assessment of the firm inducing the supplier to also extend more trade credit. Thus, banks' zombie lending seems to mislead suppliers into increasing their trade credit exposure to particularly risky zombie firms, exposing suppliers to greater contagion risks (Boissay and Gropp (2013)). Furthermore, as we also find that trade credit *provision* by zombie firms increases after the VLTROs—particularly for those zombie firms that obtain more credit from VLTRO borrowers—our results also suggest that the interconnectedness of zombie firms in the trade credit network further exacerbates the systemic risks due to knock-on effects (Jacobson and von Schedvin, 2015).

Overall, our results have major implications. On the one hand, they show that in a large euro area Member State that was not affected by the sovereign debt crisis, the unconventional monetary policy measures—supposed to mitigate the crisis—undermined market discipline and impaired capital allocation. In contrast to previous analyses, our results show that unconventional monetary policy induced banks to evergreen exposures to economically non-viable firms that were not simply impaired by the adverse macroeconomic conditions which prevailed in crisis countries and which the ECB was actually aiming to contain with its unconventional measures. More importantly, our results also show that unconventional monetary policy measures, and the zombie lending they induce, lead to an increase in trade credit exposures vis-a-vis zombie firms, resulting in more interconnected firms and an elevated risk of financial contagion within the non-financial sector (Jacobson and von Schedvin, 2015).

Our paper contributes to several strands of the literature. Most importantly, it speaks to the evolving literature on zombie lending and its relationship to unconventional monetary policy. Using syndicated loan data, Acharya et al. (2019) show that the ECB's announcement of its Outright Monetary Transactions (OMT) was a key driver of zombie lending, which zombie firms used to hoard cash. Based on a comprehensive dataset on Italian bank-firm credit relationships, Schivardi et al. (2017) find affirmative evidence on zombie lending induced by unconventional monetary policy—with zombie firms experiencing a lower subsequent default rate while other firms' default rate increases. Nevertheless, their analysis also suggests that the effect on those surviving healthy firms' productivity is not significant, which might be due to their focus on Italian firms.[6] Our paper contributes to this literature by first providing evidence of monetary policy induced zombie lending in a non-crisis country, eliminating the need to control for the negative effect of an ailing macroeconomy and the intended positive effects of monetary policy at the firm level (Berg and Streitz, 2019).[7] Second, our paper highlights a novel spillover effect of zombie lending to non-zombie firms via trade credit ties. In this regards, our paper is closely related to Adelino et al. (2020), who also study the effect of unconventional monetary policy on firms' trade credit provision. However, they analyze how the ECB's corporate bond purchase program affected the trade credit provision of those firms whose bonds the ECB purchased.

Through the latter point, we also contribute to the literature analysing the interaction between bank lending and the provision of trade credit. Our approach is largely inspired by the theoretical framework of Biais and Gollier (1997). Using a theoretical model, they argue that suppliers and banks obtain different complementary signals about a borrower's credit risk. In their setting, trade credit is a mechanism for aggregating information and ensuring that only borrowers for which both banks and suppliers receive a positive signal can survive. The granting of trade credit is a credible means by which the supplier can truthfully convey its signal to the lending bank. At the same time, suppliers also rely on the bank to deny

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[6]In some contrast to this, and using U.S. data, Gropp et al. (2020) find that regulatory forbearance for banks in some states was associated with impaired regional real economic development.

[7]Using also the German credit register data but matched with the German securities holding statistic (SHS) Fecht et al. (2020) show that large and persistent equity positions held by German bank in German firms also induces risky banks to evergreen credit exposures to particularly risk firms.

credit when it receives a negative signal, meaning that the borrower cannot start the project and demand trade credit. Burkart and Ellingsen (2004) also argue that bank loans and trade credit serve a complementary role in a moral hazard context. Thus, there is demand for both types of funding.

On the empirical side Petersen and Rajan (1997) provide evidence that trade credit serves as a second-tier source of funding for firms with restricted access to bank loans. They also find that suppliers can still offer credit because of complementary private information about the borrowers' credit quality and better ability to liquidate collateral. Our analysis suggests that at least for the worst-rated borrowers suppliers also rely on the main banks' lending decisions as a signal when extending further trade credit. To this end, our paper shows that trade credit providers also free-ride on the information generated by banks, as first pointed out by James (1987). More recently, Ma et al. (2019) confirm this, and show that firms that have recently obtained a bank loan can subsequently obtain more credit in the bond market at cheaper rates. Somewhat in contrast to this, Giannetti et al. (2011) find that firms that only maintain arm's length relationships with banks, i.e. whose banks do not have access to particular private information, rely more heavily on trade credit.

In contrast to Sautner and Vladimirov (2018), who provide empirical evidence that due to poorer credit enforcement distressed firms' access to trade credit is more severely restricted, our results suggest that policies that undermine market discipline might temporarily lead to greater trade credit availability. The potential of trade credit to act as a conduit for contagion is highlighted by Jacobson and von Schedvin (2015), who show that corporate bankruptcy is propagated to creditors along trade credit relationships. With a different focus, but in a similar vein, Ellingsen et al. (2016) emphasize that trade credit is not an inferior source of funding for firms. This is echoed by Amberg et al. (2016), who show that firms strategically use trade credit to adjust their liquidity position. Our paper adds an important dimension to this work: we show that bank credit as the main source of firm funding can have a potentially distorting impact on trade credit.

The remainder of the paper is organised as follows. Section 2 describes our data and

outlines the institutional setting. In Section 3 we show that unconventional monetary policy induces zombie lending in Germany. Section 4 establishes that zombie firms' probability of default increases following the ECB's unconventional monetary policy measures. Section 5 studies the interplay between bank-firm lending to zombie firms and those firms' access to and provision of trade credit. Finally, Section 6 concludes.

2 Institutional setup and data description

Our data on bank-firm credit is taken from the quarterly German credit register (MiMiK[8]), which covers loans above a threshold of € 1.5 million provided by German banks. Besides the information on the loan amounts outstanding, the credit register also covers information on the value of collateral posted, depreciations, and the default probabilities the lender assigns to the borrower. We match this at the bank-quarter level with bank balance sheet information (BISTA)[9], profit and loss information (GuV)[10], as well as banks' security holdings on security level from the securities holdings statistics (SHS)[11], to which we add the collateral eligibility criteria from the ECB. For the classification of zombie firms as well as the analysis of trade credit we merge yearly firm balance sheet information (Dafne).[12] For a list of definitions for all variables used throughout the paper see Table 1. We restrict the sample to lending to the real sector for the period from 2009Q4 to 2013Q4. Our final sample comprises 26,806 unique bank-firm relationships with 965 banks and more than 3,300 firms. Total assets of firms in our sample represent 51% of GDP in Germany.[13]

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[8]Schmieder, C. (2006). The Deutsche Bundesbank´s Large Credit Database (BAKIS-M and MiMiK). Schmollers Jahrbuch 126, 653 - 663

[9]Beier, R., M. Krueger, and M. Schaefer (2017). Monthly balance sheet statistics 01/1999-12/2016, Data Report 2017-02 - Metadata Version 1, Deutsche Bundesbank Research Data and Service Center (RDSC)

[10]From the German "Gewinn und Verlust". See Stahl, Harald and Christine Rauth (2018), Statistics of the banks' profit and loss accounts 1999-2017, Data Report 2018-07 - Metadata Version 6, Deutsche Bundesbank, Research Data and Service Centre (RDSC)

[11]Bade, M., Flory, J., Gomolka, M., and T. Schönberg (2017). SHS-Base plus, Data Report 2017-08 – Metadata Version 1-1. Deutsche Bundesbank Research Data and Service Centre

[12]Dafne is the part of Bureau van Dijk's Amadeus data consisting of information on German firms. We are grateful to our colleagues in Bundesbank's Research Data Service Center (RDSC) and have compiled a matching table between MiMiK and the external firm level dataset Dafne following Schild, C.-J., Schultz, S. and F. Wieser (2017). Linking Deutsche Bundesbank Company Data using Machine-Learning-Based Classification. Technical Report 2017-01, Deutsche Bundesbank Research Data and Service Centre

[13]Genesis database from Destatis accessible via: https://www.destatis.de/DE/Home/_inhalt.html

In response to the tensions in money markets caused by the failure of Lehman Brothers, the Eurosystem moved to a fixed-rate full-allotment policy, implying that banks would obtain for one week at the fixed interest rate as much credit as they wanted through the ECB's weekly main refinancing operations, provided they could pledge sufficient collateral.[14] As a measure to combat the emerging sovereign debt crisis which endangered the solvency of some euro area Member States, the Eurosystem announced on 8 December 2011 two very long-term refinancing operations (VLTRO) with a maturity of three years. These two VLTROs were allotted on 21 December 2011 and 29 February 2012, respectively.[15] Both VLTROs were conducted as repurchase agreements with a maturity of three years. Interest payments on these VLTROs are dictated by the average interest rate of the main refinancing operation (MRO) over the tenure of the VLTRO. The VLTROs provided banks with the option to repay the borrowed amount in parts or completely at their discretion at any time one year after the allotment. Thus, the VLTROs did not provide banks with *cheaper* access to central bank funding than the continuously rolled over MROs. But they alleviated banks' concern about future access to funding, providing banks with access to the allocated funds irrespective of the ECB conducting MROs again as variable rate tender auctions with limited allotment volume. In variable rate tender auctions banks always face an auction risk, i.e. the risk of accidentally bidding below the marginal bid rate and thus not obtaining the required funding. Almost half of the banks in our sample (425 banks) make use of the three year VLTRO funding from the European Central Bank (see Table 2). Also, among the banks participating in the VLTROs, there is a large heterogeneity in terms of the credit volume they demanded in the VLTROs. For the median bank the VLTRO funding represents 2.5% of total funding. Interestingly, for almost all banks the VLTRO funding equals the total central bank funding.

The ECB's decision to conduct the VLTROs was clearly not a response to the macroeconomic conditions prevailing in Germany at that time, but rather a reaction to the conditions in the euro area as a whole and the emerging expectations of the currency union breaking

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[14]Although the collateral framework was expanded significantly prior to our sample period, ECB statistics show that total eligible marketable assets of euro area banks remained roughly constant throughout our sample period.

[15]See: https://www.ecb.europa.eu/press/pr/date/2011/html/pr111208_1.en.html

up due to concerns about sovereign solvencies in some countries. In contrast to other parts of the euro area, the German economy was booming in 2011: GDP growth was substantially above the long-term trend in 2010 and 2011 and the unemployment rate declined in 2011 for the second year in a row. In 2010 and 2011, non-financial firms in Germany experienced a strong sales growth and extraordinary cash inflows which enabled them to both increase their equity ratios and finance their elevated investments largely through retained earnings.[16] While credit demand from the corporate sector was low, the German banking sector was well capitalized overall and total loan growth in 2011 far exceeded the long-term average. At the same time, though, some banks were still impaired by losses incurred during the 2008-09 crisis and affected by exposures to the Greek sovereign debt crisis.[17]

There is no indication of reversed causality in our setting: Monetary policy measures were clearly not taken by the ECB in order to stabilize the impact of the German banking sector being unable to realize losses from lending to zombie firms. When we check for differences in bank characteristics between German banks using VLTRO funding and those not using VLTRO funding prior to the VLTRO in Table 3, we likewise find no statistical differences with respect to the banks' lending share towards zombie firms—either with respect to volume or to the relative number. Nor do the banks' equity ratio, income or loss provision differ significantly. So, *on average*, German banks that were more exposed to zombie firms *or* more weakly capitalized did not use the VLTROs for a larger liquidity uptake. For the observable difference in size that exists between banks, we control by using bank times time fixed effects in our panel regressions. This approach also captures potential further unobserved differences.

In Table 4, we show firm characteristics for non-zombie firms and zombie firms. The main zombie definition classifies zombies as having an interest coverage ratio of below one in the previous three years. These groups do not seem to differ greatly in terms of size and leverage. As expected, the profit to debt ratio is much lower and the cash flow negative for

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[16]For a detailed discussion of German non-financial corporates' conditions in 2011 see for example Deutsche Bundesbank (2012*a*).

[17]For a detailed discussion of German banks' balance sheet evolvement in 2011 and the corresponding profits see Deutsche Bundesbank (2012*b*).

zombie firms. Furthermore zombie firms have a lower equity ratio and seem to be somewhat younger. Nevertheless, the firms we capture as zombie firms are not start-up companies, as the average zombie firm has an age of 37 years.

3 Does unconventional monetary policy induce zombie lending in Germany?

In this section we first pin down the effect of unconventional monetary policy on German banks' lending decisions, especially their decision to lend to zombie firms. In the first step, we identify whether the liquidity allotment through the ECB's VLTROs did indeed increase lending to zombie firms by those banks relying more heavily on ECB funding. Next, we take a closer look at bank and firm characteristics, identifying which banks in particular used the relaxed refinancing conditions offered by the ECB to engage in zombie lending and which kind of zombie firms were most likely to benefit from banks' evergreening.[18] Finally, we study the characteristics of the bank-firm relationship to see whether closer bank-firm relationships increase banks' propensity to evergreen a credit exposure.

3.1 Identification strategy

We use the monetary policy decision to offer liquidity through the fixed-rate full-allotment VLTROs as an exogenous event to the German banking sector. This decision provided banks with an additional option to obtain very long-term refinancing at relatively stable conditions, thus mitigating their exposure to monetary policy uncertainty. The extent to which a bank made use of this option reveals the extent to which it benefited from this option and therefore serves as measure for the scale of its individual treatment of the general monetary policy measure. In order to identify the effect of the unconventional monetary policy measure on German banks' lending to zombie firms, we use a panel regression approach,

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[18]Note that this does not imply that banks are violating the minimum requirements for risk management as outlined by BaFin. Details can be found here (accessed 2020-07-21).

whereby the continuously measured liquidity uptake in the VLTRO by a bank allows us to estimate the bank specific treatment effect.[19] It is important to note that with this approach we can be largely agnostic as to whether banks increased their VLTRO uptake because they planned to evergreen their zombie exposure or whether they only decided to evergreen their zombie exposure after they obtained the VLTRO funding, e.g. due to a lack of more profitable lending opportunities.

Figure 1 depicts the normalized lending to zombie and non-zombie firms by German banks. Here and in our baseline regressions we follow McGowan et al. (2018) and define zombie firms as firms with a ratio of operating profit to interest payments of less than one. Figure 1 shows an increase in zombie lending after the three-year VLTRO announcement, while lending to non-zombie firms largely remained flat at the common trend of zombie and non-zombie lending prior to the VLTRO-announcement. This increase in zombie lending after the VLTRO-announcement is largely driven by banks that actually make extensive use of the ECB's VLTRO funding opportunity (see Figure 2), while zombie lending by banks that did not obtain funding in the VLTRO remained largely subdued following the common pre-LTRO-announcement trend.

As discussed in the previous section, the characteristics of banks participating and not participating in the VLTROs shown in Tables 3 differ slightly. Similarly, in some characteristics zombie and non-zombie firms differ as highlighted by Table 4. Consequently, observed and unobserved heterogeneity at the bank and firm level as well as sorting into VLTRO-participating lenders and non-participating lenders by zombie firms might affect our results. In order to address these concerns and identify whether indeed the ECB's unconventional monetary policy measures induced banks to evergreen loans to zombie firms, we run as our main specification the following regression saturated with both time-varying

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[19]In this regards, Jasova et al. (2020) follow a similar approach. They use the difference in the haircut applied by the ECB in the VLTROs and private repo markets on the securities held by each bank as a measure for the bank specific treatment of the VLTRO. Since German banks were not collateral constrained, this proxy is less useful in our case and we resort to the bank specific liquidity uptake in the VLTRO as the treatment variable.

bank and time-varying firm fixed effects as well as bank-firm pair fixed effects:

$$LogLoanVol_{ijt} = \beta_1 Zombie_{jt} \times \Delta CBFundingLTRO_{it} + \alpha_{jt} + \alpha_{it} + \alpha_{ij}, \qquad (1)$$

where $LogLoanVol_{ijt}$ is the log of one plus the amount of the loan provided by bank i to firm j at date t. $Zombie_{jt}$ is a dummy for zombie firms. For our main zombie definition, this dummy indicates whether the interest coverage ratio was below one for the previous three years. $\Delta CBFundingLTRO_{it}$ is the additional funding that bank i obtains through the VLTROs relative to the previous quarter. This variable reflects bank i's liquidity uptake in the VLTROs. After the VLTRO allotments, this measure also captures (as negative values) how much of the initial VLTRO allotment bank i repaid prematurely. Besides the demand for funding in the VLTRO, the repayment decision also reflects the extent to which a bank benefits from the funding opportunity provided by this unconventional policy measure. In complementary specifications, we control for other sources of ECB funding obtained and use the overall increase in funding obtained from the ECB during the entire sample period in order to account for potential substitution effects between VLTROs and other ECB funding options.[20]

One particular challenge to our identification strategy—even in a panel estimation fully saturated with fixed effects—is the existence of an unobserved bank variable that affects both banks' provision of loans to zombie firms and their VLTRO uptake. The canonical candidate for such a variable is capitalization. Therefore, we add to specification (1) the interaction of $Zombie_{jt}$ and $EquityRatio_{it-1}$ to explicitly control for the matching of weakly capitalized banks and zombie firms.

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[20]Note that we also address the concern of serial correlation formulated by Bertrand et al. (2004), potentially biasing standard errors, by using a collapsed sample of four quarters before and after the introduction of the VLTRO and controlling for firm specific loan demand following Khwaja and Mian (2008) in the Online Appendix Table 19. Our results hold in this case as well.

3.2 Evidence of VLTRO-induced zombie lending

Table 5 summarizes our main results for this analysis: Columns (1) - (4) report some preliminary findings and column (5) presents the results of our baseline regression. The baseline regression shows that, controlling for both time-varying bank as well as time-varying firm fixed effects together with bank-firm pair fixed effects, a zombie firm obtains significantly larger loans from a bank that borrows more heavily in the ECB's VLTROs. The effect is statistically significant at the 5% level and economically relevant. The difference in lending to a zombie firm between otherwise similar banks with one obtaining an additional € 1 billion in VLTRO funding corresponds to a 5.6% increase in lending to zombie firms. As the results presented in column (1)-(4) indicate it is essential to account for effects from established lending relationships using bank-firm fixed effects. With the bank-firm relationship fixed, our key findings are robust to the inclusion of other combinations of fixed effects (columns 3 and 4). However, when we do not include bank-firm fixed effects, the unobserved persistent heterogeneity in bank-firm credit relationships blurs the effect of the VLTRO on banks' lending policies.[21]

In order to further alleviate residual concerns about bank-firm sorting, we include time-varying bank-industry fixed effects. However, as the results in column (6) indicate, their inclusion does not affect our key result either qualitatively or quantitatively. Sorting in bank-firm relationships typically occurs along firm size with smaller firms borrowing from smaller banks. Thus, we include in column (7) firm size as a further time-varying borrower characteristic and interact it with the respective lending bank's change in ECB VLTRO borrowing and the zombie dummy. As the results indicate, larger firms indeed obtain more funding from banks that borrow more in the ECB's VLTRO. However, larger zombie firms do not systematically obtain more funding from banks borrowing more heavily in the ECB's VLTROs than smaller zombie firms. Most importantly, even when controlling for the sorting by firm size, we do still find that a zombie firm obtains more funding from those banks that borrow more extensively in the ECB's VLTROs.

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[21]We discuss the bank-firm selection in Section 3.5.

Another concern is that banks used the additional VLTRO funding to substitute other short-term ECB funding such as repos obtained in MROs. But if banks only substituted different means of ECB funding, their elevated VLTRO borrowing did not increase their capacity to extend further loans to non-financial firms. In regressions reported in columns (8)-(11) we therefore explicitly control for changes in other borrowings from the ECB (column (8)) and also allow for a differential effect of these other ECB borrowings after the VLTRO (column (9)). Funding obtained from the ECB—other than through the VLTRO—did not affect significantly banks' lending policy. More importantly, funding received through the VLTROs significantly increases lending to zombie firms even after controlling for changes in other central bank funding. Instead of using only a bank's change in recourse to VLTRO refinancing in column (10), we use changes in the overall funding received from the ECB, allowing for a differential effect on banks' lending policy after the VLTRO. Using this overall increase in a bank's borrowing from the central bank, we are able to focus on the *additional* overall funding that a bank obtained through the ECB's unconventional policy measure. Interestingly, banks more dependent on central bank funding lent significantly less to zombie firms, while with the introduction of the VLTRO they increase their lending to zombie firms significantly. Column (11) uses the same aggregate measure but puts it into relation to the bank's balance sheet total in order to proxy how much of its balance sheet a bank is refinancing through ECB borrowing. Using this proxy, we find that it was only with the introduction of the VLTRO that banks which funded a larger proportion of their balance sheet via the ECB also significantly stepped up their lending to zombie firms.

A potential further concern is that the decision to conduct the VLTROs coincides with the extension of collateral eligible for the ECB's open market operations. Thus banks extended recourse to ECB funding might instead have been induced purely by relaxed collateral constraints. In order to control for this, in column (12), we add to our baseline regression the value of the eligible collateral held by a bank in a quarter interacted with the zombie dummy at the firm quarter level. Our findings are qualitatively and quantitatively robust to the inclusion of this additional control variable suggesting that the increase in lending to zombie firms can indeed be attributed to banks obtaining additional funding in the VLTROs.

In contrast, increased holdings of eligible collateral do not seem to significantly affect banks' lending decisions.

To address the particular identification challenge of assortative matching between weakly capitalized banks and zombie firms—which could give rise to an endogeneity problem between VLTRO uptake and zombie lending—we augment Model (1) with the interaction term of the firm's zombie variable and bank health. We measure bank health as the bank's lagged equity ratio, the lag of the normalized (by total asset size) loss provisions, and the lag of the normalized operating profits. We explicitly also allow for the possibility that this channel is differently strong before and after the introduction of the VLTRO, by adding a binary Post-VLTRO dummy variable and including it in a three-way interaction term as well. Results of this estimation are shown in Table 6. Our main results hold both qualitatively and quantitatively across these specifications.

Next, we focus on the extensive margin and assess whether the unconventional monetary policy measures also affect banks' decision to cut, maintain, expand or even enter lending relations with zombie firms. In order to do so, we re-estimate Model (1) but use as the endogenous variable various extensive margin measures for banks' lending decisions. Results of this estimation are shown in Table 7.

In the first regression (column (1)) we use as the endogenous variable a dummy (Access) that simply indicates whether or not the bank had a credit outstanding with the respective firm in the given quarter. As the results indicate, banks that borrow more from the ECB's VLTRO are more likely to have a credit relationship with a zombie firm. A € 1 billion increase in VLTRO funding leads to a 9.81% increase in the likelihood that a bank has credit outstanding with a zombie firm. However, Access is a comprehensive measure–it does not allow us to distinguish whether the bank was less likely to cut its credit relations or more likely to enter a new credit relationship with a zombie firm. In column (2) we therefore use as the endogenous variable a dummy which is one if bank i's credit exposure to firm j increased in quarter t, which presumably indicates that a new loan was granted. Interestingly, we find that indeed a bank which obtained more funding in the ECB's VLTROs was more likely to ex-

tend a new loan to a zombie firm. The likelihood that a bank extends a new loan to a zombie firm increases by about 2.9% if the bank increases its VLTRO borrowing by € 1 billion.

Regression results in column (3) to (5) allow us to further dissect this finding. In column (3) the LHS variable "Entry" is an indicator variable which is one whenever bank j granted a loan to firm j in quarter t while there was no credit outstanding in $t-1$, while in columns (4) and (5) the dummy "Add. Loan" indicates whether there was a new loan granted in t between bank j and firm i that already had a credit relationship in $t-1$. As our results indicate, banks were only significantly more likely to extend a new loan to a zombie firm with which they already had some credit exposure. We do not find that banks with more VLTRO funding were more likely to establish new credit relationships with zombie firms (column (3)). This is in line with our prior, as it suggests that banks engaged in evergreening and lent to zombie firms in order to avoid losses from existing credit exposures. In columns (6) to (8) we do the complementary analysis: We would expect banks that obtained more VLTRO funding to be less likely to cut lending relations to zombie firms and less likely to decrease their credit outstanding to those firms. The dummy "Exit" equals one whenever there is no credit exposure observed between bank j and firm i in quarter t while there was a credit outstanding between this bank-firm pair in $t-1$–and equals zero otherwise. The dummy "Decrease" equals one when the amount outstanding between bank j and firm i was positive in $t-1$ and is only lowered in t. Surprisingly, with both regressions we do not find evidence that banks that obtained more funding from the ECB's VLTROs were less likely to cut their credit relationships or decrease their exposure to zombie firms.

Our main results for the extensive and intensive margin are robust to different definitions of zombie firms. Table 8 uses alternative measures identifying a firm as a zombie firm when estimating the intensive margin (Panel A) and the extensive margin (Panel B). Column (1) simply copies our earlier results for comparison. Here, the zombie dummy variable relates to the firm's interest coverage ratio and is one when the ratio of its operating profits to interest payments is below one three years in a row. In column (2) we use the debt service capacity, measured as operating profits to total debt. In this specification our

zombie dummy equals one, whenever the variable is below 0.05 for three consecutive years. Column (3) combines both previous definitions using a dummy variable that equals one whenever a firm is a zombie firm according to both of the previous definitions. Overall, the results confirm our previous findings: Even when we fully saturate the model with fixed effects, we find for the intensive margin (Panel A) that banks which obtained more funding through the unconventional policy extend more credit to a given zombie firm–irrespective of the particular definition of a zombie firm. The estimated effect is not only qualitatively but also quantitatively similar for the different definitions of zombie firms.[22] Furthermore, we obtain the same findings when we use time-invariant zombie status of 4 and 5 consecutive years prior to the VLTRO uptake (Table 20). Similarly, Panel (B) shows for the extensive margin that a bank with more VLTRO funding obtained from the ECB was signficantly more likely to extend an additional new loan to an existing borrower (Add. Loan). Again, the results are qualitatively and quantitatively similar to our main specification in column (4) of Table 7.

3.3 Which banks particularly engage in zombie lending?

Evergreening allows banks to avoid having to recognize losses on their loan portfolio immediately. This is particularly attractive the closer a bank is to the regulatory capital requirements and the more closely capital ratios are monitored by investors. In order to provide further evidence on banks' motives for zombie lending along those lines, we next use the cross-section of banks in our sample.

In a first set of regressions reported in Table 9, we split the sample into well- and poorly capitalized banks using for robustness two different measures of capitalization and run the baseline regression separately for the sub-samples. In Columns (1) and (2) we split the sample according to banks' (unweighted) equity ratio, defined as the book value of a bank's equity divided by its total assets before the first VLTRO, which is equivalent to the Basel III

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[22]Unreported regressions also show that the results reported in column (10) of Table 5 are robust to these alternative definitions of zombie firms. These results are available upon request.

leverage ratio. Results on the intensive margin reported in Panel (A) of Table 9 show that only for those banks with an equity ratio below the median (column (1)) is increased funding through the VLTROs associated with significantly more lending to zombie firms, while we do not find a significant effect for well capitalized banks (column (2)). Similarly, when we use the *risk-weighted* equity ratio pre-LTRO we also find that only poorly capitalized banks increase their lending to zombie firms after obtaining further VLTRO funding (column (3)), while well capitalized banks that receive more VLTRO funding do not expand their zombie lending (column (4)). Panel (B) of Table 9 reports the respective sample splits for the extensive margin, using as endogenous variable the dummy "Add. Loan", indicating whether a new loan was granted in an already existing credit relationship between a bank and a firm. As results in Panel (B) columns (1) and (2) highlight, only banks with a relatively poor equity ratio were also more likely to use VLTRO funding to grant a new loan to an existing zombie borrower, while banks with a high equity ratio actually reduced their zombie lending. With regard to the risk-weighted equity ratio (columns (3) and (4)) we do not find a significant difference in behavior between well and poorer capitalized banks. Both have a significantly higher propensity to grant a new loan to an existing zombie borrower the more funding they obtain through the VLTROs. In sum, though, our results support the view that particularly banks that were relatively poorly capitalized used alleviated funding restrictions through the ECB's VLTROs to engage in zombie lending.

Obviously, besides meeting regulatory capital requirements, banks are also concerned about their equity ratio, which investors might interpret as a signal about the bank's credit quality. The banks in our sample are rather heterogeneous in this regard, too: small banks, which are mostly cooperative and savings banks, refinance their lending largely with insured retail deposits. Their equity is not publicly traded and retained earnings are largely their only source of new equity. By contrast, the large and internationally active banks in our sample issue bonds, use the interbank market as a refinancing source and increase equity by issuing shares traded in the stock market. Thus, while the latter need to maintain a solid equity ratio in order to keep funding costs low, the former are less dependent on zombie lending as a means of artificially maintaining a higher equity ratio.

In order to test for supporting evidence along those lines, we first split the sample into relatively small banks and banks above the median size by total assets and run our baseline regression. Columns (1) and (2) in Table 10 show the results on the intensive margin (Panel (A)) and extensive margin (Panel (B)), respectively. We do indeed find that only for relatively large banks was the increased ECB funding associated with a higher propensity to grant new loans and larger amounts to zombie firms. We do not find similar evidence for relatively smaller banks. Interestingly, when splitting the sample according to banks' overall business models (Panel (A) and (B), columns (3) and (4) of Table 10), we do indeed find that only the internationally active banks (those that presumably use wholesale markets to refinance themselves) engage more extensively and intensively in zombie lending after the VLTROs, while cooperative and savings banks did not use additional VLTRO funding to grant new and larger loans to zombie borrowers. Specifically, for the average bank in the sub-sample of banks larger than the median bank, we find that a € 1 billion increase in VLTRO funding leads to a 7.7% increase in the bank's lending to zombie firms. Similarly, banks that are internationally active provide 8.0% more lending to zombie firms for every € 1 billion in additional VLTRO funding.

3.4 Which zombie firms benefit from banks' elevated zombie lending?

Transparency requirements constrain firms' ability to conceal any over-indebtedness and instead force them into debt restructuring. Consequently, zombie lending allows banks to avoid recognizing losses on their outstanding loans only for relatively opaque firms. Thus, we hypothesize that banks obtaining more VLTRO funding will only extend more loans to zombie firms that have lower reporting requirements. Listed firms and particularly those that also issue bonds are typically considered more transparent. Listed firms have stringent reporting requirements and are often covered by stock market analysts. Firms with bonds outstanding usually also obtain a credit rating.

The regressions reported in Table 11 make use of the cross-section of firms in our sample. In columns (1) and (2) we split the sample into firms that issue bonds and those that

don't. Columns (3) and (4) split the sample into listed and non-listed firms, while columns (5) and (6) report results for regressions run separately for below median-sized and above median-sized firms. Panel (A) of Table 11 focuses on the intensive margin and Panel (B) reports the respective results for the extensive margin, i.e. for the probability that a bank with additional VLTRO funding will grant a new loan to an existing zombie borrower. Table 11 provides ample evidence that zombie lending is more prevalent for more opaque firms. We find that only zombie firms that do not issue bonds were more likely to receive a further loan (Panel (B) column (1) of Table 11) and a larger loan (Panel (A) column (1) of Table 11) from a bank that obtained more VLTRO funding. On average, additional VLTRO funding of €1 billion is correlated with a 5.4% rise in lending to zombie firms that have no bonds outstanding. We do not find the same effects for zombie firms with outstanding bonds either at the extensive or the intensive margin (Column (2) in Panel (A) and (B) of Table 11).

Surprisingly, for listed and non-listed zombie firms we do not find a statistically different tendency to evergreen credit exposures. Both the likelihood that a new loan is granted to a listed and non-listed zombie borrower (columns (3) and (4) in Panel (B) of Table 11) and the amount that a listed and non-listed zombie firm obtains (Columns (3) and (4) in Panel (A) of Table 11) are higher for banks that obtain more VLTRO funding but the effects are statistically not different for the different sub-samples.

Finally, as the sample split along firm size in columns (5) and (6) reveals, small zombie firms receive 12.8% more funding from their bank for every €1 billion additional VLTRO funding, while there is no statistically significant effect for large firms (columns (5) and (6) in Panel (A) of Table 11). Similarly, while banks that obtain more ECB VLTRO funding have a significantly higher propensity to lend to both small and large zombie firms, the effect is significantly stronger for smaller firms.

In sum, these findings support the view that banks engage in evergreening with less transparent firms because their opacity allows banks to temporarily avoid writing off those loans. The observation that it is particularly outstanding bonds that constrain banks' tendency to engage in evergreening is also in line with a further interpretation: Banks might be

less inclined to provide loans if the zombie firm uses the additional funding to largely repay outstanding debt with other lenders. In this case, zombie lending generates positive externalities that the lending bank cannot reap. The next subsection explores this latter argument further.

3.5 Do established lending relationships matter for banks' zombie lending?

Our earlier results presented in Table 5, columns (1)–(4) show that bank-firm fixed effects matter. This is in line with earlier evidence about the importance of lending relationships and suggests that banks and firms do not randomly enter credit relations, but rather that bank as well as firm characteristics matter when a bank and a firm consider entering a lending relationship. It also suggests that the persistent intensity of the existing credit relationship matters when a bank considers whether or not to engage in evergreening a loan exposure to a firm. Next, we study the effect of relationship lending on evergreening more closely.

We follow Cocco et al. (2009) and define two related measures of bank-firm relationships. First, the borrower preference index (BPI) is defined as:

$$BPI_{ijt} = \frac{LoanVolume_{ijt}}{Debt_{jt}}.$$

It measures the extent to which a firm's overall borrowing is focused on bank i and captures how dependent the firm is on loans from this particular bank. Similar to our findings in the previous subsection we hypothesize that the larger the proportion of loans outstanding with bank i the more bank i internalized positive externalities from evergreening exposures with j and the larger bank i's incentives to engage in zombie lending with firm j. And second, the lender preference index (LPI) is defined as:

$$LPI_{ijt} = \frac{LoanVolume_{ijt}}{Loans_{it}}.$$

It measures how concentrated bank i's portfolio is on the credit exposure to firm j. Hence, it proxies the proportion of bank i's loan portfolio that is at stake if bank i does not engage in zombie lending but rather lets firm j fail.

We use the LPI and BPI prior to the VLTRO announcement to split our sample into closer and less close bank-firm credit relationships. Panel (A) in Table 12 reports our results when we estimate the intensive margin, while Panel (B) in Table 12 summarizes our results on the extensive margin using as endogenous variable "Add. Loan", a dummy variable which is one whenever there was a positive credit exposure between i and j in $t-1$ and the exposure is larger in t. Interestingly, while we do not find any substantial evidence that the intensity of bank-firm-relationships affects the intensive margin of zombie lending, we do find strong evidence that a bank, after obtaining funding from the VLTROs, is overall more likely to extend a new loan to a zombie firm if it holds a relatively large fraction of this borrower's outstanding credit (Panel (B) columns (1) and (2) of Table 12). Splitting the sample along different characteristics of the respective bank further reveals that only banks with a strong international focus (Panel (B) columns (3) and (4) of Table 12) and banks with a relatively low equity ratio (Panel (B) columns (5) and (6) of Table 12) are more likely to extend further loans to zombie firms if they are a main lender to the respective firm. This supports the view that evergreening is particularly appealing for banks if the externalities to other lenders are contained.

Looking at the effect of the LPI (Panel (B) columns (7) and (8) of Table 12), we find that, overall, banks obtaining more VLTRO funding are only significantly more inclined to engage in evergreening an exposure with a zombie firm if the exposure is large relative to the bank's loan portfolio (high LPI borrowers). While this effect is present for both local and internationally active banks (columns (9) and (10)), it is particularly banks with a low equity ratio that use VLTRO funding to extend new loans to zombie firms to which they have already a relatively large exposure (columns (11) and (12)). In sum, these findings provide further evidence that banks with a particular focus on their equity ratio do indeed engage in evergreening in order to avoid large write-offs on their loan portfolio.

4 Does zombie lending affect banks' loan losses?

Zombie firms have a substantially higher probability of default than non-zombie firms (see Figure 3).[23] However, we cannot rule out the possibility that a bank lends to a zombie firm based on positive private information that the bank has about this particular firm. In particular, banks that make more extensive use of VLTRO funding might use alleviated refinancing constraints to extend more credit to those firms in particular for which their private information deviates most significantly from the negative public signals—e.g. the firm having a very low interest coverage ratio.

In order to tackle this concern, we run a panel model estimating the default probability of firms at the end of our sample using the bank's decision to grant a new loan pre- and post VLTRO as an exogenous variable. The underlying hypothesis is that if a bank uses VLTRO funding to extend credit to a zombie firm based on a positive private signal this positive information should have become public at least to all banks lending to that firm by the end of our sample. More precisely, we estimate the following model:

$$
\begin{aligned}
AvgPD_{j4Q13} \quad = \quad & \beta_1 Zombie_{jt} + \beta_2 \text{Add. Log Loan Vol.}_{ijt} + \beta_3 \text{Add. Log Loan Vol.}_{ijt} \times PostLTRO_t \quad (2) \\
& + \beta_4 \text{Add. Log Loan Vol.}_{ijt} \times Zombie_{jt} + \beta_5 PostLTRO_t \times Zombie_{jt} \\
& + \beta_6 Zombie_{jt} \times PostLTRO_t \times \text{Add. Log Loan Vol.}_{ijt} + \alpha_{it},
\end{aligned}
$$

where $AvgPD_{j4Q13} = \frac{1}{n} \sum_i \Delta PD_{ij4Q13}$ is the average default probability reported in the 2013/Q4 for firm j by all banks $i = 1...n$ using an internal ratings-based (IRB) approach and having an exposure to firm j.

As exogenous variables we use "*Add. Log Loan Vol.*", the log of one plus additional loan volume granted by the bank to the firm, as well as our time-varying dummy identifying

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[23]We focus here on banks' average PDs as we are interested in using banks' information sets at the lending decision excluding realized macroeconomic shocks. Due to the very positive macroeconomic environment in Germany actual firm defaults are fairly rare in our sample period and too limited to run a panel regression. The estimated default probability of lenders serves as a useful proxy. Banks particularly concerned with their low equity ratio (which are also more likely to engage in zombie lending as our earlier results indicate) have an incentive to use the internal ratings-based approach and thus report their estimated default probabilities of their borrowers in order to reduce their risk weighted capital requirements.

zombie firms. The key coefficient of interest is the three-way interaction term. Intuitively, this coefficient allows us to assess whether the default probability that banks on average assign to a firm at the end of our sample is significantly higher—particularly for those zombie firms that received further and larger loans after banks had access to additional ECB funding through the VLTROs. While our left-hand variable is at the firm level, our identifying explanatory variable—the three-way interaction term—is at the bank-firm-quarter level, which permits us to saturate the model with bank-time fixed effects to account, for example, for differences in lender specific IRB-models.

Table 13 summarizes our results on this exercise. Panel (A) represents the specification in regression (2) and uses as the exogenous variable the intensive margin of the loan decision, i.e. the amounts of the new loan that was granted, whereas Panel (B) uses the extensive margin of the loan decision, i.e. whether a new loan was granted or not. Columns (1) and (2) of Table 13 are based on the entire sample with different fixed effects. They highlight that, generally, zombie firms that obtain a new loan (Panel (B) of Table 13) and more credit (Panel (A) of Table 13) tend to have a somewhat lower subsequent default probability at the end of the sample, which might indeed reflect the positive private information held by the lending banks. However, zombie firms that received new and larger new loans *after* the ECB introduced its VLTROs had a substantially elevated subsequent default probability. The economic magnitude of this effect is substantial and robust to variations in the used fixed effect: Compared to a zombie borrower that obtained a loan prior to the VLTROs, a zombie firm that received a new loan after the VLTRO has a default probability that is 7.2 percentage points higher. And compared to a zombie firm that did not obtain fresh credit in the sample, a zombie borrower which received a new loan only after the VLTRO still has a 4.9 percentage points higher probability of default at the end of the sample.

In order to better attribute this effect to the ECB's unconventional monetary policy from column (3) of Table 13 onward, we restrict the sample to four quarters before and after the introduction of the VLTROs. These results indicate that the economic magnitude of our key parameter is muted when we run our baseline regression on this restricted sample.[24]

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[24]This might be due to the fact that those banks that prematurely repaid their VLTRO borrowings were also

In column (4) of Table 13 we additionally include as a control variable the initial level of the average PD reported on j by all lenders when the respective loan was granted. Ultimately, the lending bank might be aware of an elevated default probability of a zombie firm that it is lending to and will simply charge an adequate credit risk premium. But this will be based on the credit risk assessment at the time when the loan was granted. Including the average reported default probability of the borrower when the loan was granted takes care of this effect. Furthermore, columns (5)-(7) of Table 13 use the *change* in the average reported PD from the quarter the loan was granted by the respective bank to the end of the sample period as an endogenous variable, allowing us to assess whether indeed the reported default probability increased particularly for those zombie firms that obtained further and larger credit after the ECB's unconventional monetary policy measure. In columns (6) and (7) of Table 13 we saturate the model with additional industry and industry-time fixed effects, respectively, in order to control for heterogeneous development across industries. Our key results remain qualitatively and quantitatively unaffected across all these variations.

Overall, these results suggest that those banks that evergreened credit exposures to zombie firms subsequent to the ECB's unconventional monetary policy were actually extending their exposures to firms that subsequently pose a particularly high credit risk. While prior to the VLTROs banks were potentially able to discriminate between well and poorly performing zombie firms and lend only to those whose credit risk declined subsequently, with the ECB's VLTROs banks extend more and further loans to zombie firms whose credit risk later increased substantially.

In our previous analysis we used the *average* end-of-sample default probability of a firm across the reporting lenders because the average evens out potential individual reporting biases as, for instance, reported by Behn et al. (2016).[25] However, the downside to this approach is that it relies on the assumption that any positive private information that the bank lending to a zombie firm obtained is publicly known by all lenders to that firm by the

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less engaged in zombie lending.

[25] In our subsequent analysis we provide also evidence of a reporting bias of banks lending to zombie firms. See Column (3) in Table 15.

end of the sample. If the private information persists and remains private, it might only be reflected in the reported PD of the bank that extends the new and larger loan after the VLTROs. In order to rule out this concern, we rerun our analysis using as the endogenous variable the probability of default that each respective lender reports by the end of the sample.

The results reported in Table 14 confirm our previous findings. Zombie firms that obtained a new and larger loan after the VLTRO not only had a significantly higher probability of default than other zombie firms according to the assessment of the respective lender (Columns (1)-(4)) but also experienced a larger increase in the probability of default reported by the respective lender between its lending decision and the end of the sample (Columns (5)-(7)). In sum, this suggests that either positive private information that might have induced a bank to engage in zombie lending after the VLTROs did not, on average, materialize even in the view of the respective lender or that the decision to engage in zombie lending was not driven by any such private information.

One factor could alleviate the detrimental consequences of our finding for banks credit risk: Banks using the VLTROs to evergreen zombie credit relationships might have covered the elevated credit risk that those exposures–according to their own estimates–entailed by asking borrowers to pledge more collateral. Our rich data set also comprises, at the exposure level, quarterly information on the value of pledged collateral. We use this data in order to test whether banks that provided further credit to a zombie firm after the ECB's VLTROs indeed required further collateral from the firm. Column (1) in Table 15 reports the results of a panel model in which we regress the value of collateral in the bank-firm exposure at quarterly frequency on the banks' decision to provide larger new credit (Panel A of Table 15) and grant a further loan (Panel B of Table 15). Interestingly, even if we fully saturate the model with fixed effects, our results indicate that banks required more collateral from borrowers to which they granted new and larger loans after the VLTROs. However, zombie borrowers that received new and larger loans were not required to pledge additional collateral. On the contrary, the value of collateral in evergreened exposures to zombie firms actually declined.

This suggests that zombie lending induced by unconventional monetary policy not only exposed banks to larger credit default probabilities but also left them with a higher loss given default.

Column (2) in Table 15 reports the results of a number of complementary analyses. Our data set also comprises quarterly loan loss provisions at the exposure level. This permits us to test whether evergreening of a particular exposure was also associated with a reduction in the contemporary loan loss provision.[26] After the ECB's VLTROs, new and larger loans by a bank to a particular zombie firm were associated with a lower loan loss provision for this exposure by the bank.[27] This suggests that even though banks reduced the collateralisation of their exposure to a zombie firm, they did not set aside additional provisions for higher loan losses—presumably because this would reduce profits and retained earnings.

Finally, in Column (3) of Table 15 we test whether those banks that extend new and larger loans after the VLTROs to zombie firms contemporaneously reported a lower probability of default for this particular zombie firm than other lenders that are still exposed to this borrower. Our results are only marginally significant but nevertheless indicate that, prior to the VLTROs the reported probability of default of a lender which provides new and larger loans to a zombie firm was larger than the average PD reported for this zombie borrower reported by other banks. After the VLTROs, however, the larger the new zombie loan, the larger the amount by which the reported PD undercut the average PD reported by other lenders on that firm in the same quarter. These results are in line with evidence reported by Behn et al. (2016) on the reporting bias and misreporting incentives in internal ratings-based credit risk assessments. They might, however, also be seen as an indication that banks were indeed relying on positive private information when extending a new and larger loan to a zombie firm after the VLTROs. That this occurred only after the VLTROs and that this private information mostly turned out to be wrong (as our results in Table 14 suggest) casts doubt on this latter interpretation.

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[26]The sample is limited in this analysis because the extensive set of fixed effects necessary to cleanly identify the effect requires that at least two banks report loan loss provisions for their exposure to one particular firm in a given quarter.

[27]Results hold when using Log Loan Vol. instead of Add. Log Loan Vol.

5 Does banks' zombie lending affect firms' trade credit?

In this section, we study whether banks' zombie lending has an effect on the availability of trade credit to zombie firms. In particular, we aim to understand whether evergreening and the resulting delay in market cleansing allows zombie firms to leverage their trade credit, thus exposing other firms to an elevated contagion risk.

In the lending process banks obtain private information about their borrowers. This information allows them to perform a more precise credit risk assessment (Petersen and Rajan, 1994). Other investors are aware of this informational advantage and use banks' lending decision as a positive signal for their own investment decisions (Mateut, 2014). Upstream and downstream firms in the supply chain of a company are usually better informed about the company's business conditions than other market participants (Petersen and Rajan, 1997). However, as banks might have complementary information, firms in the supply chain might also make their decision to extend further trade credit contingent on the main lenders' willingness to extend further loans (Biais and Gollier, 1997). If a company is known to have an operating income that falls short of its interest payments (i.e. is known to be a *zombie* in our context), a precise assessment of its credit risk is particularly crucial for suppliers. Thus, suppliers might closely monitor the main bank's lending decision (for example, requiring a credit approval from the main bank to provide further trade credit or learning from the firm's early payment of outstanding bills that the bank has provided further credit), interpret the observation that a bank continues to lend to that company as a positive signal about this borrower's credit quality, and be more inclined to extend more trade credit to that company.

Our analysis in the previous section indicates that this rationale might have been reasonable in normal times, i.e. prior to the ECB's unconventional monetary policy measures. For this period, zombie firms to which a bank granted new and larger loans subsequently had a significantly lower default probability. However, with the introduction of the ECB's VLTROs, zombie firms that obtained larger and further loans subsequently posed a higher

credit risk. Next, we assess whether zombie lending increases the availability of trade credit and whether the effect was different before and after the introduction of the VLTROs.

5.1 Zombie firms' trade credit borrowing

In a first step, we test whether zombie firms that obtain further loans from their bank after the ECB's VLTROs also receive more trade credit. The trade credit data is part of our annual firm balance sheet information. Consequently, we need to estimate the effect at the firm-year level. In order to identify whether banks' zombie lending was associated with zombie firms obtaining more trade credit in particular after the ECB's VLTROs we estimate the following baseline model:

$$
\begin{aligned}
\Delta TradeCredit_{jt}^{B} \;=\; & \beta_1 Zombie_{jt} + \beta_2 MAINLogLoanVol_{jt} \qquad\qquad\qquad (3)\\
& + \beta_3 MAINLogLoanVol_{jt} \times PostLTRO_t \\
& + \beta_4 MAINLogLoanVol_{jt} \times Zombie_{jt} \\
& + \beta_5 PostLTRO_t \times Zombie_{jt} \\
& + \beta_6 Zombie_{jt} \times PostLTRO_t \times MAINLogLoanVol_{jt} \\
& + FirmControls_{jt} + \alpha_j + \alpha_t,
\end{aligned}
$$

where $\Delta TradeCredit_{jt}^{B}$ is the increase in the trade credit that firm j obtained in quarter t. Since the data is at the firm-year level we can only saturate our regression with firm fixed effects α_j to account for persistent unobserved heterogeneity across firms and time fixed effects α_t to control for aggregate changes in trade credit provision. In addition, we include observable time-varying firm controls (size, cash, equity ratio and return to assets) as well as time-varying characteristics of the firm's main bank. $MAINLoanVol_{ijt}$ is the log of the overall loan volume with the firm's main bank. Since the ECB's unconventional monetary policy has apparently affected banks' zombie lending activity (see Section 3.2), we use again the VLTRO ($PostLTRO_t$) as the exogenous shock that allows previously refinancing constrained banks to extend more zombie loans. Our key coefficient of interest is β_6, which

allows us to distinguish whether zombie firms that obtained more credit from their main bank after the VLTRO were indeed able to obtain more trade credit than other zombie firms.

Table 16 presents the results of this analysis. Before turning to the baseline results, column (1) reveals that zombie firms experienced a significant decline in outstanding trade credit compared to other firms. By contrast, zombie firms significantly increased their trade credit after the VLTROs compared to non-zombie firms. The baseline results presented in column (2) of Table 16 allow us to further dissect this finding. Considering also the loan extension of the main bank, we find that zombie firms generally increased their trade credit prior to the VLTROs but not if they were able to obtain larger loans from their main bank. In contrast, after the VLTROs, the extension of credit from the main bank to a zombie firm was associated with more trade credit *obtained* by this firm. Thus, while trade credit and loans from the relationship lender were substitutes for zombie firms before the VLTROs, they became complements after the ECB's unconventional monetary policy measures.

In columns (3) and (4) of Table 16 we broaden the perspective and also consider banks other than the main bank. In column (3) we use as the key explanatory variable a simple dummy that identifies all firms with a credit relation to a bank that has obtained VLTRO funding. This allows us to better attribute the findings to the change in banks' refinancing conditions and thus to the unconventional monetary policy measures. Again, for this specification we find that the key variable of interest–the three-way interaction term–is both statistically and economically significant. Zombie firms that obtained credit from a bank with VLTRO access received 5% more trade credit. Column (4) of Table 16 uses as the key explanatory variable the aggregate loan volume of the respective firm vis-à-vis all German banks that obtained VLTRO funding. Again, we find consistent results, not only for our key variable of interest but also for the other explanatory variables. Finally, in order to control for time-varying industry wide fluctuations in trade-credit provision, that might, for instance, result from industry specific bankruptcy waves, we also include time-varying industry fixed effects. Even with the large set of fixed effects and small remaining variation we do indeed find that zombie firms received more trade credit after obtaining more credit from VLTRO

funded banks.

Besides accounts receivable, which are usually considered as trade credit, our firm level dataset also entails the advance payments received by a firm. Advance payments received also constitute a credit but in contrast to account receivable (which is usually trade credit collateralised by the delivered products) advance payments are mostly uncollateralised. We use this additional form of trade credit to check the consistency of our previous results. Since there are fewer firms reporting advance payments received, however, the sample size for this exercise is much smaller. Results are reported in columns (6)-(10) of Table 16. While the statistical significance is weaker due to the smaller sample, the results are consistent. We also find that zombie firms obtained less advance payments prior to VLTROs, but significantly more with the introduction of the VLTROs (column (6)). Furthermore, zombie firms which maintained credit relationships with at least one bank that made use of the VLTROs and those who received more loans from banks with VLTRO access, obtained significantly more advance payments (columns (8) and (9)).

In sum, these findings provide strong evidence that, due to the unconventional monetary policy measures of the ECB and the induced zombie lending, zombie firms were also able to obtain more trade credit. However, this does not necessarily imply that those zombie firms that obtain additional trade credit exposed their suppliers to particularly elevated credit risk. This will be addressed in the next section.

5.2 Credit risk of zombie firms' trade credit borrowing

A key concern could be that because suppliers are privy to more precise information than other market participants and complementary information to the lending banks, they might ultimately not lend to the average zombie firm that obtained larger and new loans and was shown to pose a higher credit risk. Instead, they might only extend trade credit to those zombie firms that indeed turn out to be a good credit risk.

In order to address this concern, we again use the average of the credit default prob-

abilities reported by IRB banks that have an outstanding exposure to the respective firm at the end of our sample as a proxy for a firm's credit quality after lending decisions are taken. We then test whether zombie firms that obtain more credit from their main bank after the ECB's VLTROs and that at the same time also obtain more trade credit subsequently posed a larger perceived credit risk. Specifically, we estimate the end-of-sample average expected default probability of a firm with the dummy indicating a zombie firm, the increase in trade credit obtained by the firm in a given year, and a variable that measures the amount of new loans granted by the main bank conditional on the main bank taking recourse to the VLTRO. Our key variable of interest is the three-way interaction term of these explanatory variables.

Table 17 presents the results of this analysis. In columns (1)-(3) we sequentially saturate the baseline model with fixed effects. In order to take into account the respective firm's initial credit risk that banks and suppliers might have incorporated in their lending decision, we include in columns (4)-(6) of Table 17 also the average expected default probability of the firm reported in the respective year across all banks with an exposure to that firm and applying an internal ratings-based approach. Furthermore, in columns (7)-(10) of Table 17, we consider as a left-hand variable the change in the average expected default probability from the respective year the lending decisions were taken to the end of our sample. In addition to industry-quarter and bank-quarter fixed effects, this approach allows us to also include firm fixed effects to account for unobserved heterogeneity across firms.

The results are significant and consistent across all specifications. We find that zombie firms that obtained more credit from their ECB-refinanced main bank and at the same time also received more trade credit had a significantly higher average expected default probability at the end of our sample and experienced a significantly larger deterioration in credit quality.

In conclusion, not only do we find that zombie lending induced by unconventional monetary policy also fostered trade credit provision to zombie firms, but our results also provide empirical evidence that this trade credit extension to firms benefiting from zombie lending exposes suppliers to elevated credit risk. Undermining the cleansing effect through

VLTROs not only leads to zombie lending and elevated credit risk on banks' balance sheet, it also increases the risk of spillovers to suppliers, if the trade credit cannot be repaid.

5.3 Zombie firms' provision of trade credit

Finally, in this subsection we provide a complementary analysis of the trade credit *provision* of zombie firms and how this is affected by extension of new and larger bank loans due to unconventional monetary policy. We replicate the analysis presented in Table 16, using as the endogenous variable the trade credit provided by the respective firms, in order to assess whether zombie firms' that obtained larger new loans from their bank subsequent to the ECB's VLTROs also provided more liquidity to their production network. While obtaining more trade credit from a zombie firm might be beneficial for downstream firms at first, it might also pose a threat to the financial soundness of the downstream firm if the extended trade credit is suddenly called due to the insolvency of the zombie firm.

Table 18 shows the results of these regressions. While we do not find evidence that zombie firms have a trade credit provision different from other firms before the VLTROs, they provide more trade credit than their peers after the VLTROs (column (1)), although this difference is only marginally significant. While we do not find that the extended trade credit provision is related to the volume of bank loans the zombie firm obtains from its main banks after the VLTRO (column (2)), our results show that it was particularly zombie firms that increased their trade credit provision that had credit relationships with banks drawing on the ECB's VLTROs (column (3)) and that obtained more additional credit from those banks affected by the VLTROs (column (4)). Including additional time-varying industry fixed effects renders our results insignificant. Results using the advance payments made as alternative endogenous variable to trade credit provision also fail to provide further evidence. Those estimates do not show any significant effect either, which might again be due to the substantially smaller sample.

While our results on trade credit provision are less pronounced and robust than those

for trade credit received, we do find, overall, that also trade credit provided by zombie firms increased after the VLTROs—in particular by those zombie firms that obtain more credit from banks dependent on the ECB's VLTROs. This further indicates that the VLTRO-induced zombie lending caused zombie firms to become more interwoven in the network of trade credit, potentially also further increasing systemic contagion risks: As zombie lending leads to inflated trade credit, all else being equal, it increases the risk and severity of potential knock-on effects.

6   Conclusion

In this paper we study whether German banks' zombie lending, induced by the European Central Bank's Long Term Refinancing Operations, allows zombie firms to leverage their trade credit borrowing. We provide evidence that particularly weak banks use the VLTROs to evergreen their exposures to zombie firms. This poses additional credit risk, because, as we show, creditor banks assign a higher probability of default to these zombie firms and zombie firms which obtain more credit from banks that obtained more funding in the VLTROs are themselves more likely to fail.

We then show that zombie firms that obtain more funding from their main bank are able to increase their accounts payable and advance payments received from downstream and upstream firms. Our findings suggest that zombie lending has a particularly distorting effect on suppliers which rely on banks' lending decisions as a signal about borrowers' credit quality. Therefore, our paper highlights the interplay of bank credit and firm-to-firm credit and in particular the distortionary effects unconventional monetary policy can have, even–or perhaps especially–in a country like Germany that was not otherwise affected by the adverse economic conditions that led to the ECB's decision to engage in unconventional monetary policy measures.

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Appendix

Figure 1: Lending volume (normalized prior to the VLTRO) by banks to zombie and non-zombie firms. A firm is classified as a zombie firm if it has an interest coverage ratio of below one in the previous three years. The vertical red line is prior to the introduction of the three-year VLTRO in December 2011.
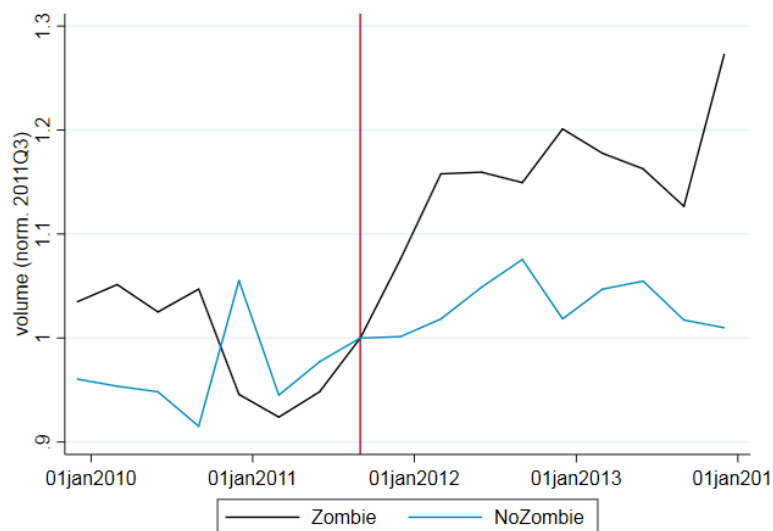
Figure 2: Lending volume (normalized prior to the VLTRO) by banks using three year VLTRO funding to zombie firms compared to the lending by non-VLTRO funding banks to zombie firms. A firm is classified as a zombie firm if it has an interest coverage ratio of below one in the previous three years. The vertical red line is prior to the introduction of the three-year VLTRO in December 2011.
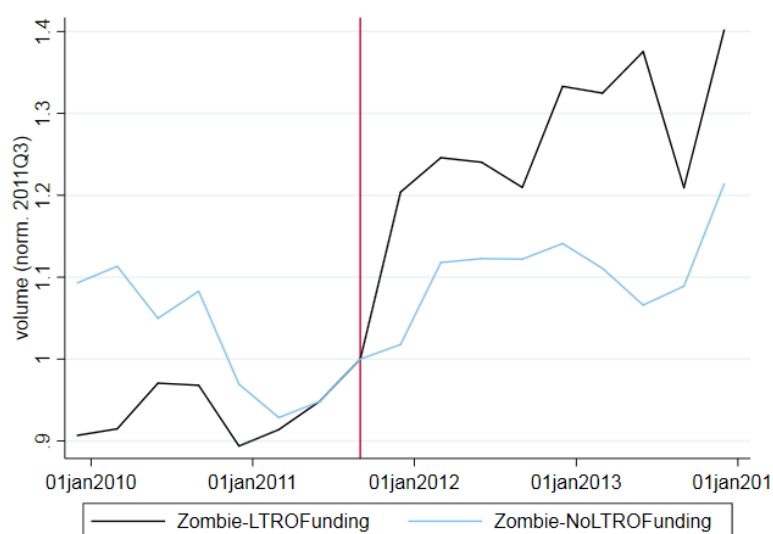
Figure 3: Probability of default for zombie and non-zombie firms over time, depending on whether the firm has access to a bank using the three year VLTRO funding. The probability of default is computed as the average probability of default reported by banks using the internal rating based approach for credit assessment. A firm is classified as a zombie if it has an interest coverage ratio of below one in the previous three years. The vertical red line is prior to the introduction of the three-year VLTRO in December 2011.
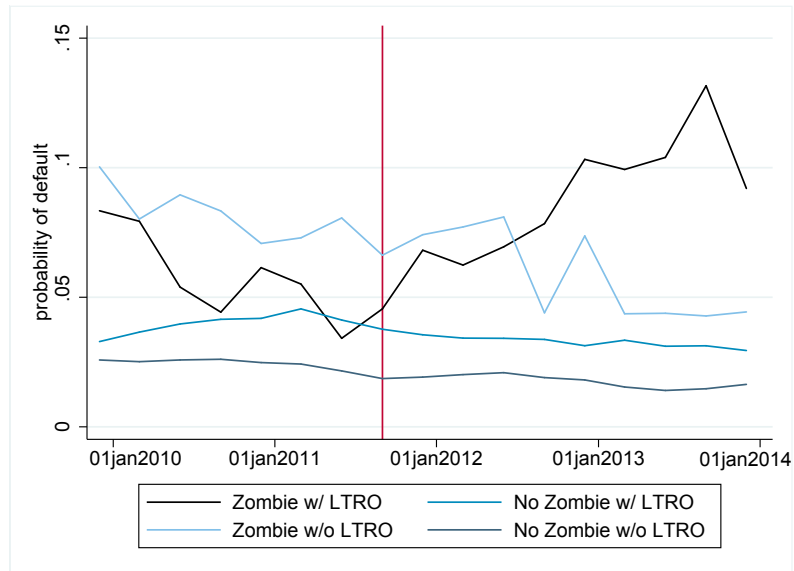
Figure 4: Firms' trade credit borrowing (normalized prior to the VLTRO) is shown over time separately depending on the criteria of the firms' main bank usage of VLTRO funding. The firms' lender with the highest borrower preference index (lending between firm j and bank i relative to the total borrowing of firm j) prior to the VLTRO is classified as the main bank.
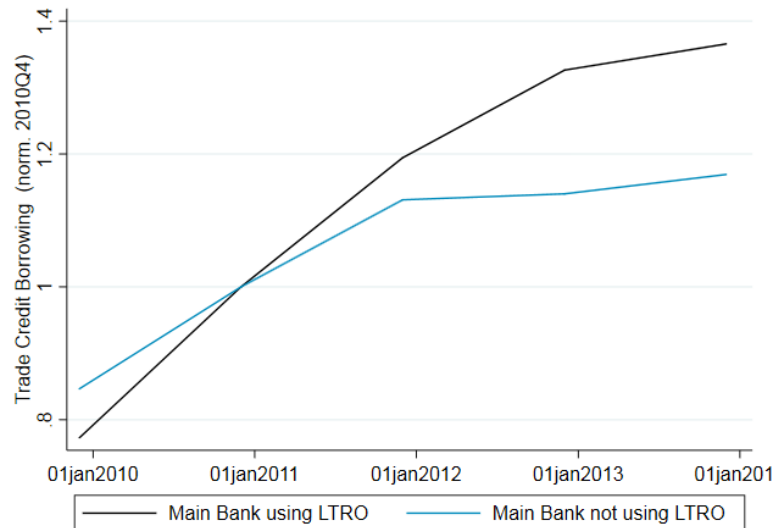
Figure 5: Firms' trade credit provision (normalized prior to the VLTRO) is shown over time separately depending on the criteria of the firms' main bank usage of VLTRO funding. The firms' lender with the highest borrower preference index (lending between firm j and bank i relative to the total borrowing of firm j) prior to the VLTRO is classified as the main bank.
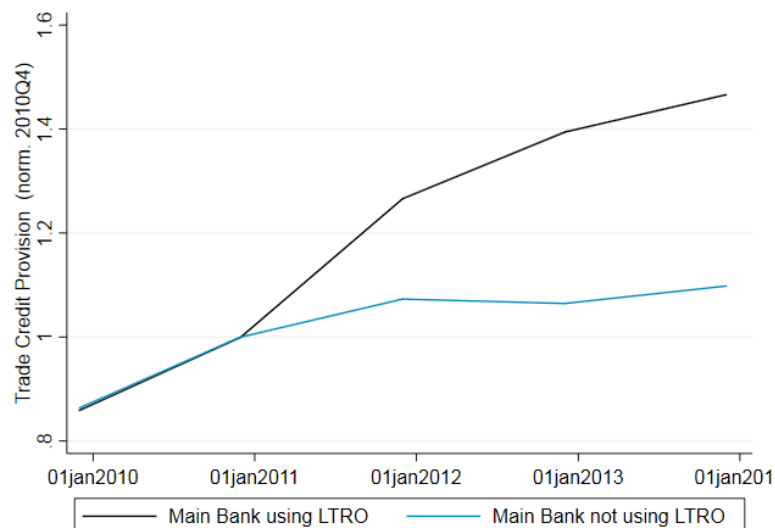
Table 1: Variable definitions for the variables used throughout the paper. First section lists definition on bank-firm level, second section on bank level and third section on firm level.

Variable Name	Definition
Log Loan Vol.	Logarithm of loan amount outstanding between bank i and firm j
Access	Dummy is 1 if bank i lends to firm j at time t, and zero otherwise
New Loan	Dummy is 1 if bank i increased lending to firm j at time t
Entry	Dummy is 1 if bank i is lending to firm j at time t, but did not in time t-1, and zero otherwise
Add. Loan	Dummy is 1 if bank i increased lending to firm j at time t and has already been lending to firm j at time t-1, and zero otherwise
Add. Log Loan Vol.	Log Loan Vol. times Add. Loan
Exit	Dummy is 1 if bank i´s lending to firm j is zero at time t, but positive at time t-1
Decrease	Dummy is 1 if bank i´s lending to firm j at time t is smaller than lending at time t-1 but not zero, and zero otherwise
PD (probabilty of default)	Probability of default reported by bank i (using an internal rating based approach) for firm j
Log Collateral	Logarithm of collateral between bank i and firm j
Log Loan Provision	Logarithm of loan provisions for between bank i and firm j
Deviation PD	Deviation from bank i reported probability of default of firm j from average reporting of all banks
BPI (Borrower Preference Index)	Loan amount between bank i and firm j / Total borrowing of firm j
LPI (Lender Preference Index)	Loan amount between bank i and firm j / Total lending of bank i
Δ CB Funding [bn.]	Change in central bank funding (t minus t-1)
Δ CB Funding (VLTRO) [bn.]	Change in long-term refinancing operation funding (t minus t-1)
Δ CB Funding (remaining) [bn.]	Change in non-VLTRO central bank funding (t minus t-1)
Log Size (Bank)	Logarithm of bank's total assets
Equity Ratio (Bank)	Reported equity value / Total assets
Zombie Share (Volume)	Zombie lending / Total lending
Zombie Share (Count)	Number of borrower in zombie status / Total number of borrower
Interbank Funding Share	Interbank funding / Total funding
Provision Income (norm)	Provision income / Total assets
Trading Income (norm) [in %]	Trading income / Total assets
Loss Provision (norm) [in %]	Loss provision / Total assets
Log Size (Firm)	Logarithm of firm´s total assets
Age	Firm age till foundation
Equity Ratio (Firm)	Reported equity value / Total assets
Leverage	Debt / Assets
Cash (norm.)	Cash / Total assets
Tangible (norm.)	Tangible assets / Total assets
Profit / Debt	Profit / Total debt
Cashflow (norm.)	Net surplus / Assets
Interest Coverage Ratio	Operating profits / Interest payments
Debt Service Capacity	Operating profits / Total debt
Log Trade Credit Provision	Logarithm of trade credit provision
Log Trade Credit Borrowing	Logarithm of trade credit borrowing

Table 2: Descriptive statistics for the main dependent variable Log Loan Vol. and the main explanatory variable Δ CB Funding (VLTRO) [bn.]. Log Loan Vol. is the logarithm of the loan amount outstanding from bank i to firm j in a given quarter t. Δ CB Funding (VLTRO) [bn.] is the change in three year VLTRO funding of bank i. The first part of the table refers to all banks and the entire time period used in the regressions, the second part refers to the time of three year VLTRO uptake (2011q4 and 2012q1) and banks using the VLTRO funding. Whereas the upper two parts of the table are on bank-firm level, the third part shows descriptive statistics for the VLTRO funding on bank level. The full list of variable definitions is shown in Table 1.

| | all banks (entire period) | | | | | | |
	mean	sd	p5	p25	p50	p75	p95
Log Loan Vol.	7.875	2.232	2.639	7.427	8.141	9.067	10.554
Δ CB Funding [bn.]	-0.101	1.365	-1.933	-0.01	0	0	1.607
Δ CB Funding (norm.)	-0.001	0.015	-0.022	0	0	0	0.016
N	245612						

| | VLTRO banks (2011Q4-2012Q1) | | | | | | |
	mean	sd	p5	p25	p50	p75	p95
Log Loan Vol.	8.012	2.093	4.174	7.519	8.189	9.152	10.592
Δ CB Funding [bn.]	0.529	1.048	-0.4	0	0.03	0.3	3
Δ CB Funding (norm.)	0.013	0.019	-0.007	0	0.009	0.022	0.045
Δ CB Funding (VLTRO) [bn.]	0.545	0.894	0	0	.06	0.6	3
Δ CB Funding (rem.) [bn.]	-0.016	0.645	-1.4	-0.027	0	0	0.2
N	9316						

| | VLTRO banks (bank-level) | | | | | | |
	mean	sd	p5	p25	p50	p75	p95
VLTRO Funding [bn.]	0.084	0.338	0.003	0.01	0.02	0.05	0.25
VLTRO / CB Funding	0.96	0.14	0.615	1	1	1	1
VLTRO / Total Funding	0.033	0.024	0.009	0.016	0.026	0.042	0.084
N	425						

Table 3: Bank characteristics (pre VLTRO) depending on the usage of the three-year VLTRO funding from the central bank and testing the statistical mean difference between characteristics of the two groups. The full list of variable definitions is shown in Table 1.

| | VLTRO Funding Bank | | | | | | |
| | no | | | yes | | | |
	mean	sd	N	mean	sd	N	t-Stat
Zombie Share (Volume)	0.028	0.111	540	0.023	0.099	425	0.825
Zombie Share (Count)	0.047	0.128	540	0.037	0.142	425	1.137
Log Size (Bank)	14.112	1.402	540	13.744	1.195	425	4.329
Equity Ratio (Bank)	0.055	0.018	540	0.056	0.015	425	-1.211
Interbank Funding Share	0.347	0.215	540	0.365	0.196	424	-1.399
Provision Income (norm) [in %]	0.667	0.387	540	0.667	0.331	425	-0.002
Trading Income (norm) [in %]	0.021	0.125	133	0.008	0.084	90	0.896
Loss Provision (norm) [in %]	0.284	0.228	284	0.301	0.296	253	-0.755

Table 4: Firm characteristics pre VLTRO by non-zombie compared to zombie firms. In the paper, zombie firms are primarily defined as firms with an interest coverage ratio of below one in the previous three years. Debt service capacity refers to firms having operating profit to interest payments below 0.05 for the three previous years. The full list of variable definitions is shown in Table 1.

| mean | Non-zombie | Zombie | |
| | | Interest Coverage Ratio | Debt Service Capacity |
	(1)	(2)	(3)
Log Size (Firm)	10.86	10.91	10.87
Age	41.87	37.49	37.97
Equity Ratio (Firm)	0.34	0.23	0.23
Leverage	0.49	0.54	0.55
Cash (norm.)	0.08	0.04	0.04
Tangible (norm.)	0.41	0.58	0.64
Profit / Debt	10.03	-4.80	-1.66
Cashflow (norm.)	0.04	-0.02	-0.03
Interest Coverage Ratio	8.36	-4.61	-4.78
Debt Service Capacity	12.06	-23.03	-0.77
Log Trade Credit Provision	8.50	7.33	7.03
Log Trade Credit Borrowing	8.05	7.36	7.16
N	3162	172	158

Table 5: Intensive margin of bank lending to zombie firms, where the dependent variable is Log Loan Vol., the amount of lending from bank i to firm j in a given quarter t, obtained from the credit registry. Zombie firm is an indicator variable for whether a given firm has a persistent interest coverage ratio of below one. Post VLTRO is a dummy variable that equals one if the quarter is 2011/Q4 or later, and zero otherwise. Δ CB Funding (VLTRO) [bn.] is the change in CB Funding obtained from the central bank in the three-year VLTRO operations which took place in 2011Q4 and 2012Q1. Δ CB Funding (norm.) is Delta CB Funding divided by the bank's total assets including the new central bank funding. Δ CB Funding (remaining) [bn.] is the change in non-LTRO central bank funding. Bank Share of Pledgeable Securities is the volume of securities a bank has (obtained from the securities holdings statistics) that are central bank eligible collateral. The sample period is from 2009Q4 until 2013Q4, except for column (10) and (11) where the sample period starts in 2011Q1 to avoid the main explanatory variable being affected by previous (one year) longer term refinancing operations. The full list of variable definitions is shown in Table 1.

Log Loan Vol.	Δ CB Funding (VLTRO) [bn.]							delta CB Funding (VLTRO & remaining)		delta CB Funding	delta CB Funding (norm.)	control for pledgable securities
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Zombie (Interest Coverage Ratio)	-0.123		-0.0694	-0.0620								
	(0.0915)		(0.0449)	(0.0520)								
Zombie (Interest Coverage Ratio) # Δ CB Funding (VLTRO) [bn.]	0.00866	0.0297	0.0334**	0.0355**	0.0560**	0.0531**	0.268*	0.0552**	0.0554**			0.0517**
	(0.0343)	(0.0447)	(0.0165)	(0.0171)	(0.0236)	(0.0240)	(0.137)	(0.0236)	(0.0233)			(0.0230)
Δ CB Funding (VLTRO) [bn.]			-0.0000912									
			(0.0117)									
Δ CB Funding (VLTRO) [bn.] # Log Size (Firm)							0.00781*					
							(0.00425)					
Zombie (Interest Coverage Ratio) # Δ CB Funding (VLTRO) [bn.] # Log Size (Firm)							-0.0173					
							(0.0121)					
Zombie (Interest Coverage Ratio) # Δ CB Funding (remaining) [bn.]								-0.00733	-0.00819			
								(0.0103)	(0.0136)			
Zombie (Interest Coverage Ratio) # Post VLTRO # Δ CB Funding (remaining) [bn.]									0.00292			
									(0.0169)			
Zombie (Interest Coverage Ratio) # Δ CB Funding [bn.]										-0.0645*		
										(0.0377)		
Zombie (Interest Coverage Ratio) # Post VLTRO # Δ CB Funding [bn.]										0.0715*		
										(0.0418)		
Zombie (Interest Coverage Ratio) # Δ CB Funding (norm.)											-5.584	
											(4.191)	
Zombie (Interest Coverage Ratio) # Post VLTRO # Δ CB Funding (norm.)											10.63**	
											(5.191)	
Zombie (Interest Coverage Ratio) # Bank Share of Pledgable Securities												-0.428
												(0.416)
Bank x Quarter FE	yes	yes		yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm x Quarter FE		yes			yes	yes	yes	yes	yes	yes	yes	yes
Bank x Firm FE			yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Bank x Industry x Quarter FE							yes					
N	196019	175833	197535	194750	174331	154747	174331	174331	174331	128210	128210	174080
R2	0.0816	0.408	0.690	0.712	0.785	0.804	0.785	0.785	0.785	0.806	0.806	0.785
R2 adjusted	0.0312	0.196	0.659	0.664	0.666	0.655	0.666	0.666	0.666	0.688	0.688	0.666

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Table 6: Intensive margin of bank lending to zombie firms controlling for potential endogeneity issues. The dependent variable is Log Loan Vol., the amount of lending from bank i to firm j in a given quarter t, obtained from the credit registry. Zombie firm is an indicator variable for whether a given firm has a persistent interest coverage ratio of below one. Post VLTRO is a dummy variable that equals one if the quarter is 2011/Q4 or later, and zero otherwise. Δ CB Funding (VLTRO) [bn.] is the change in CB Funding obtained from the central bank in the three-year VLTRO operations which took place in 2011Q4 and 2012Q1. The sample period is from 2009Q4 until 2013Q4. The full list of variable definitions is shown in Table 1.

Log Loan Vol.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Zombie (Interest Coverage Ratio) # Δ CB Funding (VLTRO) [bn.]	0.0560**	0.0864**	0.0598**	0.0888**	0.0558**	0.0877**	0.0635**	0.0989***
	(0.0233)	(0.0372)	(0.0241)	(0.0363)	(0.0235)	(0.0376)	(0.0249)	(0.0354)
Zombie (Interest Coverage Ratio) # Equity Ratio lag (Bank)	2.077			-1.698	2.919			-1.746
	(1.937)			(2.673)	(2.767)			(2.950)
Zombie (Interest Coverage Ratio) # Loss Provision lag (norm)		22.24		20.01		23.79		23.66
		(17.03)		(18.44)		(16.08)		(17.96)
Zombie (Interest Coverage Ratio) # Operating Profits lag (norm)			11.62**	10.11*			6.776	4.065
			(5.068)	(5.476)			(6.364)	(5.976)
Zombie (Interest Coverage Ratio) # Equity Ratio lag (Bank) # Post VLTRO					-2.582			-0.215
					(4.273)			(3.928)
Zombie (Interest Coverage Ratio) # Loss Provision lag (norm) # Post VLTRO						-10.59		-33.84
						(50.34)		(46.17)
Zombie (Interest Coverage Ratio) # Operating Profits lag (norm) # Post VLTRO							11.10	19.72**
							(7.346)	(7.925)
Bank x Quarter FE	yes	yes	yes	yes	yes	yes	yes	yes
Firm x Quarter FE	yes	yes	yes	yes	yes	yes	yes	yes
Bank x Firm FE	yes	yes	yes	yes	yes	yes	yes	yes
N	174331	131191	174331	131191	174331	131191	174331	131191
R2	0.785	0.797	0.785	0.797	0.785	0.797	0.785	0.797
R2 adjusted	0.666	0.664	0.666	0.664	0.666	0.664	0.666	0.664

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Table 7: Extensive margin of bank lending to zombie firms. The dependent variable is either (i) Access, which equals one if bank i lends to firm j at time t and is zero otherwise; (ii) New Loan, which equals one if bank i increased lending to firm j at time t and is zero otherwise; This can be decomposed into (iii) Entry and (iv-v) Add. Loan. Entry equals one if bank i is lending to firm j at time t, but did not at time $t-1$ (and is zero otherwise). Add. Loan equals one if bank i increased lending to firm j at time t, and has already been lending to firm j at time $t-1$ (and is zero otherwise); (vi) Exit equals one if bank i's lending to firm j is zero at time t, but positive at time $t-1$; and (vii-viii) Decrease equals one if bank i's lending to firm j at time t is smaller than its lending at time $t-1$. Zombie Firm is an indicator variable whether a given firm has a persistent interest coverage ratio below one. Delta CB Funding LTRO is the change in CB Funding obtained from the Central Bank in the 3 years LTRO operation, which took place in 2011Q4 and 2012Q1. The sample period is from 2009Q4 until 2013Q4. The full list of variable definitions is shown in Table 1.

Dependent Variable	Access	New Loan	Entry	ADD. LOAN	ADD. LOAN	Exit	Decrease	Decrease
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Zombie # Δ CB Funding (VLTRO) [bn.]	0.0109*	0.0289***	0.00662	0.0214***	0.0204***	0.00228	-0.00407	-0.00849
	(0.00597)	(0.00873)	(0.00516)	(0.00593)	(0.00469)	(0.00350)	(0.00723)	(0.00572)
Bank x Quarter FE	yes	yes	yes	yes	yes	yes	yes	yes
Firm x Quarter FE	yes	yes	yes	yes	yes	yes	yes	yes
Bank x Firm FE					yes			yes
N	342504	342504	342504	342504	342504	342504	342504	342504
R2	0.306	0.282	0.252	0.274	0.454	0.224	0.313	0.588
R2 adjusted	0.149	0.119	0.0823	0.110	0.274	0.0485	0.157	0.452

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Table 8: Intensive margin of bank lending to zombie firms using different definitions for zombie classification. For Panel A the dependent variable is Log Loan Vol. and Add. Loan for Panel B, where Log Loan Vol. is the amount of lending from bank i to firm j in a given quarter t, obtained from the credit registry and Add. Loan equals one if bank i increased lending to firm j at time t, and has already been lending to firm j at time $t-1$ (and is zero otherwise). Zombie firm is an indicator variable for whether a given firm has a persistent (1) interest coverage ratio of below one, (2) debt to service capacity below 0.05 or (3) the intersection of (1) and (2). Delta CB Funding LTRO is the change in CB Funding obtained from the Central Bank in the three-year VLTRO operation which took place in 2011Q4 and 2012Q1. The sample period is from 2009Q4 until 2013Q4. The full list of variable definitions is shown in Table 1.

Panel A

Zombie Definition	Interest Coverage Ratio < 1	Debt Service Capacity < 5%	Intersection of definition used in (1) and (2)
Log Loan Vol.	(1)	(2)	(3)
Zombie # Δ CB Funding (VLTRO) [bn.]	0.0560**	0.0456**	0.0543**
	(0.0236)	(0.0209)	(0.0248)
Bank x Quarter FE	yes	yes	yes
Bank x Firm FE	yes	yes	yes
Firm x Quarter FE	yes	yes	yes
N	174331	174331	174331
R2	0.785	0.785	0.785
R2 adjusted	0.666	0.666	0.666

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Panel B

Zombie Definition	Interest Coverage Ratio < 1	Debt Service Capacity < 5%	Intersection of definition used in (1) and (2)
Add. Loan	(1)	(2)	(3)
Zombie # Δ CB Funding (VLTRO) [bn.]	0.0204***	0.0163**	0.0218***
	(0.00717)	(0.00655)	(0.00762)
Bank x Quarter FE	yes	yes	yes
Bank x Firm FE	yes	yes	yes
Firm x Quarter FE	yes	yes	yes
N	342504	342504	342504
R2	0.454	0.454	0.454
R2 adjusted	0.274	0.274	0.274

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Table 9: Bank lending to zombie firms where banks are categorized by different definitions of capitalization. Where Equity Ratio refers to the balance sheet equity over total assets and RW Equity Ratio is the risk-weighted equity ratio from supervisory reporting. The bank sample is split into high and low according to the median of the respective characteristics. For Panel A the dependent variable is Log Loan Vol. and Add. Loan for Panel B, where Log Loan Vol. is the amount of lending from bank i to firm j in a given quarter t, obtained from the credit registry and Add. Loan equals one if bank i increased lending to firm j at time t, and has already been lending to firm j at time $t-1$ (and is zero otherwise). Zombie firm is an indicator variable whether a given firm has a persistent interest coverage ratio of below one. Delta CB Funding VLTRO is the change in CB Funding obtained from the central bank in the three-year VLTRO operation, which took place in 2011Q4 and 2012Q1. The sample period is from 2009Q4 until 2013Q4. The full list of variable definitions is shown in Table 1.

| **Panel A** | Equity Ratio | | RW Equity Ratio | |
| | low | high | low | high |
Log Loan Vol.	(1)	(2)	(3)	(4)
Zombie # Δ CB Funding (VLTRO) [bn.]	0.0867**	-0.0611	0.0634**	0.0282
	(0.0350)	(0.545)	(0.0259)	(0.0350)
Bank x Quarter FE	yes	yes	yes	yes
Bank x Firm FE	yes	yes	yes	yes
Firm x Quarter FE	yes	yes	yes	yes
N	80182	68818	65068	84747
R2	0.793	0.797	0.784	0.807
R2 adjusted	0.657	0.639	0.618	0.675

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

| **Panel B** | Equity Ratio | | RW Equity Ratio | |
| | low | high | low | high |
Add. Loan	(1)	(2)	(3)	(4)
Zombie # Δ CB Funding (VLTRO) [bn.]	0.0230***	-0.119**	0.0190**	0.0269**
	(0.00585)	(0.0589)	(0.00834)	(0.0107)
Bank x Quarter FE	yes	yes	yes	yes
Bank x Firm FE	yes	yes	yes	yes
Firm x Quarter FE	yes	yes	yes	yes
N	160800	155872	143280	174200
R2	0.488	0.522	0.500	0.499
R2 adjusted	0.266	0.298	0.271	0.280

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Table 10: Bank lending to zombie firms where banks are categorized by size and business model. Large (small) banks have above (below) median balance sheet size. Internationally active banks include (i) Commercial banks (i.e. Large banks–which is a separate Bundesbank classification and more restrictive than having above-median balance sheet size as well as Regional banks); (ii) Landesbanken; and (iii) Cooperative head institutions (WGZ and DZ Bank). Savings & Cooperative banks include all savings and cooperative banks, irrespective of their size. For Panel A the dependent variable is Log Loan Vol. and Add. Loan for Panel B, where Log Loan Vol. is the amount of lending from bank i to firm j in a given quarter t, obtained from the credit registry and Add. Loan equals one if bank i increased lending to firm j at time t, and has already been lending to firm j at time $t-1$ (and is zero otherwise). Zombie firm is an indicator variable whether a given firm has a persistent interest coverage ratio below one. Δ CB Funding (VLTRO) [bn.] is the change in CB Funding obtained from the central bank in the three-year VLTRO operation which took place in 2011Q4 and 2012Q1. The sample period is from 2009Q4 until 2013Q4. The full list of variable definitions is shown in Table 1.

| **Panel A** | Large Bank | | Business Modell | |
| | yes | no | Internat. Active | Savings & Cooperative |
Log Loan Vol.	(1)	(2)	(3)	(4)
Zombie # Δ CB Funding (VLTRO) [bn.]	0.0765**	0.239	0.0801**	-0.427
	(0.0323)	(0.505)	(0.0344)	(0.390)
Bank x Quarter FE	yes	yes	yes	yes
Bank x Firm FE	yes	yes	yes	yes
Firm x Quarter FE	yes	yes	yes	yes
N	80559	69216	82907	53853
R2	0.793	0.789	0.787	0.795
R2 adjusted	0.665	0.625	0.660	0.627

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

| **Panel B** | Large Bank | | Business Modell | |
| | yes | no | Internat. Active | Savings & Cooperative |
Add. Loan	(1)	(2)	(3)	(4)
Zombie # Δ CB Funding (VLTRO) [bn.]	0.0208***	-0.0805	0.0244***	-0.150
	(0.00473)	(0.102)	(0.00686)	(0.167)
Bank x Quarter FE	yes	yes	yes	yes
Bank x Firm FE	yes	yes	yes	yes
Firm x Quarter FE	yes	yes	yes	yes
N	160208	155488	166576	120352
R2	0.470	0.545	0.470	0.567
R2 adjusted	0.255	0.332	0.259	0.350

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Table 11: Bank lending to zombie firms where firms are categorized by different criteria for firm opacity (issuing bonds, being publicly listed) and size, where the firm sample is split according to the median of firms total assets. For Panel A the dependent variable is Log Loan Vol. and Add. Loan for Panel B, where Log Loan Vol. is the amount of lending from bank i to firm j in a given quarter t, obtained from the credit registry and Add. Loan equals one if bank i increased lending to firm j at time t, and has already been lending to firm j at time $t-1$ (and is zero otherwise). Zombie firm is an indicator variable for whether a given firm has a persistent interest coverage ratio below one. Delta CB Funding VLTRO is the change in CB Funding obtained from the central bank in the three-year VLTRO operation which took place in 2011Q4 and 2012Q1. The sample period is from 2009Q4 until 2013Q4. The full list of variable definitions is shown in Table 1.

Panel A	Issued Bonds		Publicly Listed		Firm Size	
	no	yes	no	yes	small	large
Log Loan Vol.	(1)	(2)	(3)	(4)	(5)	(6)
Zombie # Δ CB Funding (VLTRO) [bn.]	0.0539**	0.0912	0.0611**	0.0716*	0.128**	0.0418
	(0.0238)	(0.102)	(0.0290)	(0.0372)	(0.0550)	(0.0328)
Bank x Quarter FE	yes	yes	yes	yes	yes	yes
Bank x Firm FE	yes	yes	yes	yes	yes	yes
Firm x Quarter FE	yes	yes	yes	yes	yes	yes
N	123516	47080	114215	56132	52159	117452
R2	0.819	0.732	0.822	0.740	0.850	0.766
R2 adjusted	0.694	0.611	0.693	0.625	0.693	0.655

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Panel B	Issued Bonds		Publicly Listed		Firm Size	
	no	yes	no	yes	small	large
Add. Loan	(1)	(2)	(3)	(4)	(5)	(6)
Zombie # Δ CB Funding (VLTRO) [bn.]	0.0237***	-0.0250	0.0197**	0.0240**	0.0297**	0.0142**
	(0.00551)	(0.0428)	(0.00827)	(0.00933)	(0.0126)	(0.00682)
Bank x Quarter FE	yes	yes	yes	yes	yes	yes
Bank x Firm FE	yes	yes	yes	yes	yes	yes
Firm x Quarter FE	yes	yes	yes	yes	yes	yes
N	239248	99672	223320	115296	111800	226496
R2	0.478	0.414	0.481	0.421	0.535	0.428
R2 adjusted	0.260	0.262	0.257	0.270	0.254	0.274

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Table 12: Bank lending to zombie firms where the intensity of bank-firm relationships is analyzed. The borrower preference index (BPI) is defined as the lending of bank i to firm j relative to the total borrowing of firm j, whereas the lender preference index (LPI) is relative to the total lending of bank i. Internationally active banks include (i) Commercial banks (i.e. Large banks, which is a separate Bundesbank classification as well as Regional banks); (ii) Landesbanken; and (iii) Cooperative head institutions (WGZ and DZ Bank). Banks with a low risk-weighted capital ratio have a risk-weighted capital ratio below the median. For Panel A the dependent variable is Log Loan Vol. and Add. Loan for Panel B, where Log Loan Vol. is the amount of lending from bank i to firm j in a given quarter t, obtained from the credit registry and Add. Loan equals one if bank i increased lending to firm j at time t, and has already been lending to firm j at time $t-1$ (and is zero otherwise). Zombie firm is an indicator variable for whether a given firm has a persistent interest coverage ratio below one. Δ CB Funding (VLTRO) [bn.] is the change in CB Funding obtained from the central bank in the three-year VLTRO operation which took place in 2011Q4 and 2012Q1. The sample period is from 2009Q4 until 2013Q4. The full list of variable definitions is shown in Table 1.

Panel A	BPI						LPI					
	> 0.15	<= 0.15	> 0.15 (International Active)	<= 0.15 (International Active)	> 0.15 (Low Equity Ratio)	<= 0.15 (Low Equity Ratio)	> 0.15	<= 0.15	> 0.15 (International Active)	<= 0.15 (International Active)	> 0.15 (Low Equity Ratio)	<= 0.15 (Low Equity Ratio)
Log Loan Vol.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Zombie # Δ CB Funding (VLTRO) [bn.]	0.0357	0.0926	0.0503	0.141	0.0670	0.103	0.0694	0.0684	0.241	0.0902	0.174**	0.0744
	(0.0279)	(0.0651)	(0.0561)	(0.103)	(0.0448)	(0.0976)	(0.0573)	(0.0417)	(0.151)	(0.0554)	(0.0825)	(0.0535)
Bank x Quarter FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Bank x Firm FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm x Quarter FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	91218	63835	42028	29190	39566	27855	85848	62411	20627	50254	24163	41877
R2	0.846	0.752	0.841	0.767	0.847	0.764	0.791	0.802	0.808	0.792	0.806	0.798
R2 adjusted	0.677	0.632	0.667	0.646	0.661	0.634	0.641	0.655	0.659	0.637	0.653	0.629

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Panel B	BPI						LPI					
	> 0.15	<= 0.15	> 0.15 (International Active)	<= 0.15 (International Active)	> 0.15 (Low Equity Ratio)	<= 0.15 (Low Equity Ratio)	> 0.15	<= 0.15	> 0.15 (International Active)	<= 0.15 (International Active)	> 0.15 (Low Equity Ratio)	<= 0.15 (Low Equity Ratio)
Add. Loan	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Zombie # Δ CB Funding (VLTRO) [bn.]	0.0219***	0.00867	0.0264***	0.00755	0.0239***	0.00965	0.0234***	0.0167	0.0191**	0.0298*	0.0224**	0.0196
	(0.00797)	(0.0184)	(0.00630)	(0.0245)	(0.00607)	(0.0189)	(0.00685)	(0.0151)	(0.00901)	(0.0176)	(0.00972)	(0.0120)
Bank x Quarter FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Bank x Firm FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm x Quarter FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	249612	77232	121408	35104	116000	33648	240928	75840	84752	60816	87860	50640
R2	0.510	0.488	0.530	0.477	0.548	0.498	0.484	0.526	0.487	0.528	0.490	0.556
R2 adjusted	0.294	0.274	0.280	0.236	0.287	0.252	0.281	0.218	0.235	0.210	0.230	0.221

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Table 13: Evolution of firm-specific default probability (average of pd reported by banks using the internal rating based approach) for zombie and non-zombie firms after the extension of loans following the three-year VLTRO. For Panel A the main explanatory variable is Add. Log Loan Vol. and Add. Loan for Panel B, where Add. Log Loan Vol. is the amount of lending from bank i to firm j in a given quarter t, obtained from the credit registry conditional on being an additional loan and Add. Loan equals one if bank i increased lending to firm j at time t, and has already been lending to firm j at time $t-1$ (and is zero otherwise). Zombie firm is an indicator variable for whether a given firm has a persistent interest coverage ratio of below one. Post VLTRO is a dummy variable that equals one if the quarter is 2011Q4 or later, and zero otherwise. The sample period is from 2009Q4 until 2013Q4 in the first two specifications and 4 quarters pre and post the VLTRO announcement for the remaining ones. The full list of variable definitions is shown in Table 1.

Panel A

Dependent Variable	avg. pd 13q4				change in avg. pd to 13q4		
Sample	4 quarter pre and post VLTRO announcement						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Add. Log Loan Vol.	0.0005*	0.0005*	0.0004	0.0002	0.0001	0.0002	0.0002
	(0.0003)	(0.0003)	(0.0003)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Post VLTRO # Add. Log Loan Vol.	-0.0002	-0.0002	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001
	(0.0003)	(0.0003)	(0.0003)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Zombie (Interest Coverage Ratio)	0.0240	0.0240	0.0168	0.0072	0.0034	-0.0019	-0.0008
	(0.0143)	(0.0144)	(0.0127)	(0.0085)	(0.0101)	(0.0115)	(0.0134)
Zombie (Interest Coverage Ratio) # Add. Log Loan Vol.	-0.0029*	-0.0029*	-0.0020*	-0.0019*	-0.0019	-0.0019	-0.0021*
	(0.0015)	(0.0015)	(0.0010)	(0.0009)	(0.0011)	(0.0011)	(0.0012)
Post VLTRO # Zombie (Interest Coverage Ratio)	0.0123	0.0124	0.0105	-0.0000	-0.0042	-0.0040	-0.0061
	(0.0128)	(0.0129)	(0.0087)	(0.0087)	(0.0121)	(0.0121)	(0.0155)
Post VLTRO # Zombie (Interest Coverage Ratio) # Add. Log Loan Vol.	0.0072**	0.0073**	0.0034**	0.0027**	0.0025**	0.0026**	0.0029**
	(0.0028)	(0.0028)	(0.0015)	(0.0010)	(0.0011)	(0.0011)	(0.0011)
Log Size (Firm)	-0.0016***	-0.0016***	-0.0015***	-0.0004*	0.0001	0.0004	0.0004
	(0.0004)	(0.0004)	(0.0004)	(0.0002)	(0.0002)	(0.0003)	(0.0003)
Equity Ratio (Firm)	-0.1170***	-0.1171***	-0.1262***	-0.0302***	0.0079	0.0107	0.0108
	(0.0162)	(0.0163)	(0.0174)	(0.0052)	(0.0079)	(0.0087)	(0.0088)
average pd				0.7155***			
				(0.0413)			
Bank FE	yes						
Quarter FE	yes						
Bank x Quarter FE		yes	yes	yes	yes	yes	yes
Industry FE						yes	yes
Industry x Quarter FE							yes
N	40683	40668	20343	20343	20343	20343	20319
R2	0.0726	0.0688	0.0686	0.6507	0.0105	0.0251	0.0284
R2 adjusted	0.0716	0.0601	0.0598	0.6473	0.0011	0.0132	-0.0011

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Panel B

Dependent Variable	avg. pd 13q4				change in avg. pd to 13q4		
Sample	4 quarter pre and post VLTRO announcement						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Add. Loan	0.0035	0.0036	0.0029	0.0016	0.0011	0.0018	0.0018
	(0.0025)	(0.0025)	(0.0026)	(0.0017)	(0.0017)	(0.0017)	(0.0019)
Post VLTRO # Add. Loan	-0.0012	-0.0013	-0.0010	-0.0009	-0.0009	-0.0012	-0.0010
	(0.0026)	(0.0027)	(0.0023)	(0.0018)	(0.0019)	(0.0018)	(0.0022)
Zombie (Interest Coverage Ratio)	0.0233	0.0233	0.0155	0.0078	0.0048	-0.0005	0.0009
	(0.0138)	(0.0139)	(0.0117)	(0.0075)	(0.0086)	(0.0100)	(0.0117)
Zombie (Interest Coverage Ratio) # Add. Loan	-0.0235**	-0.0237**	-0.0118	-0.0196	-0.0227	-0.0229	-0.0256
	(0.0113)	(0.0114)	(0.0075)	(0.0123)	(0.0165)	(0.0164)	(0.0170)
Post VLTRO # Zombie (Interest Coverage Ratio)	0.0108	0.0108	0.0089	-0.0019	-0.0062	-0.0060	-0.0085
	(0.0131)	(0.0132)	(0.0086)	(0.0080)	(0.0108)	(0.0108)	(0.0140)
Post VLTRO # Zombie (Interest Coverage Ratio) # Add. Loan	0.0721**	0.0726**	0.0362**	0.0318**	0.0300*	0.0312**	0.0348**
	(0.0262)	(0.0264)	(0.0160)	(0.0133)	(0.0163)	(0.0160)	(0.0162)
Log Size (Firm)	-0.0016***	-0.0016***	-0.0015***	-0.0004*	0.0001	0.0005*	0.0004*
	(0.0004)	(0.0004)	(0.0004)	(0.0002)	(0.0002)	(0.0003)	(0.0003)
Equity Ratio (Firm)	-0.1171***	-0.1171***	-0.1262***	-0.0302***	0.0079	0.0107	0.0108
	(0.0162)	(0.0163)	(0.0174)	(0.0052)	(0.0079)	(0.0087)	(0.0088)
average pd				0.7155***			
				(0.0413)			
Bank FE	yes						
Quarter FE	yes						
Bank x Quarter FE		yes	yes	yes	yes	yes	yes
Industry FE						yes	yes
Industry x Quarter FE							yes
N	40704	40688	20344	20344	20344	20344	20320
R2	0.0731	0.0690	0.0687	0.6507	0.0107	0.0253	0.0286
R2 adjusted	0.0721	0.0604	0.0598	0.6474	0.0013	0.0134	-0.0009

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Table 14: Evolution of firm-specific default probability (bank reported pd by banks using the internal ratings-based approach) for zombie and non-zombie firms after the extension of loans following the three-year VLTRO. For Panel A the main explanatory variable is Add. Log Loan Vol. and Add. Loan for Panel B, where Add. Log Loan Vol. is the amount of lending from bank i to firm j in a given quarter t, obtained from the credit registry conditional on being an additional loan and Add. Loan equals one if bank i increased lending to firm j at time t, and has already been lending to firm j at time $t-1$ (and is zero otherwise). Zombie firm is an indicator variable whether a given firm has a persistent interest coverage ratio below one. Post LTRO is a dummy variable that equals one if the quarter is 2011Q4 or later, and zero otherwise. The sample period is from 2009Q4 until 2013Q4 in the first two specifications and 4 quarters pre and post the LTRO announcement for the remaining ones. The full list of variable definitions is shown in Table 1.

Panel A

Dependent Variable	pd 13q4				change in pd to 13q4		
Sample	4 quarter pre and post VLTRO announcement						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Add. Log Loan Vol.	0.0004	0.0004	0.0002	0.0002	0.0002	0.0003	0.0002
	(0.0004)	(0.0004)	(0.0004)	(0.0003)	(0.0003)	(0.0002)	(0.0002)
Post VLTRO # Add. Log Loan Vol.	-0.0003	-0.0003	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0004)	(0.0004)	(0.0004)
Zombie (Interest Coverage Ratio)	0.0326	0.0326	0.0241	0.0169	0.0131	0.0083	0.0122
	(0.0220)	(0.0220)	(0.0198)	(0.0160)	(0.0168)	(0.0202)	(0.0215)
Zombie (Interest Coverage Ratio) # Add. Log Loan Vol.	-0.0047**	-0.0047**	-0.0033	-0.0032*	-0.0031	-0.0032	-0.0036
	(0.0021)	(0.0021)	(0.0020)	(0.0018)	(0.0020)	(0.0021)	(0.0021)
Post VLTRO # Zombie (Interest Coverage Ratio)	0.0056	0.0056	0.0069	-0.0155	-0.0273	-0.0272	-0.0346
	(0.0130)	(0.0131)	(0.0071)	(0.0125)	(0.0188)	(0.0189)	(0.0231)
Post VLTRO # Zombie (Interest Coverage Ratio) # Add. Log Loan Vol.	0.0085**	0.0086**	0.0050**	0.0057**	0.0061**	0.0062**	0.0068**
	(0.0032)	(0.0032)	(0.0024)	(0.0022)	(0.0026)	(0.0027)	(0.0027)
Log Size (Firm)	-0.0019***	-0.0019***	-0.0018***	-0.0003	0.0004	0.0010**	0.0010**
	(0.0006)	(0.0006)	(0.0006)	(0.0003)	(0.0003)	(0.0004)	(0.0004)
Equity Ratio (Firm)	-0.1144***	-0.1145***	-0.1222***	-0.0374***	0.0071	0.0124	0.0125
	(0.0251)	(0.0251)	(0.0274)	(0.0107)	(0.0078)	(0.0088)	(0.0088)
pd				0.6561***			
				(0.0517)			
Bank FE	yes						
Quarter FE	yes						
Bank x Quarter FE		yes	yes	yes	yes	yes	yes
Industry FE						yes	yes
Industry x Quarter FE							yes
N	40683	40668	20343	20343	20343	20343	20319
R2	0.0785	0.0559	0.0555	0.5283	0.0085	0.0174	0.0199
R2 adjusted	0.0775	0.0472	0.0465	0.5238	-0.0009	0.0055	-0.0099

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Panel B

Dependent Variable	pd 13q4				change in pd to 13q4		
Sample	4 quarter pre and post VLTRO announcement						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Add. Loan	0.0026	0.0027	0.0014	0.0020	0.0023	0.0031	0.0030
	(0.0031)	(0.0031)	(0.0032)	(0.0023)	(0.0024)	(0.0021)	(0.0022)
Post VLTRO # Add. Loan	-0.0022	-0.0024	-0.0010	-0.0021	-0.0026	-0.0030	-0.0027
	(0.0027)	(0.0028)	(0.0031)	(0.0032)	(0.0035)	(0.0034)	(0.0038)
Zombie (Interest Coverage Ratio)	0.0320	0.0320	0.0228	0.0178	0.0152	0.0105	0.0147
	(0.0217)	(0.0218)	(0.0194)	(0.0159)	(0.0163)	(0.0198)	(0.0209)
Zombie (Interest Coverage Ratio) # Add. Loan	-0.0392**	-0.0395**	-0.0235	-0.0320*	-0.0364	-0.0373	-0.0420*
	(0.0184)	(0.0185)	(0.0175)	(0.0184)	(0.0217)	(0.0226)	(0.0236)
Post VLTRO # Zombie (Interest Coverage Ratio)	0.0037	0.0037	0.0055	-0.0177	-0.0298	-0.0297	-0.0379
	(0.0133)	(0.0134)	(0.0074)	(0.0125)	(0.0183)	(0.0184)	(0.0225)
Post VLTRO # Zombie (Interest Coverage Ratio) # Add. Loan	0.0846**	0.0852**	0.0488*	0.0592**	0.0647**	0.0658**	0.0732**
	(0.0320)	(0.0322)	(0.0254)	(0.0231)	(0.0275)	(0.0274)	(0.0281)
Log Size (Firm)	-0.0019***	-0.0019***	-0.0018**	-0.0003	0.0004	0.0010**	0.0010**
	(0.0006)	(0.0006)	(0.0007)	(0.0003)	(0.0003)	(0.0004)	(0.0004)
Equity Ratio (Firm)	-0.1144***	-0.1144***	-0.1222***	-0.0374***	0.0070	0.0124	0.0125
	(0.0251)	(0.0251)	(0.0274)	(0.0107)	(0.0078)	(0.0088)	(0.0088)
pd				0.6562***			
				(0.0517)			
Bank FE	yes						
Quarter FE	yes						
Bank x Quarter FE		yes	yes	yes	yes	yes	yes
Industry FE						yes	yes
Industry x Quarter FE							yes
N	40704	40688	20344	20344	20344	20344	20320
R2	0.0801	0.0561	0.0555	0.5284	0.0087	0.0177	0.0202
R2 adjusted	0.0791	0.0473	0.0466	0.5239	-0.0007	0.0057	-0.0096

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Table 15: Analysis regarding collateral, loan provision and deviation from the average reported probability of default at the time of loan extensions. For Panel A the main explanatory variable is Add. Log Loan Vol. and Add. Loan for Panel B, where Add. Log Loan Vol. is the amount of lending from bank i to firm j in a given quarter t, obtained from the credit registry conditional on being an additional loan and Add. Loan equals one if bank i increased lending to firm j at time t, and has already been lending to firm j at time $t-1$ (and is zero otherwise). Zombie firm is an indicator variable for whether a given firm has a persistent interest coverage ratio of below one. Post VLTRO is a dummy variable that equals one if the quarter is 2011Q4 or later, and zero otherwise. The sample period is from 2009Q4 until 2013Q4. The full list of variable definitions is shown in Table 1.

Panel A

Dependent Variable	Log Collateral	Log Loan Provision	Deviation PD
	(1)	(2)	(3)
Add. Log Loan Vol.	-0.000302	-0.00786	-0.000122
	(0.00428)	(0.0119)	(0.0000811)
Zombie (Interest Coverage Ratio) # Add. Log Loan Vol.	0.0206*	0.0593*	0.00184*
	(0.0123)	(0.0307)	(0.00104)
Post VLTRO # Add. Log Loan Vol.	0.0267***	0.0164	0.0000971
	(0.00496)	(0.0137)	(0.000100)
Zombie (Interest Coverage Ratio) # Post VLTRO # Add. Log Loan Vol.	-0.0348***	-0.0698**	-0.00250*
	(0.0129)	(0.0327)	(0.00123)
Bank x Quarter FE	yes	yes	yes
Bank x Firm FE	yes	yes	yes
Firm x Quarter FE	yes	yes	yes
N	56022	692	62218
R2	0.914	0.967	0.697
R2 adjusted	0.809	0.836	0.501

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Panel B

Dependent Variable	Log Collateral	Log Loan Provision	Deviation PD
	(1)	(2)	(3)
Add. Loan	-0.0131	-0.0545	-0.00181**
	(0.0342)	(0.126)	(0.000745)
Zombie (Interest Coverage Ratio) # Add. Loan	0.196*	0.537*	0.0187*
	(0.119)	(0.303)	(0.00943)
Post VLTRO # Add. Loan	0.234***	0.137	0.00187*
	(0.0414)	(0.144)	(0.00102)
Zombie (Interest Coverage Ratio) # Post VLTRO # Add. Loan	-0.307***	-0.561*	-0.0148
	(0.118)	(0.316)	(0.0122)
Bank x Quarter FE	yes	yes	yes
Bank x Firm FE	yes	yes	yes
Firm x Quarter FE	yes	yes	yes
N	56022	692	62218
R2	0.914	0.967	0.697
R2 adjusted	0.809	0.837	0.501

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Table 16: Trade credit borrowing and advanced payments received is analyzed following extended lending after the VLTRO. Zombie firm is an indicator variable for whether a given firm has a persistent interest coverage ratio of below one. Post dummy variable equals one after the allotment of the VLTRO and zero otherwise. Log Loan Vol. lag main bank is the borrowing of firm j from its main bank i. VLTRO access is a dummy if a firm related bank uses VLTRO funding. And Log Loan Vol. lag VLTRO banks is the total amount a firm j receives from banks using VLTRO funding. The data sample period is from 2009 until 2013. Using firm balance sheet data as dependent variable (trade credit and advance payments), requires the regression to be on yearly basis. The full list of variable definitions is shown in Table 1.

Dependent Variable	Δ Trade Credit Borrowing					Δ Advance Payments Received				
Main Explanatory Variable	Log Loan Vol. lag (main bank)	Log Loan Vol. firm has VLTRO access		Log Loan Vol. lag (VLTRO banks)		Log Loan Vol. lag (main bank)	Log Loan Vol. firm has VLTRO access		Log Loan Vol. lag (VLTRO banks)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Zombie (Interest Coverage Ratio)	-1.752**	16.90*	-0.271	3.904**	8.599	-2.187*	11.52	-0.229	3.039	-13.93
	(0.713)	(9.483)	(0.447)	(1.856)	(5.838)	(1.309)	(9.532)	(0.349)	(1.979)	(20.85)
Zombie (Interest Coverage Ratio) # Post VLTRO	3.810**	-21.52	0.163	-5.235*	-4.876	3.311*	-19.89	-0.121	-6.656*	0.376
	(1.612)	(14.09)	(0.837)	(2.703)	(4.080)	(1.824)	(17.01)	(0.329)	(4.023)	(10.69)
Explanatory Variable (see header)		2.752*		1.049**	1.075**		1.011		0.908	0.767
		(1.482)		(0.438)	(0.462)		(0.719)		(0.614)	(0.512)
Zombie (Interest Coverage Ratio) # Explanatory Variable (see header)		-2.175*	-2.109**	-0.982**	-1.270*		-1.453	-2.659	-0.811	0.598
		(1.189)	(0.854)	(0.417)	(0.695)		(1.176)	(1.704)	(0.496)	(1.905)
Post VLTRO # Explanatory Variable (see header)		-3.025*	-4.349***	-1.640**	-1.855**		-2.173	-4.326*	-1.557*	-1.810*
		(1.692)	(1.631)	(0.669)	(0.778)		(1.774)	(2.532)	(0.902)	(1.029)
Zombie (Interest Coverage Ratio) # Post VLTRO # Explanatory Variable (see header)		3.009*	5.160***	1.698**	1.468*		2.546	4.739*	1.690*	1.318
		(1.804)	(1.844)	(0.699)	(0.771)		(2.121)	(2.784)	(0.983)	(1.289)
Firm FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Quarter FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry x Quarter FE					yes					yes
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	11848	10615	11848	8284	8276	5592	5011	5592	4000	3973
R2	0.609	0.526	0.609	0.610	0.623	0.250	0.162	0.250	0.252	0.319
R2 adjusted	0.478	0.347	0.478	0.479	0.480	-0.0122	-0.164	-0.0126	-0.0106	0.0216

Standard errors in parentheses, clustered on firm level
* p<0.1, ** p<0.05, *** p<0.01

Table 17: Evolution of firm-specific default probability (average of pd reported by banks using the internal ratings-based approach) for zombie and non-zombie firms after the extension of trade credit, following lending extension by the firms' main bank using VLTRO funding. The main explanatory variable is composed by the additional loan volume a firm receives from its main bank after the introduction of the VLTRO. Zombie firm is an indicator variable for whether a given firm has a persistent interest coverage ratio of below one. Δ Trade Credit Borrowing is the change in trade credit borrowing. The sample period is from 2009 until 2013. The full list of variable definitions is shown in Table 1.

Dependent Variable	avg. pd 13q4						change in avg. pd to 13q4			
Main Explanatory Variable defined as: Post VLTRO * Main Bank uses VLTRO * Add. Log Loan Vol.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Δ Trade Credit Borrowing	-0.00000907	-0.0000152	-0.0000154	-0.00000533	-0.00000765	-0.00000920	-0.00000387	-0.00000447	-0.00000663	-0.00000672
	(0.00000769)	(0.0000111)	(0.0000115)	(0.00000593)	(0.00000730)	(0.00000757)	(0.00000655)	(0.00000713)	(0.00000740)	(0.00000570)
Zombie (Interest Coverage Ratio)	0.0519**	0.0505**	0.0517**	0.0122	0.0132	0.0136	-0.00341	-0.00260	-0.00202	-0.0235
	(0.0253)	(0.0223)	(0.0232)	(0.00889)	(0.00818)	(0.00839)	(0.00696)	(0.00662)	(0.00656)	(0.0160)
Zombie (Interest Coverage Ratio) # Δ Trade Credit Borrowing	0.0238	0.0336	0.0454**	0.0101	0.0129	0.0228**	0.00472	0.00413	0.0135*	0.00701
	(0.0309)	(0.0271)	(0.0191)	(0.0116)	(0.0145)	(0.00965)	(0.00597)	(0.0102)	(0.00744)	(0.00884)
Main Explanatory Variable	0.00656	0.00300	0.00467	-0.00110	-0.00228	-0.00323	-0.00411	-0.00452	-0.00647	-0.00394
	(0.00793)	(0.00527)	(0.00760)	(0.00411)	(0.00428)	(0.00583)	(0.00535)	(0.00595)	(0.00827)	(0.00469)
Main Explanatory Variable # Δ Trade Credit Borrowing	-0.0000717	0.0000804	0.0000877	0.00000836	-0.0000204	0.0000521	0.0000398	-0.0000632	0.0000375	0.000138
	(0.0000748)	(0.000105)	(0.000122)	(0.0000376)	(0.0000923)	(0.0000458)	(0.0000471)	(0.000124)	(0.0000414)	(0.000171)
Zombie (Interest Coverage Ratio) # Main Explanatory Variable	0.0442	0.0338	0.0368	-0.0159	-0.00364	-0.0160	-0.0395	-0.0195	-0.0377	0.0971***
	(0.0419)	(0.0309)	(0.0324)	(0.0254)	(0.0215)	(0.0257)	(0.0421)	(0.0324)	(0.0384)	(0.0239)
Zombie (Interest Coverage Ratio) # Main Explanatory Variable # Δ Trade Credit Borrowing	35.46**	18.36**	20.51**	61.45**	59.60*	52.17**	71.65*	77.08*	65.14*	117.0***
	(16.81)	(9.184)	(9.806)	(27.85)	(30.58)	(26.26)	(40.26)	(44.34)	(38.46)	(35.62)
average pd				0.718***	0.702***	0.709***				
				(0.0841)	(0.0855)	(0.0868)				
Industry x Quarter FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Bank FE		yes			yes			yes		
Bank x Quarter FE			yes			yes			yes	yes
Firm FE										yes
N	4896	4896	4576	4896	4896	4576	4896	4896	4576	4576
R2	0.0463	0.130	0.109	0.631	0.648	0.644	0.0301	0.0583	0.0660	0.580
R2 adjusted	0.00611	0.0630	0.00169	0.615	0.620	0.601	-0.0107	-0.0147	-0.0470	0.346

Standard errors in parentheses, clustered on firm level
* p<0.1, ** p<0.05, *** p<0.01

Table 18: Trade credit provision and advanced payments made is analyzed following extended lending after the VLTRO. Zombie firm is an indicator variable for whether a given firm has a persistent interest coverage ratio of below one. Post dummy variable equals one after the allotment of the VLTRO and zero otherwise. Log Loan Vol. lag main bank is the borrowing of firm j from its main bank i. VLTRO access is a dummy if a firm related bank uses VLTRO funding. And Log Loan Vol. lag VLTRO banks is the total amount a firm j receives from banks using VLTRO funding. The data sample period is from 2009 until 2013. Using firm balance sheet data as the dependent variable (trade credit and advanced payments), requires the regression to be on yearly basis. The full list of variable definitions is shown in Table 1.

Dependent Variable	Δ Trade Credit Provision					Δ Advance Payments Made				
Main Explanatory Variable	Log Loan Vol.firm lag (main bank)	has VLTRO access		Log Loan Vol. lag (VLTRO banks)		Log Loan Vol.firm lag (main bank)	has VLTRO access		Log Loan Vol. lag (VLTRO banks)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Zombie (Interest Coverage Ratio)	-1.241	2.678	0.122	4.004**	4.562	-4.481	30.56	-1.494	3.743	26.54
	(0.794)	(10.63)	(0.460)	(1.991)	(7.679)	(4.954)	(33.06)	(2.095)	(6.116)	(32.58)
Zombie (Interest Coverage Ratio) # Post VLTRO	3.079*	-9.786	-0.209	-6.210*	-5.570	8.255	-43.63	2.304	-6.033	-17.25
	(1.606)	(13.09)	(0.786)	(3.193)	(5.411)	(8.473)	(57.82)	(2.932)	(7.355)	(20.83)
Explanatory Variable (see header)		0.147		0.914*	0.967*		11.65		0.409	0.702
		(1.880)		(0.478)	(0.498)		(11.46)		(0.670)	(1.044)
Zombie (Interest Coverage Ratio) # Explanatory Variable (see header)		-0.414	-1.951*	-0.881*	-0.710		-3.839	-3.273	-0.792	-2.001
		(1.325)	(1.054)	(0.450)	(0.860)		(4.041)	(4.199)	(0.892)	(2.608)
Post VLTRO # Explanatory Variable (see header)		-1.288	-3.836**	-1.599**	-1.930**		-5.487	-7.953	-1.984	-2.696
		(1.628)	(1.857)	(0.734)	(0.830)		(7.008)	(8.005)	(2.173)	(3.050)
Zombie (Interest Coverage Ratio) # Post VLTRO # Explanatory Variable (see header)		1.418	4.667**	1.688**	1.444		5.483	7.359	2.237	2.812
		(1.695)	(2.072)	(0.785)	(0.886)		(7.114)	(7.557)	(2.365)	(3.199)
Firm FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Quarter FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry x Quarter FE					yes					yes
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	11732	10524	11732	8184	8176	2481	2242	2481	1961	1934
R2	0.333	0.323	0.333	0.334	0.362	0.0604	0.0869	0.0606	0.0619	0.0717
R2 adjusted	0.109	0.0669	0.109	0.110	0.118	-0.292	-0.291	-0.293	-0.291	-0.426

Standard errors in parentheses, clustered on firm level
* p<0.1, ** p<0.05, *** p<0.01

Internet Appendix

Table 19: Regression analyses the change in lending before and after the VLTRO uptake. The sample is collapsed 4 quarters pre and post the introduction of the VLTRO. Zombie firm is an indicator variable for whether a given firm has a persistent interest coverage ratio of below one. Note that due to the time-varying zombie definition, it is possible that a firm might not be assigned to one category (either zombie or non-zombie) throughout the whole pre-VLTRO period, so that taking the mean creates a continuous variable as used in specifications (3) and (4). In specifications (1) and (2) the dummy for zombie firms takes on the value of 1 if the firm has been classified as such at least at one point in time during the pre-VLTRO period. Δ VLTRO Funding is the bank-specific VLTRO uptake. The full list of variable definitions is shown in Table 1.

	Zombie dummy		continuous Zombie	
Δ Loan Vol.	(1)	(2)	(3)	(4)
Δ VLTRO Funding	0.0472		0.0472	
	(0.0857)		(0.0857)	
Δ VLTRO Funding # Zombie (Interest Coverage ratio, max)	0.193***	0.150***		
	(0.0442)	(0.0501)		
Δ VLTRO Funding # Zombie (Interest Coverage Ratio, mean)			0.193***	0.150***
			(0.0445)	(0.0504)
Firm FE	yes	yes	yes	yes
Bank FE		yes		yes
N	21556	21409	21556	21409
R2	0.218	0.278	0.218	0.278
R2 adjusted	0.0823	0.114	0.0823	0.114

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Table 20: Robustness for baseline regression using non time-varying firm zombie status pre VLTRO throughout the time period. Non-time varying definition allows for more than 3 consecutive years to construct the zombie variable. Here, 4 and 5 years are used. Log Loan Vol. is the amount of lending from bank i to firm j in a given quarter t, obtained from the credit registry. Δ CB Funding (VLTRO) [bn.] is the change in CB Funding obtained from the central bank in the three-year VLTRO operation, which took place in 2011Q4 and 2012Q1. The sample period is from 2009Q4 until 2013Q4. The full list of variable definitions is shown in Table 1.

Log Loan Vol.	(1)	(2)
Zombie (Interest Coverage Ratio, fix 4yr pre VLTRO) # Δ CB Funding (VLTRO) [bn.]	0.0397** (0.0199)	
Zombie (Interest Coverage Ratio, fix 5yr pre VLTRO) # Δ CB Funding (VLTRO) [bn.]		0.0439** (0.0218)
Bank x Quarter FE	yes	yes
Bank x Firm FE	yes	yes
Firm x Quarter FE	yes	yes
N	174331	174331
R2	0.785	0.785
R2 adjusted	0.666	0.666

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01

Table 21: Robustness for baseline results using Add. Log Loan Vol. as dependent variable, where Add. Log Loan Vol. is the amount of lending from bank i to firm j in a given quarter t, obtained from the credit registry conditional on being an additional loan. Zombie firm is an indicator variable for whether a given firm has a persistent interest coverage ratio of below one. Δ CB Funding (VLTRO) [bn.] is the change in CB Funding obtained from the central bank in the three-year VLTRO operation, which took place in 2011Q4 and 2012Q1. The sample period is from 2009Q4 until 2013Q4. The full list of variable definitions is shown in Table 1.

Add. Log Loan Vol.	(1)	(2)	(3)	(4)	(5)	(6)
Zombie (Interest Coverage Ratio)	-0.352***		-0.278***	-0.218**		
	(0.134)		(0.0849)	(0.0909)		
Zombie (Interest Coverage Ratio) # Δ CB Funding (VLTRO) [bn.]	0.255***	0.205*	0.259***	0.255***	0.217**	0.204**
	(0.0839)	(0.106)	(0.0770)	(0.0726)	(0.0850)	(0.101)
Δ CB Funding (VLTRO) [bn.]			-0.0302			
			(0.0761)			
Bank x Quarter FE	yes	yes		yes	yes	yes
Firm x Quarter FE		yes			yes	yes
Bank x Firm FE			yes	yes	yes	yes
Bank x Industry x Quarter FE						yes
N	185574	166647	186951	184348	165207	146708
R2	0.0845	0.369	0.262	0.299	0.507	0.545
R2 adjusted	0.0342	0.144	0.186	0.180	0.229	0.193

Standard errors in parentheses, clustered on bank level
* p<0.1, ** p<0.05, *** p<0.01