The Augmented Bank Balance-Sheet Channel of Monetary Policy*

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Abstract

This paper studies how banks' balance sheets and funding costs interact in the transmission of monetary-policy rates to banks' credit supply to firms. To do so, we use credit-registry data from Germany and Portugal together with the European Central Bank's policy-rate cuts in mid-2014. The pass-through of the rate cuts to banks' funding costs differs across the euro-area currency union because deposit rates vary in their distance to the zero lower bound (ZLB). When the distance is shorter, banks' financing constraints matter less for the supply of credit and there is more risk taking. To rationalize these findings, we provide a simple model of an augmented bank balance-sheet channel where in addition to costly external financing, there is screening of borrowers and a ZLB on retail deposit rates. An impaired pass-through of monetary policy to banks' funding costs reduces their ability to lever up and weakens their lending standards.

Keywords: transmission of monetary policy, bank lending, bank risk taking, bank balance sheets, euro-area heterogeneity

JEL classification codes: E44, E52, E58, E63, F45, G20, G21

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1 Introduction

How do monetary-policy rates affect the credit supply of banks? This is a long-standing question with different, though related answers. In the bank lending channel, a lower policy rate reduces banks' cost of funding (Bernanke and Blinder, 1988; Bernanke and Gertler, 1995). Making loans becomes more profitable and, hence, banks expand their credit supply. In the bank balance-sheet channel, the expansion of credit, however, is constrained by agency frictions between banks and investors who provide external funding (Kashyap and Stein, 2000; Jiménez et al., 2012). A lower policy rate improves the quality of banks' balance sheets, which allows them to lever up and earn the agency rent more often.

This paper integrates these two influential notions of monetary-policy transmission in a single framework, which we dub the *augmented bank balance-sheet channel*. We show empirically how the pass-through of monetary-policy rates to banks' cost of funding affects their ability to lever up and supply credit to the real economy. We then provide a simple model to describe the economic mechanism. At the heart of the model is an external-financing constraint for banks similar to the one in the literature on macroeconomic fluctuations with financial frictions (Gertler and Kiyotaki, 2010).

The question of how monetary-policy rates transmit to banks' cost of funding is particularly relevant given the low interest-rate environment prevalent since the Great Financial Crisis. In a low interest-rate environment, where the nominal zero lower bound (ZLB) potentially weakens the pass-through to banks' cost of funding and erodes bank profits, the effectiveness of further policy-rate cuts could be limited or even reversed (Brunnermeier and Koby, 2019). In the same vein, low interest-rate environments may induce banks to take risks (Rajan, 2005; Borio and Zhu, 2012).

Our augmented bank balance-sheet channel sheds lights on bank risk taking and the effectiveness of policy-rate cuts when the economy is in a low-rate environment. We empirically document bank risk taking, in the form of looser lending standards, and a muting of the traditional bank balance-sheet channel at the ZLB. Our model ties these two findings together. When it is more difficult for a bank to lever up and expand lending, the benefit of maintaining tighter lending standards decreases. Looser lending standards in turn make it more difficult for banks to attract outside funding and lever up.

To examine the interaction of the pass-through of policy rates to banks' funding costs and balance sheets, we exploit a unique setting where the same policy-rate cuts occur in both an environment with a strong pass-through to funding costs and an environment in which this pass-through is weak.

While this sounds somewhat paradoxical, the heterogeneity of the euro area, with core and periphery countries, offers such a setting in mid-2014 when the European Central Bank (ECB) lowered the policy rate (to below zero).

By combining information from credit-registry data in Portugal (periphery) and Germany (core), which differ in their levels of deposit rates, we can show how the pass-through of monetary policy to bank funding costs interacts with cross-sectional heterogeneity in bank balance sheets. In 2014, banks in Portugal operate in a high-rate environment with a strong pass-through of the policy-rate cuts to banks' funding costs. In contrast, banks in Germany operate in a low-rate environment with a weak pass-through because of a hard zero lower bound on retail deposit rates (see, e.g., Heider, Saidi, and Schepens, 2019). The average rate on deposits, a major source of funding for banks, in Portugal is 1.7% in May 2014. In contrast, the average rate on bank deposits in Germany is only 0.6% at the time.[1]

To establish our augmented bank balance-sheet channel, we proceed in three steps. First, in Portugal the traditional bank balance-sheet channel is at play, while it is muted in Germany. Portuguese banks with a higher equity-to-assets ratio, the standard measure for the tightness of the external-financing constraint, expand their credit supply by less when the ECB cuts the policy rate in mid-2014. In contrast, German banks with a high equity-to-assets ratio exhibit the same lending behavior as do low-equity banks.

Second, a weak pass-through of the ECB's rate cuts to bank funding costs leads to bank risk taking. Our measure of bank risk taking is when banks establish more new lending relationships with risky firms than with safe ones. The deposits-to-assets ratio captures variation in the pass-through to bank funding costs because there is a hard ZLB on retail deposit rates, but not on wholesale/non-deposit bank debt. We show that German banks with a higher deposits-to-assets ratio lend more to risky firms but not to safe firms. In contrast to German banks, Portuguese banks with a high deposits-to-assets ratio have the same lending behavior as low-deposit banks. After controlling for differences in lending opportunities across banks and countries using the granularity of our data, and exploiting the fact that both countries share the same monetary-policy regime, the key difference that remains between Portugal and Germany is the distance to the nominal ZLB. Therefore, the deposits-to-assets ratio indeed measures the strength of the rate pass-through to bank funding costs.

Third, our model explains why a weak pass-through, such as in Germany, leads to bank risk

[1] We link this variation in deposit rates to the difference in government bond yields in the aftermath of the euro-area sovereign debt crisis in Section 2.

taking and a muting of the traditional bank balance-sheet channel. A weak pass-through to bank funding costs has a direct and an indirect effect on how a lower policy rate affects bank credit supply. With a weak pass-through, a lower policy rate reduces the rate that outside investors require less, holding bank risk constant. This directly tightens the financing constraint. The indirect effect occurs via bank risk taking. The lower policy rate leads to risk taking because the tighter financing constraint reduces the marginal benefit of maintaining high lending standards, which further amplifies the tightening of the financing constraint. This overall tightening of banks' financing constraint reduces the scope for variation in the constraint across banks to show up in the data. As a result, the traditional bank balance-sheet channel is muted in Germany.

An "out-of-sample" test provides further evidence of an augmented bank balance-sheet channel. At the time of the mid-2014 ECB rate cuts, Portugal is in a high-rate environment and we show the traditional bank balance-sheet channel to be at play. When the ECB cuts its policy rate for the last time (up to now), in 2019, Portugal is in a low-rate environment, too. In line with the idea that this weakens the pass-through to bank funding costs, we find risk taking by Portuguese banks and a muted bank balance-sheet channel in 2019, similar to what we document for German banks in 2014.

The threat to interpreting our empirical results as causal effects of monetary-policy transmission to bank credit supply is the confounding influence of the economic environment in which banks, firms, and the ECB operate. The economic environment determines the ECB's policy rate and influences bank behavior. Moreover, the economic environment influences (unobserved) credit demand by firms, which together with (unobserved) bank credit supply determines the observed lending volume. Finally, the ECB's policy rate also affects firms' credit demand.

To address this, we exploit the granularity of our credit-registry data from two countries within a currency union. First, we use a difference-in-differences specification where pre-determined balance-sheet characteristics group banks into treated and control units, which we then observe before and after the policy-rate change (the treatment). Second, we combine the difference-in-differences specification with firm-time fixed effects, absorbing time-varying unobserved heterogeneity at the firm level, including but not limited to loan demand (e.g., Khwaja and Mian, 2008). We therefore estimate the effect of the policy-rate cuts on credit supply using firms that borrow from multiple banks with different balance-sheet characteristics. In this manner, we also keep constant the potentially different investment opportunities for banks in Germany and Portugal. Third, the ECB sets monetary-policy rates for the euro area as a whole, so economic conditions in individual countries do not determine the ECB's policy. This feature of a currency union further limits the confounding role of (local) economic conditions (e.g., Jiménez et al., 2012, 2014).

Our theoretical model of a bank's lending decisions in reaction to a change in the monetary-policy rate describes a plausible, coherent economic mechanism for our different empirical results. The model explains why the pass-through to banks' funding costs warrants an augmentation of the bank balance-sheet channel. The central building block of the model is an external-financing constraint for banks: outside financing is costly because of an information problem between the banker and outside investors (similar to Holmström and Tirole, 1997).

To this standard information problem, we add two elements. First, we add a pass-through of monetary-policy rates to banks' cost of funding. Changes in this pass-through are an important source of variation in our empirical setup. In the model, the policy rate affects the rate outside investors can earn when they do not invest in banks, e.g., by holding government bonds. Krishnamurthy and Vissing-Jørgensen (2015) document a strong link between bank liabilities and government bonds, the yields on which depend on monetary policy (e.g., Gertler and Karadi, 2015). The pass-through of the policy rate to deposit rates, but not to rates on wholesale debt, weakens at the ZLB because retail depositors, unlike wholesale investors, can also store their money in cash.

Second, we add bank risk taking: when making loans, the banker exerts a costly screening effort to improve the quality of loans. In the data, such risk taking shows up reliably in the form of making new loans to riskier firms. The ex-ante screening effort and the external-financing constraint interact. The marginal benefit of screening depends on the ability to lever up and lend more. The ability to attract financing from outsiders and lever up, in turn, depends on how risky it is for outsiders to invest in the bank.

The transmission of the ECB's rate cuts in mid-2014 is heterogeneous across the euro area because of the different interest-rate levels across member states. We use our estimates from the two ends of the spectrum of the currency union—Germany (core) and Portugal (periphery)—to extrapolate how the pass-through of monetary-policy rates to bank funding costs affects bank credit supply in other member countries. The pass-through is strong and the traditional bank balance-sheet channel operates in the periphery of the euro area (e.g., Spain), while the pass-through is weak and the augmented bank balance-sheet channel is at play in the core of the euro area (e.g., Finland, Austria, and France).

We close our empirical analysis with implications of the augmented bank balance-sheet channel for the real economy. To trace the impact of the policy-induced credit-supply shock to investment and employment, we link firms to the balance-sheet characteristics of their (potentially new) lenders. In Portugal, firms in new lending relationships invest more and increase employment. In Germany, only firms in new lending relationships with high-deposit banks invest more and increase employment. High-deposit banks in Germany start lending more to risky firms, and risky firms are more likely to be credit constrained (see, among others, Stiglitz and Weiss, 1981). Therefore, one plausible interpretation is that bank risk taking, induced by policy-rate cuts in a low-rate environment, overcomes credit rationing.

Related literature. Our paper makes three contributions to the literature. First, we develop a framework to explain the transmission of monetary policy to the credit supply of banks. Our augmented bank balance-sheet channel combines elements of the bank lending and bank balance-sheet channels (Bernanke and Blinder, 1988; Bernanke and Gertler, 1995; Kashyap and Stein, 1994, 1995, 2000; Stein, 1998; Jayaratne and Morgan, 2000; Kishan and Opiela, 2000; Jiménez et al., 2012; Gomez et al., 2021), as well as of the bank risk-taking channel (Adrian and Shin, 2010; Maddaloni and Peydró, 2011; Jiménez et al., 2014; Ioannidou, Ongena, and Peydró, 2015; Martinez-Miera and Repullo, 2016; Dell'Ariccia, Laeven, and Suarez, 2017; Paligorova and Santos, 2017; Bonfim and Soares, 2018). To the best of our knowledge, we are the first to offer such a combined view of the transmission of monetary policy through banks.

Second, the main insight of our empirical evidence and model concerns the transmission of monetary policy to banks' cost of funding. We share our focus on banks' liabilities, and in particular deposit funding, with Drechsler, Savov, and Schnabl (2017, 2021) and Wang et al. (2021) who examine the effect of market power in local deposit markets. De Fiore, Hoerova, and Uhlig (2019) and Bianchi and Bigio (2021) also scrutinize the role of bank funding for the transmission of monetary policy, but focus on the smoothing of liquidity shocks in interbank markets.

Third, our empirical strategy exploits the ECB's rate cuts in mid-2014. With these cuts, the ECB sets a negative rate on its deposit facility. Our augmented bank balance-sheet channel applies both to high-rate environments and to low-rate environments where a rate cut by the central bank sends the policy rate to close to, or below, zero. We therefore contribute to the recent literature on the impact of, specifically, negative policy rates on banks (Heider, Saidi, and Schepens, 2019; Ampudia and Van den Heuvel, 2018; Bubeck, Maddaloni, and Peydró, 2020; Eggertsson et al., 2020; Bottero et al., 2021).[2] In particular, Ulate (2021) shares with us the comparison of a policy-rate cut away from the ZLB and one close to the ZLB. While he compares two scenarios in a macroeconomic DSGE model, we compare the effect of the same policy-rate cut empirically in two countries with different interest-rate levels using granular credit-registry data.

[2]For a survey of this literature, see Heider, Saidi, and Schepens (2021).

2 Heterogeneity in Deposit Rates across Euro-area Countries

In this section, we explain how the difference in the level of interest rates, and in particular bank deposit rates, between Portugal and Germany together with a hard ZLB on deposit rates generates variation in the pass-through of the ECB's rate cuts in mid-2014 to banks' funding costs.

While bank deposit rates typically fall quickly when the central bank cuts the policy rate (Hannan and Berger, 1991; Driscoll and Judson, 2013), this is not the case when deposit rates are already close to zero. Figure 1 shows the weighted deposit rate in Portugal and in Germany, alongside the ECB's policy rate (the Deposit Facility Rate, DFR) and a market rate for short-term bank debt (3-month Euribor).[3] The vertical line indicates the start of the two ECB rate cuts, from 0% to -0.10% on June 5, 2014, and again shortly after on September 4 from -0.10% to -0.20%. Around the mid-2014 rate cuts, there is a window of no policy-rate changes.[4] While the deposit rate in Portugal falls after the ECB's rate cuts (relative to its pre-cuts trend), the deposit rate in Germany is unaffected.

More generally, the ECB's rate cuts in mid-2014 lower bank deposit rates more in countries where the level of deposit rates prior to the rate cuts is higher. Figure 2 shows the percentage-point change in country-level weighted deposit rates between May 2014, prior to the rate cuts, and four points in time thereafter: December 2014, June 2015, December 2015, and June 2016. In Germany, the weighted deposit rate is 0.6% in May 2014, and it drops by nearly 30 basis points by December 2015 (before the ECB cuts the policy rate again). In Portugal, the weighted deposit rate is around 1.7% in May 2014, and it drops by 90 basis points by December 2015. The deposit rates in Italy and in Spain confirm the positive relationship between the level of rates and the size of the subsequent drop (we make use of this relationship in Section 4.2). France, however, is an exception because the rates on some deposit accounts are fixed by the government (Duquerroy, Matray, and Saidi, 2022).

Unlike deposit rates close to the ZLB, and like deposit rates away from the ZLB, market rates on bank debt do fall after the ECB's rate cuts in mid-2014. For example, the 3-month Euribor, a benchmark rate for short-term unsecured bank debt, closely follows the ECB's policy rate (DFR) even as the policy rate becomes negative (Figure 1).

That the distance of deposit rates to the ZLB matters for how they react to a policy-rate cut is further evidence of banks' reluctance to charge negative deposit rates (Bech and Malkhozov, 2016;

[3]We use volumes and rates on overnight deposits, deposits with agreed maturity, and deposits redeemable at notice to calculate the volume-weighted average rate. Figure A.1 in the Supplementary Appendix documents the evolution of deposit rates for a broader set of euro-area countries, which shows considerable heterogeneity.

[4]The last policy-rate change before mid-2014 is a cut by 25 basis points on July 11, 2012, and the next policy-rate change is a cut by 10 basis points on December 9, 2015.

Heider, Saidi, and Schepens, 2019; Eggertsson et al., 2020). A plausible reason for such a hard ZLB is the possibility for retail depositors to withdraw and hold cash instead, which offers a zero return, should their bank charge a negative deposit rate. For wholesale investors in bank debt, it is not feasible, or very costly, to hold large sums of cash and, hence, there is no hard ZLB on market rates of bank debt. The cost of holding large sums of cash instead of bank liabilities can also explain why some banks are able to charge negative rates on deposits held by corporations (Heider, Saidi, and Schepens, 2019; Albertazzi et al., 2020).[5]

The hard ZLB on deposit rates renders banks' deposits-to-assets ratio a measure of the pass-through of the ECB's rate cuts to banks' funding costs. The funding cost of a bank with a high deposits-to-assets ratio and that operates in a low-rate environment (e.g., Germany) does not fall much when the policy rate is cut. Such a bank cannot reduce its cost of attracting deposits, its main source of funding, because of the ZLB on deposit rates. In contrast, the funding cost of a high-deposit bank that operates in a high-rate environment (e.g., Portugal), as well as the funding cost of any low-deposit bank, does fall when the policy rate is cut. The funding cost falls either because there is no ZLB on market rates of bank debt or because the distance to the ZLB is large and there is room for deposit rates to fall.

While the pass-through of the ECB's rate cuts to bank funding costs differs between the high-rate environment in Portugal and the low-rate environment in Germany, the pass-through to rates for corporate loans is similar (Figure 3). The different pass-through to deposit rates, together with the similar pass-through to loan rates, creates a markedly different impact of the ECB's rate cuts in mid-2014 for banks' intermediation environment in Portugal and Germany (Figure 4). Prior to the rate cut, the spread between loan and deposit rates is nearly the same for German and Portuguese banks at roughly 2.5%. Moreover, fluctuation of said spread around that level is the same in Germany and Portugal. This changes after the ECB's rate cuts. The loan-deposit spread falls in Germany because loan rates come down more than do deposit rates. In contrast, the spread in Portugal increases slightly and remains high at 2.6% well into 2016.

A plausible explanation for the difference in deposit rates lies in the difference in government bond yields across euro-area countries—as the sovereign debt crisis exposed structural weaknesses in the euro area—and their positive correlation with deposit rates. The correlation between the deposit rate and the rate on five-year government bonds over the period from 2005 to 2019 in Germany,

[5]Additionally, there could be legal constraints and behavioral reasons (with zero being a focal point for banks and depositors) for why there is a ZLB on deposit rates.

France, Portugal, and Italy is, respectively, 0.95, 0.91, 0.64, and 0.69.

There are several reasons for a link between the government bond yields of a country and deposit rates of banks in the same country. First, bank liabilities, including deposits, and government bonds are substitutes (Krishnamurthy and Vissing-Jørgensen, 2015; Li, Ma, and Zhao, 2020). When bond rates increase, banks have to increase deposit rates to be able to attract and to retain deposits. Second, banks and governments form a nexus (Brunnermeier et al., 2016; Farhi and Tirole, 2018; Gennaioli, Martin, and Rossi, 2018): banks hold government bonds and governments support their banking sector, either explicitly or implicitly. The close connection between the financial health of banks and governments plausibly links bank deposit rates and the yields of government bonds.

In the case of Portugal, there is an additional, related reason for the high level of interest rates. The Troika intervention[6] during the sovereign debt crisis in 2011 had the objective, among others, to safeguard stable deposit funding for the largest Portuguese banks. This has induced Portuguese banks treated under the Troika agreement, and potentially other banks through a competition effect, to offer high deposit rates.

3 Empirical Strategy and Data

In this section, we first describe our data and variable constructions. We then present our empirical strategy for estimating the effect of the ECB's mid-2014 rate cuts on bank credit supply in Germany and Portugal.

3.1 Data Description and Summary Statistics

We collect data on bank loans to firms in Germany and Portugal, as well as data on banks' and firms' balance sheets, from 2011 to 2016. The loan data used in this paper are based on confidential credit registers available at the Deutsche Bundesbank and Banco de Portugal. This allows us to have a unique coverage of lending activities in these two economies over this time period.[7] In both cases, the data can only be explored on site and, thus, need to be analyzed separately. Though there are some differences in the data sources across the two countries, all variables are constructed in the most consistent way whenever an identical definition is not available, and we report results for Germany

[6] The Memorandum of Understanding signed by the Portuguese authorities and by the International Monetary Fund, the European Central Bank, and the European Commission (the Troika) included a long list of commitments in a three-year-long adjustment program.

[7] Note that there is no euro-area-wide credit register covering the time period before 2018.

and Portugal simultaneously. Table 1 presents summary statistics on all the variables for the two countries.

The bank-level data come from the Balance Sheet Items (BSI) statistics for Portugal and from the BISTA dataset[8] (Beier, Krüger, and Schäfer, 2017) for Germany. There are three main types of banks in Germany: savings banks, cooperative banks, and commercial (universal) banks. The savings banks in Germany (the so-called Sparkassen) are manifold, but they all are legally independent. So are the cooperative banks (the Volksbanken and Raiffeisenbanken), which outnumber the Sparkassen. Each one of these entities has multiple branches, often with a regional scope. We focus on the bank-holding-company level for each independent bank in Germany, which amounts to 1,103 banks in our data (Table 1, Panel A). This matches the level at which credit transactions are recorded in the German credit register (Schmieder, 2006).

Similarly, we focus on the bank-holding-company level also in Portugal. However, some of these banks are part of banking groups, which often are functionally but not geographically diversified. The geographic focus of these banking groups in Portugal matches the activity of German banks in our data. Therefore, when determining a Portuguese bank's exposure to the ECB's rate cuts, we use the exposure of the main entity of the banking group if the bank in question is part of such a group. Moreover, we limit our sample of banks to those with a deposits-to-assets ratio over 5%. The resulting set of 47 Portuguese banks comprises 26 stand-alone banks. Of the remaining 21 banks, 5 banks are part of banking groups with a unique lending unit each, and 16 banks belong to a total of 6 banking groups with multiple lending units each. In this manner, we yield $26 + 5 + 6 = 37$ individual banks or banking groups.

The bank-firm-level information collected for the two countries uses data available in the credit registers of the two central banks. These two datasets allow us to compute the total amount of loans each firm has from each bank, the number and duration of bank relationships, and also to identify new loans granted by any bank to each firm. In Germany, data are quarterly, and in Portugal they have a monthly frequency. Both datasets allow to link the loan data with bank balance-sheet data from BISTA and BSI, using a unique bank identifier.

We also merge the information from the credit registers with data on firms' balance sheets and profit-and-loss statements. For Portugal, data on firms are available through a joint initiative of the Banco de Portugal, Statistics Portugal, the Ministry of Finance, and the Ministry of Justice (In-

[8]Data ID: 10.12757/BBk.BISTA.99Q1-16Q4.01.01.

formação Empresarial Simplificada).[9] In Germany, we collect data on firms through Bureau van Dijk's Orbis database (see Schild, Schultz, and Wieser, 2017), and limit our sample to firms with such balance-sheet data.

In this manner, we obtain 1,529,890 observations in Portugal and 345,180 observations in Germany for the period 2013 − 2015 around the ECB's policy-rate cuts in mid-2014 (Table 1, Panel B). The larger sample for Portugal reflects not only the different reporting frequency but also the different data coverage in the two countries. For credit-registry data, the threshold is €50 in Portugal, while in Germany it is at least €1 million.[10] To adjust for the different coverage of firms, we use only Portuguese firms with at least ten employees. Moreover, the use of firm-time fixed effects in our regressions (see the next subsection) eliminates remaining differences in the distribution of firms and in the real economic landscape in Portugal and Germany.

We use two variables to measure a bank's exposure to the ECB's rate cuts: the equity-to-assets ratio and the deposits-to-assets ratio (both in 2013). Variation in the equity ratio, where equity refers to the book value, captures variation in the tightness of banks' external-financing constraint (Jayaratne and Morgan, 2000; Kishan and Opiela, 2000; Gambacorta and Shin, 2018). Variation in the deposit ratio captures variation in the strength of the policy-rate pass-through to bank funding costs (Bech and Malkhozov, 2016; Heider, Saidi, and Schepens, 2019; Eggertsson et al., 2020). At the bank level (Table 1, Panel A), the mean equity ratio is larger in Portugal (13.5% vs. 6%) while the mean deposit ratio is larger in Germany (38.1% vs. 53.9%). At the bank-firm level (Table 1, Panel B), the mean exposure of Portuguese and German banks to the ECB's rate cuts is more similar (9.7% vs. 6% for the equity ratio and 31.8% vs. 36.7% for the deposit ratio). The difference across Panel A and Panel B reflects the implicit weighting of bank characteristics by the number of firms each bank lends to, and the presence of many small banks in Germany, which tend to rely more on deposits and have less equity than larger banks.

In Panel B of Table 1, we also report the dependent variables we use in our regressions. *New relationship*$_{bft}$ is a dummy variable that is one at time t if a firm f obtains credit from a bank b from which it did not receive credit at time $t-1$. In Germany this accounts for 5.3% of the observations,

[9]Through this initiative, all firms operating in Portugal report detailed accounting and financial information on an annual basis since 2005.

[10]In January 2015 the reporting threshold was reduced from formerly €1.5 million. Note that this reporting requirement applies for all borrowers, including those with less credit exposure, as long as the total loan amount of said borrower's parent and all affiliated units is equal to or exceeds the threshold at any point in time during the reporting period. The reported amount is as of quarter end. Moreover, for Germany there is the need to match the credit-registry data with the Orbis database, but because of the credit threshold, this is unlikely to add further restrictions.

and in Portugal 1.6% of the observations are classified this way. *Any new credit*$_{bft}$ is a dummy variable that is one at time t if the loan volume has increased, irrespective of whether a firm f has credit outstanding with b at time $t-1$ or not. This accounts for approximately 22% of the observations in both countries. Finally, the average credit amount between firm f and bank b at time t in Germany is €6.3 million, but only €728,000 in Portugal, which primarily reflects the differences in the reporting threshold for the two credit registers.

3.2 Empirical Specification

Our analysis of bank credit supply is at the bank-firm-time level bft. The main focus will be on the extensive margin of credit, i.e., banks' establishment of new lending relationships with firms. For each firm f that has an outstanding loan from bank b at some point in time t, we fill up the respective bft panel with zeros in all remaining time periods (with zero credit exposure). This enables us to examine the timing of new bank-firm relationships. We can then estimate the following difference-in-differences specification:

$$\textit{New relationship}_{bft} = \beta Exposure_b \times After(06/2014)_t + \mu_b + \theta_{ft} + \varepsilon_{bft}, \tag{1}$$

where *New relationship*$_{bft}$ is a dummy variable that is one at time t if a firm f attains credit from a bank b from which it did not receive credit at time $t-1$, i.e., $Credit_{bft} - Credit_{bft-1} > 0$ and $Credit_{bft-1} = 0$. $Exposure_b$ is a time-invariant exposure variable of bank b measured in 2013 (either the equity-to-assets or the deposits-to-assets ratio), $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards, and μ_b and θ_{ft} denote bank and firm-time fixed effects, respectively. Standard errors are clustered at the bank level.

We also estimate a specification where the dependent variable is the volume impact of this increase at the extensive margin, *Credit*$_{bft}$ conditional on *New relationship*$_{bft} = 1$, or zero otherwise.

To separately estimate the intensive margin of credit, we limit the sample to observations for which *Credit*$_{bft} \neq 0$ and use as dependent variable the first difference of the natural logarithm of *Credit*$_{bft}$, so the change in the credit volume is measured within the same bank-firm relationship (while maintaining the within-bank approach needed for the identification). We then estimate the following specification:

$$\Delta \ln(Credit_{bft}) = \beta Exposure_b \times After(06/2014)_t + \mu_b + \theta_{ft} + \varepsilon_{bft}, \tag{2}$$

where $\Delta\ln(Credit_{bft})$ is the difference in the natural logarithm of credit exposure of firm f and bank b between time t and $t-1$.

Throughout, we include firm-time fixed effects θ_{ft}. This is a powerful way to control for any source of (time-varying) unobserved heterogeneity at the firm level that determines credit over time. The restriction is that a firm f drops out of the estimation of β if it receives credit from only one bank b during the entire sample period. In the Supplementary Appendix, we show that our results are robust to using alternative ways of controlling for time-varying heterogeneity at the firm level.

In regression specification (2), using θ_{ft} compares the change in existing (non-zero) credit of a firm across at least two banks (that may or may not have different exposure to the policy-rate change). In specification (1), the use of θ_{ft} compares whether a firm receives new credit from a new bank relative to a currently existing or even non-existing (but eventually existing) lending relationship with another bank, where the banks possibly have different exposures to the policy-rate change.

4 Empirical Results

4.1 Credit Supply

In the following, we estimate specifications (1), as well as some variants thereof for robustness, and (2), using two bank exposure variables, the equity-to-assets ratio and the deposits-to-assets ratio, separately for Portugal and Germany. The equity-to-assets ratio measures the tightness of the external-financing constraint. The deposits-to-assets ratio captures the policy-rate pass-through to bank funding costs, which may differ in strength for deposit-reliant as opposed to otherwise-funded banks.

In Table 2, we start by testing whether the traditional bank balance-sheet channel depends on the pass-through of monetary-policy rates to banks' funding costs. We do so by comparing the role of bank equity in Portugal and Germany, captured by $Equity\ ratio_b$, i.e., bank b's ratio of equity over total assets in 2013. In the top panel of Table 2, we estimate specification (1) and use as dependent variable $New\ relationship_{bft}$ to capture the extensive margin of credit. The table reflects the general structure for the presentation of our results throughout the paper. We always show the baseline results for the total regression sample of a given country, and then split the sample into risky and safe firms. For this purpose, we rely on the distribution of firms' five-year sales-growth volatility, calculated using annual data from 2009 to 2013, but we also present results using alternative firm-level risk measures. We label firms as risky (safe) if they rank in the top (bottom) tercile of the distribution.

In line with the traditional bank balance-sheet channel, Portuguese banks with a lower equity-to-assets ratio respond to the ECB's rate cuts by expanding their credit supply (columns 1 to 3 of Table 2). The expansion of the credit supply of Portuguese banks with a lower equity-to-assets ratio is somewhat stronger for safe, rather than risky, borrowers. In contrast, the equity-to-assets ratio does not affect banks' credit supply following the policy-rate cuts in Germany (columns 4 to 6 of Table 2). The traditional bank balance-sheet channel is muted there.

To link the muting of the traditional bank balance-sheet channel to a weak pass-through of the policy-rate cuts to bank funding costs in Germany, we use as our bank-level exposure variable *Deposit* $ratio_b$, bank *b*'s ratio of deposits over total assets in 2013, and re-run all regressions from the top panel of Table 2 for this exposure variable. The results for Germany are in columns 10 to 12 of the bottom panel of Table 2. High-deposit German banks expand their credit supply, but this expansion is concentrated on new lending relationships with risky firms (column 11). The overall effect on credit supply to all firms is statistically indistinguishable from zero (column 10).

In the remaining columns of Table 2, we test the role of banks' funding structure in the counterfactual setting in Portugal where deposit rates do fall in response to the ECB's rate cuts. In contrast to our estimates for Germany, we find no evidence of risk taking by Portuguese banks in columns 7 to 9. The funding structure of Portuguese banks does not pick up differences in the pass-through of the ECB's rate cuts to banks' funding costs because the ZLB on deposit rates does not bind in Portugal.

All of these findings continue to hold in Table 3, where we replace the dependent variable by the actual loan amount granted whenever a new lending relationship is established. In Table B.1 of the Supplementary Appendix, the effects become stronger for the combination of the extensive and the intensive margin, i.e., using as dependent variable *Any new* $credit_{bft}$, which reflects any increase in loan exposure (and not only the establishment of new relationships).

In Table 4, we estimate the intensive margin of credit, namely specification (2). We find qualitatively similar, albeit statistically insignificant, results as for the extensive margin. This suggests that other factors than financing constraints and rate pass-through may matter more once a bank has entered a lending relationship with a firm. In addition, this is consistent with the idea that bank risk taking is governed by considerations that are associated more with the establishment of new lending relationships, e.g., a lack of screening of new borrowers.

We next present several robustness checks. First, in Table 5, we re-run all specifications from Table 2, but additionally control for the lagged alternative exposure variable. That is, we include *Deposit* $ratio_{bt-1}$ in the top panel and *Equity* $ratio_{bt-1}$ in the bottom panel (the sample size drops somewhat in both countries due to the additional bank balance-sheet data requirement over time). We do so because the equity ratio captures the tightness of the financing constraint, while the deposit ratio captures the strength of the pass-through to bank funding costs. These are two different mechanisms, and should therefore show up in the data even if we hold one of them constant.

All results remain robust. In particular, the coefficient on *Equity ratio*$_b$ $\times$ *After*(06/2014)$_t$ is negative across all three subsamples in Portugal (see columns 1 to 3) but statistically significant only for safe firms, further affirming the absence of risk taking by Portuguese banks. In Germany, the difference in coefficients on *Deposit ratio*$_b$ $\times$ *After*(06/2014)$_t$ for risky versus safe borrowers (columns 11 and 12) is more emphasized than in our baseline estimation.

Next, we change how we classify borrowers as risky or safe. To this end, we use the distribution of firms' (five-year) EBITDA margin, rather than their sales-growth volatility, and again compare lending outcomes for firms in the top and bottom terciles. In this manner, we label firms as risky if they are more likely to default due to lower profitability. The results are in Table 6 and similar to those in Tables 2 and 5. As before, credit expansion by low-capital banks in Portugal is more emphasized for safe, rather than risky, firms. We also find similar results when using (i) a discrete variable for whether a given firm defaulted in the pre-period and (ii) the distribution of firms' (five-year) operating-profit growth in, respectively, Tables B.2 and B.3 of the Supplementary Appendix.

Furthermore, one may worry that our exposure variables are correlated with other bank characteristics that may affect the transmission of the policy-rate cuts to credit supply, e.g., banks' liquidity and size, as suggested by Kashyap and Stein (2000). To address this concern, besides controlling for the lagged alternative exposure variable, as in Table 5, we also include *Securities ratio*$_{bt-1}$, which is bank b's ratio of cash and securities over total assets, and the natural logarithm of bank b's assets one year prior to time t. The results are in Table 7, and the coefficients of interest remain similar to before.

Finally, by including firm-time fixed effects (as in Khwaja and Mian, 2008), we identify the treatment effect using firms with multiple bank relationships. Such sample selection potentially limits the external validity of our findings. This concern may not be as severe in our sample, though, as the median German and the median Portuguese firm maintain two, and on average 3.07 and 3.29 bank relationships, respectively. Nonetheless, we re-estimate all specifications from Table 2, dropping firm-time fixed effects and replacing them with industry-location-size-time (ILST) fixed effects (Degryse et al., 2019), which allows to identify banks' credit supply using all firms irrespective of the number of banks they borrow from. Our results are robust to this alternative way of controlling for firm-level loan demand (see Table B.4 in the Supplementary Appendix).[11]

At the time of the ECB's rate cuts in mid-2014, the high level of deposit rates in Portugal, unlike in Germany, allows for a strong pass-through of the rate cuts to deposit rates. Since then, the ECB has lowered the policy rate further, and deposit rates in Germany and Portugal have converged close to the ZLB (Figure 1). Using the last ECB rate cut (up to now) on September 18, 2019, from -0.40% (in effect since March 16, 2016) to -0.50%, we can re-examine Portuguese banks' lending behavior in a low-rate environment. Like in Germany in mid-2014, we now expect a muting of the traditional bank balance-sheet channel and risk taking by high-deposit banks in Portugal. To test this conjecture, we re-run our most refined specifications, with bank controls, from September 2018 to August 2020.[12]

In Table 8, we estimate the same specifications as in Table 5 (columns $1-3$ and $7-9$) and Table 7 (columns $4-6$ and $10-12$) on the recent sample in Portugal. In the top panel, the equity ratio of Portuguese banks (now measured in 2018) no longer has a statistically significant effect on their lending in response to the 2019 rate cut (as was the case for German banks in mid-2014). This holds for both safe and risky firms as recipients of potential loans, and irrespective of the number of time-varying bank-level controls. In the bottom panel, we find that high-deposit banks start lending more after the rate cut, which was not the case for the mid-2014 rate cuts. The effect is somewhat larger for risky firms (columns 8 and 11), especially after controlling for banks' size and their securities ratio. This is similar to the risk taking by high-deposit banks in Germany in mid-2014. Based on the estimate in column 11, moving from the bottom 5% to the top 5% of the deposit-ratio distribution among Portuguese banks (similar to the respective 2013 values in Table 1, Panel A) is associated with a $(0.79-0.09)\times 2.5 = 1.8$ percentage-point higher likelihood of establishing a new lending relationship with a risky firm.

4.2 Implications for the Euro Area

The ECB's rate cuts in mid-2014 affect Germany, an economy in the core of the euro area, and Portugal, in the periphery, differently in terms of how the rate cuts transmit to the economy via bank credit supply. In this subsection, we predict the euro-area-wide impact of the rate cuts, which take the policy rate to below zero, by combining our estimates for Portugal and Germany with bank

[11] The drop in the sample size for Portugal is primarily due to the availability of data on locations and sectors, as very few Portuguese firms have only one bank relationship.

[12] We use a two-year window around the rate cut due to data availability at the time of writing. Our results are similar when omitting the period from March to August 2020 characterized by the COVID-19 outbreak, which primarily affects firms in our sample and is, as such, appropriately captured by firm-time fixed effects.

balance-sheet information and deposit rates for a large sample of other euro-area countries.

In line with our focus on the pass-through of policy-rate changes to banks' funding costs, we calculate for each country the change in the average weighted deposit rate between May 2014 and June 2015 (column 2 of Table B.5 in the Supplementary Appendix) and scale it by the average rate change in Germany (column 3 of Table B.5 in the Supplementary Appendix). This gives us an index of impaired pass-through to funding costs, where the index value for Germany is equal to one. Note that the index itself can be greater than one when there is even less pass-through of the policy rate to deposit rates than in Germany (e.g., in Finland). We then apply this index to the coefficient in our baseline specification for Germany (Table 2, column 11) to obtain an estimate of the extent of bank risk taking in each country (column 4 of Table B.5 in the Supplementary Appendix).

In Figure 5, we illustrate the cross-country differences in how banks' funding structure leads to bank risk taking. For each country, the figure shows the impact of a ten-percentage-point increase in deposit ratios on the likelihood of observing a new lending relationship between a bank and a risky firm after June 2014. While a change in deposit ratios has virtually no impact in countries such as Portugal, Spain, and the Netherlands, it increases the likelihood of observing a new relationship by around 0.37 percentage points in countries such as France and Austria, and by more than 0.6 percentage points in Finland.

We also assess the importance of the traditional bank balance-sheet channel across the euro area. To this end, we re-scale the index for deposit-rate changes such that it is equal to one for Portugal, where the traditional bank balance-sheet channel is at play, and apply it to the coefficient in column 1 of Table 2. Figure 6 shows the impact of a ten-percentage-point increase in equity ratios on the likelihood of observing a new bank-firm relationship. The traditional bank balance-sheet channel shows up in countries such as Portugal, Spain, and the Netherlands where the pass-through of the ECB's rate cuts to bank deposit rates is strong. In contrast, it is muted in countries close to the ZLB on deposit rates, such as Germany, Austria, and Finland, or in countries where legislation limits the pass-through (the Livret A in France, see Duquerroy, Matray, and Saidi, 2022).

In Figure A.2 (A.3) of the Supplementary Appendix, we repeat the exercise with the impact of a one-standard-deviation change in deposit (equity) ratios, which takes into account the actual distribution of the deposit (equity) ratios across banks in a country. While leading to some reshuffling in the ranking of the countries, the main takeaway remains the same: a weak pass-through of the policy-rate cuts to banks' funding costs leads to risk taking and a muting of the traditional bank balance-sheet channel. We next lay out an economic mechanism to explain how this happens.

5 A Simple Model of the Augmented Bank Balance-Sheet Channel

In this section, we explain how our different empirical results map into an augmented bank balance-sheet channel. For this purpose, we introduce a simple model of a bank's lending decisions in reaction to a change in the monetary-policy rate.

5.1 Model Setup

There are three dates, $t = 0, 1, 2$. At $t = 0$, the banker decides to lend. She takes two decisions: how intensively to screen potential borrowers and how much to lend to them. The volume of lending is L, and the loan rate is R, which the banker takes as given. The banker exerts an unobservable screening effort e. More screening improves the probability $p(e)$, with $p'(e) > 0$ and $p''(e) < 0$, of the loan repayment RL at $t = 2$. With probability $1 - p(e)$, loans default and return zero. The cost of screening for the banker is non-pecuniary, and the marginal cost of screening per unit of lending is $c > 0$. The total cost of screening therefore is ceL.

The focus on the (ex-ante) screening of borrowers matches our empirical measure of changes in bank credit supply, namely a bank's establishment of new lending relationships with firms. It is furthermore motivated by the absence of significant results within existing lending relationships (see Table 4). The absence of results can be explained, for example, by the smoothing of shocks within lending relationships (e.g., Bolton et al., 2016), which can easily mask the impact of policy-rate changes on credit supply.

The banker has a fixed amount of own funds (inside equity) E and raises an amount $L - E$ from outsiders at $t = 0$. In return, she promises a repayment D at $t = 2$. The banker is protected by limited liability and, hence, outsiders receive zero when loans default at $t = 2$. As in Holmström and Tirole (1997), lending more does not affect the probability of default p or the loan return R. Default is correlated across loans, and banks are price takers.

At $t = 1$, after loans have been made, the banker decides whether to monitor or not. If she monitors, the expected return on all loans at $t = 2$ is $p(e)RL$. If she shirks on monitoring, she obtains a private benefit b per loan, but shirking reduces the probability of loan success to $\delta p(e)$, where $\delta < 1$. Whether the banker monitors or not is unobservable.

The central bank sets a policy rate r_p that transmits to the loan rate $R(r_p)$ and to the return outsiders can earn elsewhere $r_\theta(r_p)$, e.g., by holding government bonds. The return on investors' outside opportunity is indexed by θ because we distinguish between retail depositors, $\theta = r$, and wholesale investors in interbank or bond markets, $\theta = w$. What matters for using the model to interpret our empirical findings is how the strength of the policy-rate pass-through to loan rates, $R'(r_p)$, and, importantly, to banks' cost of funding, $r'_\theta(r_p)$ (for $\theta = r$ and $\theta = w$), varies as the policy rate r_p falls. A full model of rate pass-through is beyond the scope of this simple model. Instead, we take the different strengths of the pass-through as parameters and vary them in light of the empirical evidence, which we discuss in detail below.

At $t = 1$, the banker monitors her loans if the following incentive constraint holds:

$$p(e)(R(r_p)L - D) - ceL \geq \delta p(e)(R(r_p)L - D) - ceL + bL,$$

i.e., the banker's payoff from lending and monitoring must be at least as large as the lower expected payoff plus the private benefit from shirking.

Following Holmström and Tirole (1997), we denote by $\mathcal{P}(r_p, e) \equiv p(e)R(r_p) - \frac{b}{1-\delta}$ the expected pledgeable return, i.e., the amount per loan that the banker can promise to outsiders without jeopardizing the incentive to monitor loans. As usual, we assume $0 < \mathcal{P}(r_p, e) < r_\theta(r_p)$, i.e., making loans is efficient but loans are not self-financing. The incentive constraint then becomes

$$\mathcal{P}(r_p, e)L \geq p(e)D. \tag{3}$$

When the banker monitors, outsiders are willing to contribute their funds as long as they expect a larger repayment than what they could obtain by investing elsewhere:

$$p(e)D \geq r_\theta(r_p)(L - E). \tag{4}$$

At $t = 0$, the banker chooses the screening effort e and the lending volume L to maximize

$$p(e)(R(r_p)L - D) - ceL \tag{5}$$

subject to the incentive constraint (3) and the investors' participation constraint (4). The banker always wants to reduce the payment to outsiders D and, hence, the participation constraint binds. We also assume making loans is optimal at the optimal screening effort, $p(e^*)R(r_p) - r_\theta(r_p) - ce^* > 0$.

With this assumption, the incentive constraint also binds, and the optimal lending volume is given by the following external-financing constraint:

$$L^* = k(r_p, e; \theta) E. \tag{6}$$

The lending volume is given by the banker's own funds times a multiplier that describes how much outside funding the bank can raise per unit of own funds:

$$k(r_p, e; \theta) \equiv \frac{r_\theta(r_p)}{r_\theta(r_p) - \mathcal{P}(r_p, e)} > 1. \tag{7}$$

The multiplier depends on the policy rate r_p, which affects the outside rate r_θ and the expected pledgeable return $\mathcal{P}$ via the loan rate R. The multiplier also depends on the screening effort, which affects loan repayment and, hence, the expected pledgeable return. Finally, the multiplier depends on the type of outsiders θ, i.e., whether wholesale investors or retail depositors provide bank funding.

Given (6), the value of the bank becomes

$$\rho(e)\, k(r_p, e; \theta)\, E. \tag{8}$$

The objective function is the per-loan net rent $\rho \equiv \left(\frac{b}{1-\delta} - ce\right)$ times the multiplier applied to the amount of equity.

We can also write the value of the bank in (8) as Tobin's q times the amount of (inside) equity, qE. Tobin's q is defined as the franchise value of the bank divided by its net worth (e.g., Gertler and Kiyotaki, 2015). In our model, the franchise value is $\rho k E$, net worth (assets minus liabilities) is E, and the multiplier $k(r_p, e; \theta)$ gives bank leverage $\frac{L^*}{E}$. The bank's Tobin's q then is the levered per-loan net rent, $q = \rho \frac{L}{E}$. Alternatively, the value of the bank is $r_E E$ where r_E is the return on equity (ROE). The return on bank equity is the levered return on assets (ROA), $r_A \frac{L}{E}$, and the per-loan net rent is, hence, the bank's ROA, $r_A = \rho$.

The amount of bank risk taking is given by the first-order condition of bank value (8) with respect to the screening effort e:[13]

$$\rho(e^*) \frac{\frac{dk(r_p, e^*; \theta)}{de}}{k(r_p, e^*; \theta)} = c. \tag{9}$$

The marginal benefit of screening is given by the per-loan net rent times the semi-elasticity of the

[13]The second-order condition is satisfied if $p''(e^*) < -\frac{2R(r_p)}{r_\theta(r_p) - \mathcal{P}(r_p, e^*)}$.

equity multiplier with respect to the screening effort. The marginal cost is c. This semi-elasticity is positive:

$$\frac{\frac{dk(r_p,e;\theta)}{de}}{k(r_p,e;\theta)} = \frac{R(r_p)}{r_\theta(r_p) - \mathcal{P}(r_p,e)} p'(e) > 0. \tag{10}$$

When the banker screens more, outsiders are more likely to be paid, which increases the pledgeable return and makes it easier to obtain outside funding.

5.2 Discussion of the Model

We next discuss two important modeling assumptions. First, our modeling of the external-financing constraint is meant to capture the essence of the bank balance-sheet channel. We show that our constraint is identical to the typical lending constraint in the macro-finance literature. Second, an important source of variation in our empirical setting is how the policy rate affects banks' cost of funding. We model this variation in reduced form via the return $r_\theta(r_p)$ outsiders can earn when they do not invest in the bank.

5.2.1 External-financing Constraint

The importance of an external-financing constraint for banks and the role of fixed bank capital for lending as in (6) are well documented. Negative shocks to banks' balance sheets force them to lend less, with adverse consequences for the real economy (e.g., Peek and Rosengren, 1997, 2000). The variation in banks' liabilities drives variation in lending, while bank equity does not vary much over the business cycle (Gambacorta and Shin, 2018).

To compare our external-financing constraint with that in the macro-finance literature (Gertler and Kiyotaki, 2010, 2015; Gertler and Karadi, 2011; He and Krishnamurthy, 2012, 2013; Brunnermeier and Sannikov, 2014), we ignore here the ex-ante screening problem, i.e., the probability of loan repayment p is given and there is no cost of screening.

A bank with own funds E and a lending volume L has an expected value V:

$$V = (pR - r)L + rE, \tag{11}$$

where r is the market rate. On each loan the bank earns the expected net interest margin, $pR - r$, together with the market return on own funds. For instance, the banker uses her own funds for lending and borrows $L - E$ from outside investors at the market rate r, or, equivalently, she borrows

L and invests her own funds E at the market rate.

The incentive constraint in Gertler and Kiyotaki (2010), for example, is

$$V \geq \mu L, \tag{12}$$

because the banker can steal or divert a fraction μ of loans (in which case the bank defaults), and V is what she obtains when she does not divert assets.[14]

When the agency problem is severe enough, $\mu > pR - r$, the incentive constraint binds and the maximum amount of lending is given by:

$$L = \frac{r}{r - (pR - \mu)} E,$$

which is the same as in equations (6) and (7). The market rate r takes the role of the rate r_θ outside investors earn when not investing in the bank, and the fraction of loans μ the banker can steal takes the role of the rent $\frac{b}{1-\delta}$.[15]

5.2.2 Policy-rate Pass-through

Our empirical results exploit the wedge in the transmission of a lower policy rate to banks' funding costs. In the model, the bank's per-unit cost of funding is given by the binding participation constraint (4): $\frac{p(e)D}{L-E} = r_\theta(r_p)$.

The transmission to the cost of funding in wholesale debt markets ($\theta = w$) is strong, both in a high-rate and a low-rate environment (Figure 1). To have the strong pass-through in the model, we assume $r'_w(r_p) > 0$ with $r''_w(r_p) = 0$. The return wholesale investors can earn when they do not invest in the bank decreases at a constant rate when the central bank cuts the policy rate. Instead of debt issued by the bank, wholesale investors could hold government bonds (for the substitutability of government bonds and bank liabilities, see Krishnamurthy and Vissing-Jørgensen, 2015; Li, Ma, and Zhao, 2020). Government bond yields, in turn, closely reflect changes in monetary-policy rates (e.g., Gertler and Karadi, 2015; Nakamura and Steinsson, 2018).

[14] In He and Krishnamurthy (2012, 2013), L corresponds to the amount that households invest in bank equity, and V corresponds to the amount that specialists invest in bank equity. The parameter μ captures the extent of the agency problem between (inside) specialists who run banks and (outside) households who finance them.

[15] The constraint on lending (6), or (12), is a market constraint. It originates from an information problem between bank insiders who control bank assets and outsiders who provide the financing. Lending could also be constrained because of capital regulation (Van den Heuvel, 2002; Bolton and Freixas, 2006), e.g., $\frac{E}{L} \geq \kappa$, where κ is the regulatory minimum capital ratio. Unlike the equity multiplier in (6), κ does not, however, depend on monetary policy.

In contrast, the transmission of the policy rate to retail deposit rates ($\theta = r$) weakens when rates are low. In countries where deposit rates are lower, the ECB's mid-2014 policy-rate cuts transmit less to lower deposit rates (Figure 2). The transmission to deposit rates weakens because they do not become negative, unlike rates on bonds.[16]

To capture the weaker pass-through to deposit rates as the policy rate falls, we assume $r_r'(r_p) \geq 0$, with $r_r''(r_p) > 0$ when $r_p < \bar{r}_p$ and $r_r''(r_p) = 0$ when $r_p \geq \bar{r}_p$. The return retail depositors can earn when they do not invest in the bank decreases at a constant rate when the policy rate is high, and at a decreasing rate when the policy rate is low.

An explanation for the hard ZLB on retail deposit rates, but not on banks' wholesale debt, is the ability of depositors to store their money not only using government bonds but also using cash, which offers a zero nominal net return. When the return on government bonds is high, retail depositors' best outside opportunity is to hold government bonds. When the policy rate falls and transmits to a lower return on government bonds, cash becomes a more attractive outside opportunity for depositors. When the yield of government bonds is negative, cash dominates. The return depositors can earn when not investing in the bank is therefore bounded from below by one, $r_r(r_p) \geq 1$, and the pass-through $r_r'(r_p)$ weakens as the policy rate falls (with eventually no pass-through, $r_r'(r_p) = 0$, being possible).

For wholesale investors, who invest much larger amounts per investor than retail depositors, it is too expensive, or simply infeasible, to hold physical cash. Such transaction costs can explain why deposit rates for non-financial corporations do become negative (Heider, Saidi, and Schepens, 2019, 2021; Albertazzi et al., 2020; Altavilla et al., 2021). Much like wholesale investors, corporations need to store large amounts, which is difficult with physical cash.

In addition to the transmission of the policy rate r_p to banks' funding costs, we allow for transmission to loan rates, $R(r_p)$, in line with ample empirical evidence (e.g., Berger and Udell, 1992; Mojon, 2000; Gambacorta, Illes, and Lombardi, 2014; Altavilla, Canova, and Ciccarelli, 2020). The pass-through is positive, $R'(r_p) > 0$, and constant, $R''(r_p) = 0$. Loan rates are sufficiently high, so that the pass-through does not weaken when the policy rate breaks through the ZLB (see Figure 3).

In the model, the bank is a price taker and, hence, the pass-through to loan rates does not come from changes in the lending volume. Market power reinforces the pass-through because the loan rate falls when banks lend more (e.g., Gerali et al., 2010). The pass-through of the policy rate to loan rates

[16] According to the Financial Times ("In charts: bonds with negative yields around the world," 27 September 2021), more than one-fifth, or USD 15 trillion, of all bonds are trading at negative yields, i.e., they offer a gross return of less than one. Of those bonds, 85% are government or government-related bonds.

(independent of the lending volume) can come from lower rates on corporate bonds (as in Bolton and Freixas, 2006) or from a lower cost of holding cash (as in Rocheteau, Wright, and Zhang, 2018).

5.3 Monetary Policy and Bank Credit Supply

The effect of the monetary-policy rate on bank credit supply is given by the following derivative of the optimal amount of lending in (6):

$$\frac{dL^*}{dr_p} = \underbrace{\frac{\partial k(r_p, e^*;\theta)}{\partial r_p}}_{\text{Direct effect}} E + \underbrace{\overbrace{\frac{dk(r_p, e^*;\theta)}{de}}^{>0} \frac{de^*}{dr_p}}_{\text{Effect via screening}} E. \tag{13}$$

The impact of a policy-rate change on lending depends on two effects: a direct effect of the policy rate on the multiplier, holding constant the screening effort, $\frac{\partial k(r_p,e^*;\theta)}{\partial r_p}$, and an indirect effect via the screening effort. When a lower policy rate reduces the screening effort, $\frac{de^*}{dr_p} > 0$, we say there is risk taking.

A lower policy rate r_p does not automatically lead to more bank credit supply. Consider first the direct effect $\frac{\partial k(r_p,e^*;\theta)}{\partial r_p}$. A lower policy rate reduces the return $r_\theta(r_p)$ outsiders can earn when not investing in the bank. This reduces the bank's cost of funding and increases the multiplier k. A lower policy rate, however, also reduces the loan rate $R(r_p)$ and, thus, the pledgeable return, which decreases the multiplier. Second, there is the indirect effect via screening. Risk taking, $\frac{de^*}{dr_p} > 0$, has an adverse effect on the sensitivity of credit supply to the policy rate because when the bank screens less, it becomes more difficult to raise external financing.

The following result states the conditions under which the multiplier decreases in the policy rate and there is no risk taking:[17]

Result 1 *A lower monetary-policy rate increases the equity multiplier,* $\frac{\partial k(r_p,e^*;\theta)}{\partial r_p} < 0$, *if and only if* $\frac{p(e^*)R'(r_p)}{p(e^*)R(r_p)-\frac{b}{1-\delta}} < \frac{r'_\theta(r_p)}{r_\theta(r_p)}$. *A lower monetary-policy rate induces the banker to screen more,* $\frac{de^*}{dr_p} < 0$ *(no risk taking), if and only if* $\frac{R'(r_p)}{R(r_p)} < \frac{r'_\theta(r_p)}{r_\theta(r_p)+\frac{b}{1-\delta}}$.

The pass-through of the policy rate to the bank's cost of funding (via the rate investors can earn elsewhere), $r'_\theta(r_p)$, relative to the pass-through to loan rates, $R'(r_p)$, plays an important role. When the pass-through to the cost of funding is strong, a lower policy rate increases the multiplier and does

[17] We provide the proofs for all results in the Appendix.

not lead to risk taking. When the pass-through to the cost of funding weakens, as it does for deposit rates at the ZLB, then a lower policy rate could lead to a lower multiplier and risk taking.[18]

5.4 Economic Mechanism of the Empirical Tests

To assess the impact of a lower policy rate on bank lending empirically, we require variation in terms of banks' exposure to monetary policy. The credit supply of less exposed banks serves as the counterfactual for the credit supply of more exposed banks. The empirical literature on the bank balance-sheet channel (Jayaratne and Morgan, 2000; Kishan and Opiela, 2000; Gambacorta and Shin, 2018) uses variation in banks' equity-to-assets ratio as a proxy for the tightness of the external-financing constraint. A bank with a tighter financing constraint can adjust its credit supply less, and is therefore less exposed to changes in the policy rate.

To obtain variation in the equity-to-assets ratio $\frac{E}{L^*} = \frac{1}{k(r_p,e;\theta)}$ in the model, we use variation in the parameter b, i.e., the private benefit of shirking. A bank with a larger private benefit has a tighter financing constraint because its pledgeable return $\mathcal{P}(r_p, e)$ is smaller. Note that a bank with a tighter constraint (higher private benefit b) has a higher equity-to-assets ratio because it is unable to attract a lot of outside funding and, hence, lends little per unit of equity.

The equivalent in the model of the empirical test of the bank balance-sheet channel is a positive cross-partial derivative of the sensitivity of the credit supply to the policy rate with respect to the private benefit b:

$$\frac{d^2L^*}{dr_p db} = \underbrace{\frac{d}{db}\left(\frac{\partial k(r_p, e^*;\theta)}{\partial r_p}\right)}_{\text{Direct effect}} + \underbrace{\overbrace{\frac{d}{db}\left(\frac{dk(r_p, e^*;\theta)}{de}\right)}^{<0 \ \text{(Result 3)}} \frac{de^*}{dr_p}}_{\text{Indirect effect via screening}}$$

$$+ \underbrace{\frac{d}{db}\left(\frac{de^*}{dr_p}\right)\overbrace{\frac{dk(r_p, e^*;\theta)}{de}}^{>0}}_{\text{Interaction}}. \tag{14}$$

When this cross-partial derivative is positive, $\frac{d^2L^*}{dr_p db} > 0$, then the credit supply of more constrained

[18]The condition for risk taking in Result 1 is in terms of semi-elasticities. As an example, suppose the pass-through to loan rates is constant, $R(r_p) = a + br_p$, while the pass-through to the rate investors can obtain elsewhere weakens according to $r_\theta(r_p) = \exp(Cr_p) - \frac{b}{1-\delta}$. Then $\frac{pR'(r_p)}{pR(r_p)} = \frac{b}{a+br_p}$ and $\frac{r'_\theta(r_p)}{r_\theta(r_p)+\frac{b}{1-\delta}} = C$. Hence, as the policy rate r_p becomes low enough, there will be risk taking, $\frac{de^*}{dr_p} > 0$.

banks changes less when the policy rate changes.

As an intermediate step, consider the cross-partial derivative without the indirect effect or the interaction term via the screening effort, $\frac{de^*}{dr_p} = 0$:

Result 2 *Suppose the policy rate does not affect the screening effort, $\frac{de^*}{dr_p} = 0$. The cross-partial derivative of the sensitivity of the credit supply to the policy rate with respect to the private benefit b is positive, $\frac{d^2 L^*}{dr_p db} = \frac{d}{db}\left(\frac{\partial k(r_p,e^*;\theta)}{\partial r_p}\right) > 0$, if and only if $\frac{p(e^*)R'(r_p)}{p(e^*)R(r_p)-\frac{b}{1-\delta}} < \frac{1}{2}\left(1 + \frac{r_\theta(r_p)}{\mathcal{P}(r_p,e^*)}\right)\frac{r'_\theta(r_p)}{r_\theta(r_p)}$.*

The condition in Result 2 holds when the direct effect of the policy rate on bank credit supply is negative (Result 1). This confirms the rationale of the empirical test of the traditional bank balance-sheet channel when there is no risk taking, $\frac{de^*}{dr_p} = 0$, and the pass-through of the policy rate to banks' funding costs $r'_\theta(r_p)$ is strong.

With $\frac{de^*}{dr_p} \neq 0$, there are two additional considerations. First, there is the indirect effect via the screening effort. In particular, how does the tightness of the external-financing constraint, i.e., changes in b, affect the sensitivity of the multiplier to the screening effort, $\frac{d}{db}\left(\frac{dk(r_p,e^*;\theta)}{de}\right)$? And second, there is the interaction term, i.e., how does the private benefit b affect the sensitivity of the screening effort to the policy rate, $\frac{d}{db}\left(\frac{de^*}{dr_p}\right)$?

The answer to the first question is straightforward:

Result 3 *The sensitivity of the multiplier $k(r_p, e^*;\theta)$ with respect to the screening effort e decreases in the private benefit b, $\frac{d}{db}\left(\frac{dk(r_p,e^*;\theta)}{de}\right) < 0$.*

The marginal benefit of screening borrowers is smaller when it is more difficult to finance the loans. If there is risk taking, $\frac{de^*}{dr_p} > 0$, then this effect works against a positive cross-partial $\frac{d^2 L^*}{dr_p db}$.

The answer to the second question is theoretically ambiguous, and we therefore rely on the empirical results to inform this issue. There are two countervailing effects in the model. First, a higher private benefit b decreases the marginal benefit of screening via a lower semi-elasticity $\frac{dk(r_p,e^*;\theta)}{de}/k(r_p,e^*;\theta)$ (in line with Result 3). Second, a higher b increases the marginal benefit of screening via a higher net rent ρ. The sensitivity of the optimal screening effort to the policy rate $\frac{de^*}{dr_p}$, in turn, depends on how the marginal benefit changes when the policy rate and the optimal screening effort change. Therefore, it is not possible to sign $\frac{d}{db}\left(\frac{de^*}{dr_p}\right)$ unambiguously (see the Appendix for more details).

Before we explain how we sign $\frac{d}{db}\left(\frac{de^*}{dr_p}\right)$ empirically, recall that we measure bank risk taking by estimating our credit regressions separately on the subsamples of ex-ante safe and risky firms. When banks with greater exposure to the policy-rate cuts expand their credit supply more in the group of risky firms, then there is risk taking.

We implement our empirical test of bank risk taking with the deposits-to-assets ratio of German banks. According to the model, risk taking occurs if and only if the pass-through of the policy rate to bank funding costs is weak (Result 1). We cannot compare the same bank with a strong and a weak pass-through at the same time. Instead, we compare banks with different strengths of the pass-through of the policy rate to funding costs. German banks with a higher deposits-to-assets ratio have a weaker pass-through because of the ZLB on retail deposit rates, i.e., $r_r'(r_p) < r_w'(r_p)$ in Germany. These banks extend more credit in the group of risky firms but not in the group of safe firms (column 11 vs. 12 in Tables 2, 3, 5, 6, and 7) and, thus, engage in risk taking.

Comparing banks with different deposits-to-assets ratios in Portugal is a useful placebo test. In Portugal, the ZLB on retail deposit rates does not bind and the pass-through to bank funding costs for high-deposit banks remains strong, i.e., $r_r'(r_p) \approx r_w'(r_p)$. This is as if we did not vary $r_\theta'(r_p)$ for an individual bank and we should not see more credit by high-deposit banks to risky firms. If we do, however, observe more credit by high-deposit banks to risky firms, then the deposits-to-assets ratio picks up something else relevant for bank risk taking (e.g., according to Result 1, a higher private benefit b). The comparison of columns 8 and 9 in Tables 2, 3, 5, 6, and 7 shows that this is not the case. In contrast, when we consider the rate cut in 2019 when Portuguese deposit rates are constrained by the ZLB, we do find risk taking by high-deposit banks (bottom panel of Table 8), just as we do in Germany in mid-2014.

In Portugal, the test of the bank balance-sheet channel works as in the existing literature. Banks with a higher equity-to-assets ratio, i.e., those with a tighter external-financing constraint, extend their credit supply less when the policy rate falls, $\frac{d^2L^*}{dr_p db} > 0$ (cf. column 1 in all relevant tables). According to our model (equation (14)), three forces play a role: besides the interaction term, that would be the direct effect via the multiplier, which is positive when the pass-through to bank funding costs is strong, and the indirect effect via the screening effort, which is negative when there is risk taking, $\frac{de^*}{dr_p} > 0$. Risk taking requires, however, a weak pass-through to bank funding costs (Result 1), which is not the case in Portugal.

The empirical results for the bank balance-sheet channel in Portugal would be at odds with the model if $\frac{d}{db}\left(\frac{de^*}{dr_p}\right) < 0$, i.e., if banks with a laxer financing constraint (lower b) are more likely to reduce their screening effort in response to a lower policy rate (higher $\frac{de^*}{dr_p}$). The strong pass-through to bank funding costs indicates a positive sum of the direct and the indirect effect in equation (14).

Whether $\frac{d^2 L^*}{dr_p db}$ is positive therefore depends on the interaction term, i.e., the sign of $\frac{d}{db}\left(\frac{de^*}{dr_p}\right)$. The comparison of columns 2 and 3 in Tables 2, 3, 5, 6, and 7 indicates the opposite, $\frac{d}{db}\left(\frac{de^*}{dr_p}\right) > 0$. In Portugal, banks with a lower equity-to-assets ratio, i.e., less constrained banks, expand their credit supply somewhat more in the group of safe firms than in the group of risky firms.

Our model can explain why the credit supply of banks with a tighter financing constraint reacts less to changes in the policy rate. In Portugal, the pass-through of the policy-rate cuts to lower bank funding costs is strong because deposit rates are far from the ZLB. With a strong pass-through, the direct effect via the multiplier is positive, which in turn is consistent with more credit supply. Moreover, with a strong pass-through there is no countervailing indirect effect via screening. Finally, the interaction term in (14) is also positive: more constrained banks engage more in risk taking.

In Germany, our model of an augmented bank balance-sheet channel can explain why the estimates in column 4 of Tables 2, 3, 5, 6, and 7 are insignificant. At first glance, it would seem as if the (traditional) bank balance-sheet channel was not at play close to the ZLB. Our model indicates, however, that such a conclusion is premature. The pass-through of the policy-rate cuts to bank funding costs in Germany is weak because deposit rates are close to the ZLB. A weak pass-through leads to risk taking and, hence, to a countervailing, negative indirect effect in equation (14).

Our model of an augmented bank balance-sheet channel would be at odds with the empirical results in Germany if the direct effect, the indirect effect, and the interaction term were all positive. With a weak pass-through to bank funding costs this is unlikely. Even if the direct effect is positive, which itself is less likely with a weak pass-through, the indirect effect is still negative when there is risk taking, which is the case in Germany. Moreover, the comparison of columns 5 and 6 in Tables 2, 3, 5, 6, and 7 reveals no significant difference in the expansion of credit by banks with a higher equity-to-assets ratio across risky and safe firms. This evidence indicates a small, possibly zero, interaction term in (14). Note that we also find this to be true in Portugal in 2019 when the pass-through of the last ECB rate cut to Portuguese deposit rates is also impaired (top panel of Table 8).

In summary, our simple model of an augmented bank balance-sheet channel explains the economic mechanism of the empirical results. The pass-through of monetary-policy rates to banks' cost of funding affects the multiplier, i.e., the extent to which banks can lever up, and banks' incentive to screen borrowers. When the pass-through is strong, there is no risk taking and less constrained banks expand their credit supply more. When the pass-through is weak, there is risk taking and variation in the external-financing constraint no longer matters for credit supply.

6 Real Effects

In this section, we estimate the impact of the credit-supply shock induced by the ECB's rate cuts in mid-2014 on firms in Portugal and Germany. Typically, an analysis of such an impact follows a shift-share approach (see, e.g., Greenstone, Max, and Nguyen, 2020) where a change in firm-level outcomes, e.g., investment, is linked to the characteristics of banks from which firms borrow before the credit-supply shock. The approach therefore assumes the change in credit occurs within existing lending relationships (the intensive margin).

In contrast, our results on how the ECB's rate cuts affect the supply of bank credit focus on the extensive margin, i.e., the formation of new lending relationships, also because the results for the intensive margin are statistically insignificant (Table 4). To properly account for the impact of a credit-supply shock along the extensive margin, we examine changes in a firm's outcome as a function of the characteristics of those banks that enter a new lending relationship with the firm after the policy-rate cuts.

We use six years of annual (firm balance-sheet) data, and collapse information from the pre-period ($2011-2013$) and the post-period ($2014-2016$) to a single observation for each firm f. For each firm, we then determine whether it receives credit from a new bank relationship by defining $\textit{New relationship}_f$ as an indicator variable for whether anytime from 2014 to 2016, firm f increases its loan exposure to any given bank from which it had zero credit outstanding as of the last period before the mid-2014 rate cuts. Conditional on $\textit{New relationship}_f = 1$, we then test whether new relationships with banks lead to different firm-level investment or employment as a function of those banks' exposure to the policy-rate cuts, which we measure as before with the banks' equity or deposit ratios.

In Panel C of Table 1, we present summary statistics for the firm-level analysis. Each observation shows the change from the pre-period ($2011-2013$) to the post-period ($2014-2016$). In line with the summary statistics at the bank-firm-time level (in Panel B), Portuguese firms are less likely to establish new lending relationships than German firms. Portuguese firms are also somewhat less likely to receive new credit than German firms when there is an existing lending relationship. Conditional on new lending relationships being established, firms' exposure to banks' equity ratios and deposit ratios—captured by $\textit{Equity exposure}_f$ and $\textit{Deposit exposure}_f$, respectively—is, however, quite similar in Portugal and Germany.

To test for the real effects of changes in bank credit supply induced by the ECB's rate cuts, we estimate the following regression specification:

$$y_f = \beta New\ relationship_f + \gamma New\ relationship_f \times Exposure_f + \delta New\ credit_f + \theta_{j(f)} + \varepsilon_f, \qquad (15)$$

where y_f is the first difference in the natural logarithm of firm f's tangible fixed assets or number of employees in year t, winsorized at the 1st and 99th percentiles, and $Exposure_f$ (now at the firm level f) is either the average $Equity\ ratio_b$ or $Deposit\ ratio_b$ (measured in 2013) of all banks with which firm f establishes a new lending relationship in the post-period from 2014 to 2016, weighted by the increase in credit exposure (measured as the maximum exposure in $2014 - 2016$) to each bank b. Standard errors are clustered at the firm level.

To control for the confounding effect of additional credit within an existing lending relationship (the intensive margin) on investment and employment, we include $New\ credit_f$, which is an indicator variable for whether anytime from 2014 to 2016, firm f increases its loan exposure to a bank from which it has non-zero credit outstanding as of the last period before the mid-2014 rate cuts.

Finally, $\theta_{j(f)}$ denotes a set of fixed effects based on firm f's characteristics j, which include industry, location, and/or decile in the firm-size distribution. As the level of observation in specification (15) is the result of a first difference within firms, $\theta_{j(f)}$ captures time-varying unobserved heterogeneity at the respective levels (as would industry-time, location-time, and size-time fixed effects without first-differencing).

The results from estimating specification (15) for firm-level investment and employment (Tables 9 and 10) indicate that receiving new credit at the extensive margin after the policy-rate cuts leads to positive real outcomes. In Portugal (columns 1 to 6), firms with new bank relationships increase investment and employment by more than firms that receive more credit only within existing bank relationships. Moreover, most of the interactions of $New\ relationship_f$ with the new lenders' equity and deposit ratios are not statistically significant, which is in line with the absence of risk taking by Portuguese banks. Given that riskier firms are more likely to be credit constrained (Stiglitz and Weiss, 1981; Hennessy and Whited, 2007),[19] the positive point estimates for the interaction term $New\ relationship_f \times Equity\ exposure_f$ are, if anything, consistent with low-capital banks expanding their lending somewhat more to safe firms in Portugal (cf. column 2 vs. 3 in Tables 2 to 7).

In Germany, the interaction of $New\ relationship_f$ with the new lenders' deposit ratio (but not the equity ratio) is positive and statistically significant. This implies that the investment and employment

[19] See Neuhann and Saidi (2018) and Belo, Lin, and Yang (2019) for recent empirical evidence.

effects from new relationships are significantly stronger for firms obtaining credit from high-deposit banks (columns 10 to 12 of Tables 9 and 10). Using the estimate in column 10, a one-standard-deviation increase in *Deposit exposure*$_f$ (see Panel C of Table 1) translates into $0.2 \times 0.121 = 2.42\%$ more investment and $0.2 \times 0.085 = 1.70\%$ more employment for German firms in the post-period from $2014 - 2016$ compared to the pre-period from $2011 - 2013$.

Our results are robust when controlling for time-varying unobserved heterogeneity at the industry, location, and firm-size decile level with fixed effects. They also hold up to more granular combinations of these fixed effects, e.g., at the industry-location and industry-size levels. In columns 3, 6, 9, and 12, we include industry-location-size fixed effects (in the spirit of our alternative demand controls in Table B.4 of the Supplementary Appendix), which in the case of Germany leads to a decline in statistical power due to a high number of singletons being dropped.

The positive and large coefficient on *New relationship*$_f$ $\times$ *Deposit exposure*$_f$ in Germany is consistent with the argument that the policy-induced risk taking by high-deposit banks at the ZLB overcomes the financial constraints of risky but productive firms, which then invest more and employ more workers. This is because, first, riskier firms are more likely to be credit constrained, and yet they have a higher marginal revenue product of capital (Lenzu and Manaresi, 2018). Second, as we have shown in Section 4.1, high-deposit banks extend new credit more to risky firms after the mid-2014 policy-rate cuts.

7 Conclusion

Our augmented bank balance-sheet channel links several related, yet so far unconnected mechanisms of how a change in monetary-policy rates leads to changes in bank credit. We combine the notions of interest-rate pass-through (bank lending channel), costly external financing (bank balance-sheet channel), and banks deciding not only on the volume but also on the quality of credit (bank risk-taking channel). From the combination of these channels emanates a framework applicable to both high-rate and low-rate environments where the ZLB on retail deposit rates weakens the pass-through of changes in the monetary-policy rate to bank funding costs.

We see at least two further avenues for future research. First, our simple model is designed to offer a coherent mechanism underlying the different empirical results. The model creates the pass-through of monetary policy to bank funding costs via the return outside investors can earn when they do not invest in banks, e.g., by holding government bonds. This transmission via government bonds on the liability side of banks' balance sheets complements the role of government bonds on the asset side. The model also features an interplay of bank risk taking with the ability of banks to lever up. Future research could embed these two new elements in general-equilibrium models of a macroeconomy with financial frictions and heterogeneous banks.

A second avenue for further research is how to address the heterogeneous transmission of monetary policy in a currency union such as the euro area (Santis and Surico, 2013; Grandi, 2019). Our analysis exploits differences in the level of interest rates within a currency union. These differences occur in the aftermath of the sovereign debt crisis in the euro area. This raises important issues for the conduct of fiscal policy in a currency union (Nakamura and Steinsson, 2014; Farhi and Werning, 2016; Corbi, Papaioannou, and Surico, 2018; Jiang et al., 2021). In particular, when uncoordinated fiscal policy is one of the causes for the uneven transmission of monetary policy, then under what conditions can it also rectify the uneven impact of monetary policy? Answering this question will potentially help to improve the coordination of these two policies.

References

Adrian, Tobias and Hyun Song Shin. 2010. "Financial Intermediaries and Monetary Economics." Federal Reserve Bank of New York Staff Reports No. 398.

Albertazzi, Ugo, Desislava Andreeva, Marco Belloni, Alberto Grassi, Christian Gross, Jonas Mosthaf, and Tamarah Shakir. 2020. "Prospects for Euro Area Bank Lending Margins in an Extended Low-for-Longer Interest Rate Environment." ECB Financial Stability Review (Special Feature), November.

Altavilla, Carlo, Lorenzo Burlon, Mariassunta Giannetti, and Sarah Holton. 2021. "Is There a Zero Lower Bound? The Effects of Negative Policy Rates on Banks and Firms." *Journal of Financial Economics* .

Altavilla, Carlo, Fabio Canova, and Matteo Ciccarelli. 2020. "Mending the Broken Link: Heterogenous Bank Lending Rates and Monetary Policy Pass-through." *Journal of Monetary Economics* 110:81–98.

Ampudia, Miguel and Skander J. Van den Heuvel. 2018. "Monetary Policy and Bank Equity Values in a Time of Low Interest Rates." ECB Working Paper No. 2199.

Bech, Morten L. and Aytek Malkhozov. 2016. "How Have Central Banks Implemented Negative Policy Rates?" BIS Quarterly Review No. 1.

Beier, Rafael, Miriam Krüger, and Mirko Schäfer. 2017. "Monthly Balance Sheet Statistics 01/1999–12/2016 – Data Report 2017-02 (Metadata Version 1)." Deutsche Bundesbank Research Data and Service Centre.

Belo, Frederico, Xiaoji Lin, and Fan Yang. 2019. "External Equity Financing Shocks, Financial Flows, and Asset Prices." *Review of Financial Studies* 32 (9):3500–3543.

Berger, Allen N. and Gregory F. Udell. 1992. "Some Evidence on the Empirical Significance of Credit Rationing." *Journal of Political Economy* 100 (5):1047–1077.

Bernanke, Ben S. and Alan S. Blinder. 1988. "Money, Credit and Aggregate Demand." *American Economic Review* 82:901–921.

Bernanke, Ben S. and Mark Gertler. 1995. "Inside the Black Box: The Credit Channel of Monetary Policy Transmission." *Journal of Economic Perspectives* 9 (4):27–48.

Bianchi, Javier and Saki Bigio. 2021. "Banks, Liquidity Management, and Monetary Policy." *Econometrica* .

Bolton, Patrick and Xavier Freixas. 2006. "Corporate Finance and the Monetary Transmission Mechanism." *Review of Financial Studies* 19 (3):829–870.

Bolton, Patrick, Xavier Freixas, Leonardo Gambacorta, and Paolo E. Mistrulli. 2016. "Relationship and Transaction Lending in a Crisis." *Review of Financial Studies* 29 (10):2643–2676.

Bonfim, Diana and Carla Soares. 2018. "The Risk-Taking Channel of Monetary Policy: Exploring All Avenues." *Journal of Money, Credit and Banking* 50 (7):1507–1541.

Borio, Claudio and Haibin Zhu. 2012. "Capital Regulation, Risk-Taking and Monetary Policy: A Missing Link in the Transmission Mechanism?" *Journal of Financial Stability* 8 (4):236–251.

Bottero, Margherita, Camelia Minoiu, José-Luis Peydró, Andrea Polo, Andrea F. Presbitero, and Enrico Sette. 2021. "Expansionary Yet Different: Credit Supply and Real Effects of Negative Interest Rate Policy." *Journal of Financial Economics* .

Brunnermeier, Markus K., Luis Garicano, Philip R. Lane, Marco Pagano, Ricardo Reis, Tano Santos, David Thesmar, Stijn Van Nieuwerburgh, and Dimitri Vayanos. 2016. "The Sovereign-Bank Diabolic Loop and ESBies." *American Economic Review* 106 (5):508–512.

Brunnermeier, Markus K. and Yann Koby. 2019. "The Reversal Interest Rate." NBER Working Paper No. 25406.

Brunnermeier, Markus K. and Yuliy Sannikov. 2014. "A Macroeconomic Model with a Financial Sector." *American Economic Review* 104 (2):379–421.

Bubeck, Johannes, Angela Maddaloni, and José-Luis Peydró. 2020. "Negative Monetary Policy Rates and Systemic Banks' Risk-Taking: Evidence from the Euro Area Securities Register." *Journal of Money, Credit and Banking* 52 (S1):197–231.

Corbi, Raphael, Elias Papaioannou, and Paolo Surico. 2018. "Regional Transfer Multipliers." *Review of Economic Studies* 86 (5):1901–1934.

De Fiore, Fiorella, Marie Hoerova, and Harald Uhlig. 2019. "Money Markets, Collateral, and Monetary Policy." ECB Working Paper No. 2239.

Degryse, Hans, Olivier De Jonghe, Sanja Jakovljević, Klaas Mulier, and Glenn Schepens. 2019. "Identifying Credit Supply Shocks with Bank-Firm Data: Methods and Applications." *Journal of Financial Intermediation* 40:100813.

Dell'Ariccia, Giovanni, Luc Laeven, and Gustavo A. Suarez. 2017. "Bank Leverage and Monetary Policy's Risk-Taking Channel: Evidence from the United States." *Journal of Finance* 72 (2):613–654.

Drechsler, Itamar, Alexi Savov, and Philipp Schnabl. 2017. "The Deposits Channel of Monetary Policy." *Quarterly Journal of Economics* 132 (4):1819–1876.

———. 2021. "Banking on Deposits: Maturity Transformation without Interest Rate Risk." *Journal of Finance* 76 (3):1091–1143.

Driscoll, John C. and Ruth Judson. 2013. "Sticky Deposit Rates." FEDS Working Paper No. 2013-80.

Duquerroy, Anne, Adrien Matray, and Farzad Saidi. 2022. "Tracing Banks' Credit Allocation to their Funding Costs." Unpublished working paper.

Eggertsson, Gauti B., Ragnar E. Juelsrud, Lawrence H. Summers, and Ella G. Wold. 2020. "Negative Nominal Interest Rates and the Bank Lending Channel." NBER Working Paper No. 25416.

Farhi, Emmanuel and Jean Tirole. 2018. "Deadly Embrace: Sovereign and Financial Balance Sheets Doom Loops." *Review of Economic Studies* 85 (3):1781–1823.

Farhi, Emmanuel and Ivan Werning. 2016. "Fiscal Multipliers: Liquidity Traps and Currency Unions." In *Handbook of Macroeconomics*, *Handbook of Macroeconomics*, vol. 2, edited by John B. Taylor and Harald Uhlig. Elsevier, 2417–2492.

Gambacorta, Leonardo, Anamaria Illes, and Marco J. Lombardi. 2014. "Has the Transmission of Policy Rates to Lending Rates Been Impaired by the Global Financial Crisis." BIS Working Paper No. 477.

Gambacorta, Leonardo and Hyun Song Shin. 2018. "Why Bank Capital Matters for Monetary Policy." *Journal of Financial Intermediation* 35:17–29.

Gennaioli, Nicola, Alberto Martin, and Stefano Rossi. 2018. "Banks, Government Bonds, and Default: What Do the Data Say?" *Journal of Monetary Economics* 98:98–113.

Gerali, Andrea, Stefano Neri, Luca Sessa, and Federico M. Signoretti. 2010. “Credit and Banking in a DSGE Model of the Euro Area.” *Journal of Money, Credit and Banking* 42 (s1):107–141.

Gertler, Mark and Peter Karadi. 2011. “A Model of Unconventional Monetary Policy.” *Journal of Monetary Economics* 58 (1):17–34.

———. 2015. “Monetary Policy Surprises, Credit Costs, and Economic Activity.” *American Economic Journal: Macroeconomics* 7 (1):44–76.

Gertler, Mark and Nobuhiro Kiyotaki. 2010. “Financial Intermediation and Credit Policy in Business Cycle Analysis.” In *Handbook of Monetary Economics*, vol. 3, edited by Benjamin M. Friedman and Michael Woodford, chap. 11. Elsevier, 547–599.

———. 2015. “Banking, Liquidity, and Bank Runs in an Infinite Horizon Economy.” *American Economic Review* 105 (7):2011–2043.

Gomez, Matthieu, Augustin Landier, David Sraer, and David Thesmar. 2021. “Banks’ Exposure to Interest Rate Risk and the Transmission of Monetary Policy.” *Journal of Monetary Economics* 117:543–570.

Grandi, Pietro. 2019. “Sovereign Stress and Heterogeneous Monetary Transmission to Bank Lending in the Euro Area.” *European Economic Review* 119 (C):251–273.

Greenstone, Michael, Alex Max, and Hoai-Luu Nguyen. 2020. “Do Credit Market Shocks affect the Real Economy? Quasi-experimental Evidence from the Great Recession and “Normal” Economic Times.” *American Economic Journal: Economic Policy* 12 (1):200–225.

Hannan, Timothy and Allen N. Berger. 1991. “The Rigidity of Prices: Evidence from the Banking Industry.” *American Economic Review* 81 (4):938–945.

He, Zhiguo and Arvind Krishnamurthy. 2012. “A Model of Capital and Crises.” *Review of Economic Studies* 79:735–777.

———. 2013. “Intermediary Asset Pricing.” *American Economic Review* 103 (2):732–770.

Heider, Florian, Farzad Saidi, and Glenn Schepens. 2019. “Life below Zero: Bank Lending under Negative Policy Rates.” *Review of Financial Studies* 32 (10):3728–3761.

———. 2021. “Banks and Negative Interest Rates.” *Annual Review of Financial Economics* 13 (1):201–218.

Hennessy, Christopher A. and Toni M. Whited. 2007. “How Costly Is External Financing? Evidence from a Structural Estimation.” *Journal of Finance* 62 (4):1705–1745.

Holmström, Bengt and Jean Tirole. 1997. “Financial Intermediation, Loanable Funds, and the Real Sector.” *Quarterly Journal of Economics* 106 (1):663–691.

Ioannidou, Vasso, Steven Ongena, and José-Luis Peydró. 2015. “Monetary Policy, Risk-Taking, and Pricing: Evidence from a Quasi-Natural Experiment.” *Review of Finance* 19 (1):95–144.

Jayaratne, Jith and Donald P. Morgan. 2000. “Capital Market Frictions and Deposit Constraints at Banks.” *Journal of Money, Credit and Banking* 32 (1):74–92.

Jiang, Zhengyang, Hanno N. Lustig, Stijn Van Nieuwerburgh, and Mindy Z. Xiaolan. 2021. “Bond Convenience Yields in the Eurozone Currency Union.” Columbia GSB Working Paper.

Jiménez, Gabriel, Steven Ongena, José-Luis Peydró, and Jésus Saurina. 2012. "Credit Supply and Monetary Policy: Identifying the Bank Balance-Sheet Channel with Loan Applications." *American Economic Review* 102 (5):2301–2326.

———. 2014. "Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say about the Effects of Monetary Policy on Credit Risk-Taking?" *Econometrica* 82 (2):463–505.

Kashyap, Anil K. and Jeremy C. Stein. 1994. "Monetary Policy and Bank Lending." *NBER Studies in Business Cycles* 29:221–256.

———. 1995. "The Impact of Monetary Policy on Bank Balance Sheets." *Carnegie-Rochester Conference Series on Public Policy* 42:151–195.

———. 2000. "What Do a Million Observations on Banks Say about the Transmission of Monetary Policy?" *American Economic Review* 90 (3):407–428.

Khwaja, Asim I. and Atif Mian. 2008. "Tracing the Impact of Bank Liquidity Shocks: Evidence from an Emerging Market." *American Economic Review* 98 (4):1413–1442.

Kishan, Ruby P. and Timothy P. Opiela. 2000. "Bank Size, Bank Capital, and the Bank Lending Channel." *Journal of Money, Credit and Banking* 32 (1):121–141.

Krishnamurthy, Arvind and Annette Vissing-Jørgensen. 2015. "The Impact of Treasury Supply on Financial Sector Lending and Stability." *Journal of Financial Economics* 118 (3):571–600.

Lenzu, Simone and Francesco Manaresi. 2018. "Sources and Implications of Resource Misallocation: New Evidence from Firm-Level Marginal Products and User Costs." Unpublished working paper.

Li, Wenhao, Yiming Ma, and Yang Zhao. 2020. "The Passthrough of Treasury Supply to Bank Deposit Funding." Unpublished working paper.

Maddaloni, Angela and José-Luis Peydró. 2011. "Bank Risk-taking, Securitization, Supervision, and Low Interest Rates: Evidence from the Euro-area and the U.S. Lending Standards." *Review of Financial Studies* 24 (6):2121–2165.

Martinez-Miera, David and Rafael Repullo. 2016. "Search for Yield." *Econometrica* 85:351–378.

Mojon, Benoît. 2000. "Financial Structure and the Interest Rate Channel of ECB Monetary Policy." ECB Working Paper No. 40.

Nakamura, Emi and Jón Steinsson. 2014. "Fiscal Stimulus in a Monetary Union: Evidence from US Regions." *American Economic Review* 104 (3):753–792.

Nakamura, Emi and Jon Steinsson. 2018. "High-Frequency Identification of Monetary Non-Neutrality: The Information Effect." *Quarterly Journal of Economics* 133 (3):1283–1330.

Neuhann, Daniel and Farzad Saidi. 2018. "Do Universal Banks Finance Riskier but More Productive Firms?" *Journal of Financial Economics* 128 (1):66–85.

Paligorova, Teodora and João A. C. Santos. 2017. "Monetary Policy and Bank Risk-Taking: Evidence from the Corporate Loan Market." *Journal of Financial Intermediation* 30:35–49.

Peek, Joe and Eric S. Rosengren. 1997. "The International Transmission of Financial Shocks: The Case of Japan." *American Economic Review* 87 (4):495–505.

———. 2000. "Collateral Damage: Effects of the Japanese Bank Crisis on Real Activity in the United States." *American Economic Review* 90 (1):30–45.

Rajan, Raghuram G. 2005. "Has Financial Development Made the World Riskier?" In *Proceedings, Federal Reserve Bank of Kansas City*. 313–369.

Rocheteau, Guillaume, Randall Wright, and Cathy Zhang. 2018. "Corporate Finance and Monetary Policy." *American Economic Review* 108 (4-5):1147–1186.

Santis, Roberto De and Paolo Surico. 2013. "Bank Lending and Monetary Transmission in the Euro Area." *Economic Policy* :423–457.

Schild, Christopher-Johannes, Simone Schultz, and Franco Wieser. 2017. "Linking Deutsche Bundesbank Company Data using Machine-Learning-Based Classification – Technical Report 2017-01." Deutsche Bundesbank Research Data and Service Centre.

Schmieder, Christian. 2006. "The Deutsche Bundesbank's Large Credit Database (BAKIS-M and MiMiK)." *Schmollers Jahrbuch* 126 (4):653–663.

Stein, Jeremy C. 1998. "An Adverse-Selection Model of Bank Asset and Liability Management with Implications for the Transmission of Monetary Policy." *RAND Journal of Economics* 29:466–486.

Stiglitz, Joseph E. and Andrew Weiss. 1981. "Credit Rationing in Markets with Imperfect Information." *American Economic Review* 71 (3):393–410.

Ulate, Mauricio. 2021. "Going Negative at the ZLB: The Effects of Negative Nominal Interest Rates." *American Economic Review* 111 (1):1–40.

Van den Heuvel, Skander J. 2002. "The Bank Capital Channel of Monetary Policy." Unpublished working paper.

Wang, Yifei, Toni M. Whited, Yufeng Wu, and Kairong Xiao. 2021. "Bank Market Power and Monetary Policy Transmission: Evidence from a Structural Estimation." *Journal of Finance* .

Proofs

Proof of Result 1

For the first part of the result, we have

$$\begin{aligned}\frac{\partial k(r_p, e^*);\theta)}{\partial r_p} &= \frac{\partial}{\partial r_p}\left(\frac{r_\theta(r_p)}{r_\theta(r_p) - P(r_p, e^*)}\right) \\ &= \frac{r_\theta(r_p)p(e^*)R'(r_p) - r'_\theta(r_p)\mathcal{P}(r_p, e^*)}{[r_\theta(r_p) - \mathcal{P}(r_p, e^*)]^2},\end{aligned}$$

which is negative if and only if the condition in Result 1 holds.

For the second part, our starting point is the first-order condition (9), which characterizes the optimal amount of screening e^*:

$$\left(\frac{b}{1-\delta} - ce^*\right)\frac{p'(e^*)R(r_p)}{r_\theta(r_p) - \mathcal{P}(r_p, e^*)} = c. \tag{16}$$

Implicit differentiation yields:

$$\frac{de^*}{dr_p} = -\frac{\frac{\partial F(e^*, r_p)}{\partial r_p}}{\frac{\partial F(e^*, r_p)}{\partial e^*}}, \tag{17}$$

where $F(e^*, r_p)$ denotes the left-hand side of (16).

Because the second-order condition is $\frac{\partial F(e^*, r_p)}{\partial e^*} < 0$, we have no risk taking, $\frac{de^*}{dr_p} < 0$, if and only if $\frac{\partial F(e^*, r_p)}{\partial r_p} < 0$ or

$$\begin{aligned}\left(\frac{b}{1-\delta} - ce^*\right)p'(e^*)\frac{R'(r_p)[r_\theta(r_p) - \mathcal{P}(r_p, e^*)] - R(r_p)\left[r'_\theta(r_p) - \frac{\partial \mathcal{P}(r_p, e^*)}{dr_p}\right]}{[r_\theta(r_p) - \mathcal{P}(r_p, e^*)]^2} &< 0 \\ R'(r_p)[r_\theta(r_p) - \mathcal{P}(r_p, e^*)] - R(r_p)[r'_\theta(r_p) - p(e^*)R'(r_p)] &< 0 \\ R'(r_p)[r_\theta(r_p) + p(e^*)R(r_p) - \mathcal{P}(r_p, e^*)] - R(r_p)r'_\theta(r_p) &< 0,\end{aligned}$$

which can be written as the condition in Result 1.

Proof of Result 2

When $\frac{de^*}{dr_p} = 0$, then

$$\begin{aligned}\frac{d^2L^*}{dr_p db} &= \frac{d}{db}\left(\frac{\partial k(r_p, e^*;\theta)}{\partial r_p}\right) \\ &= \frac{d}{db}\left(\frac{r_\theta(r_p)p(e^*)R'(r_p) - r'_\theta(r_p)\mathcal{P}(r_p, e^*)}{[r_\theta(r_p) - \mathcal{P}(r_p, e^*)]^2}\right) \\ &= \frac{-r'_\theta(r_p)\frac{d\mathcal{P}(r_p, e^*)}{db}[r_\theta(r_p) - \mathcal{P}(r_p, e^*)] - [r_\theta(r_p)p(e^*)R'(r_p) - r'_\theta(r_p)\mathcal{P}(r_p, e^*)]2\left(-\frac{d\mathcal{P}(r_p, e^*)}{db}\right)}{[r_\theta(r_p) - \mathcal{P}(r_p, e^*)]^3} \\ &= \frac{\frac{d\mathcal{P}(r_p, e^*)}{db}}{[r_\theta(r_p) - \mathcal{P}(r_p, e^*)]^3}\left[-r'_\theta(r_p)[r_\theta(r_p) - \mathcal{P}(r_p, e^*)] + 2[r_\theta(r_p)p(e^*)R'(r_p) - r'_\theta(r_p)\mathcal{P}(r_p, e^*)]\right] \\ &= \frac{\frac{d\mathcal{P}(r_p, e^*)}{db}}{[r_\theta(r_p) - \mathcal{P}(r_p, e^*)]^3}\left[-r'_\theta(r_p)r_\theta(r_p) + 2r_\theta(r_p)p(e^*)R'(r_p) - r'_\theta(r_p)\left(p(e^*)R(r_p) - \frac{b}{1-\delta}\right)\right].\end{aligned}$$

Because $\frac{d\mathcal{P}(r_p,e^*)}{db} < 0$, the expression is positive if and only if the condition in Result 2 holds.

Proof of Result 3

The derivative of $\frac{dk(r_p,e^*;\theta)}{de}$ with respect to b is given by:

$$\frac{d}{db}\left(\frac{r_\theta(r_p)R(r_p)p'(e^*)}{[r_\theta(r_p)-\mathcal{P}(r_p,e^*)]^2}\right)$$
$$=\frac{2r_\theta(r_p)R(r_p)p'(e^*)\frac{d\mathcal{P}(r_p,e^*)}{db}}{[r_\theta(r_p)-\mathcal{P}(r_p,e^*)]^3},$$

which is negative because $\frac{d\mathcal{P}(r_p,e^*)}{db}$ is negative.

Impact of b on $\frac{de^*}{dr_p}$ is ambiguous

The response of the optimal screening effort to the policy rate is given by (17), where $\frac{\partial F(e^*,r_p)}{\partial r_p}$ is

$$\left(\frac{b}{1-\delta}-ce^*\right)p'(e^*)\frac{R'(r_p)r_\theta(r_p)-R'(r_p)\mathcal{P}(r_p,e^*)-R(r_p)r'_\theta(r_p)+p(e^*)R'(r_p)R(r_p)}{[r_\theta(r_p)-\mathcal{P}(r_p,e^*)]^2}.$$

This term changes in a complex way when the private benefit b changes. First, a higher b increases the net rent $\frac{b}{1-\delta}-ce^*$. Second, a higher b decreases the pledgeable return $\mathcal{P}(r_p,e^*)$, which appears in the numerator and the denominator with a minus sign.

The expression for $\frac{\partial F(e^*,r_p)}{\partial e}$ is

$$-c\frac{R(r_p)p'(e^*)}{r_\theta(r_p)-\mathcal{P}(r_p,e^*)}+\left(\frac{b}{1-\delta}-ce^*\right)\frac{R(r_p)p''(e^*)}{r_\theta(r_p)-\mathcal{P}(r_p,e^*)}$$
$$+\left(\frac{b}{1-\delta}-ce^*\right)\left(\frac{R(r_p)p'(e^*)}{r_\theta(r_p)-\mathcal{P}(r_p,e^*)}\right)^2.$$

Again, this expression depends in a non-trivial way on the private benefit b. As a higher b decreases $\mathcal{P}(r_p,e^*)$, the fractions with $\mathcal{P}(r_p,e^*)$ in the denominator all decrease (note that the first fraction has a minus sign). As before, a higher b has a countervailing effect via a higher net rent $\frac{b}{1-\delta}-ce^*$.

Figures

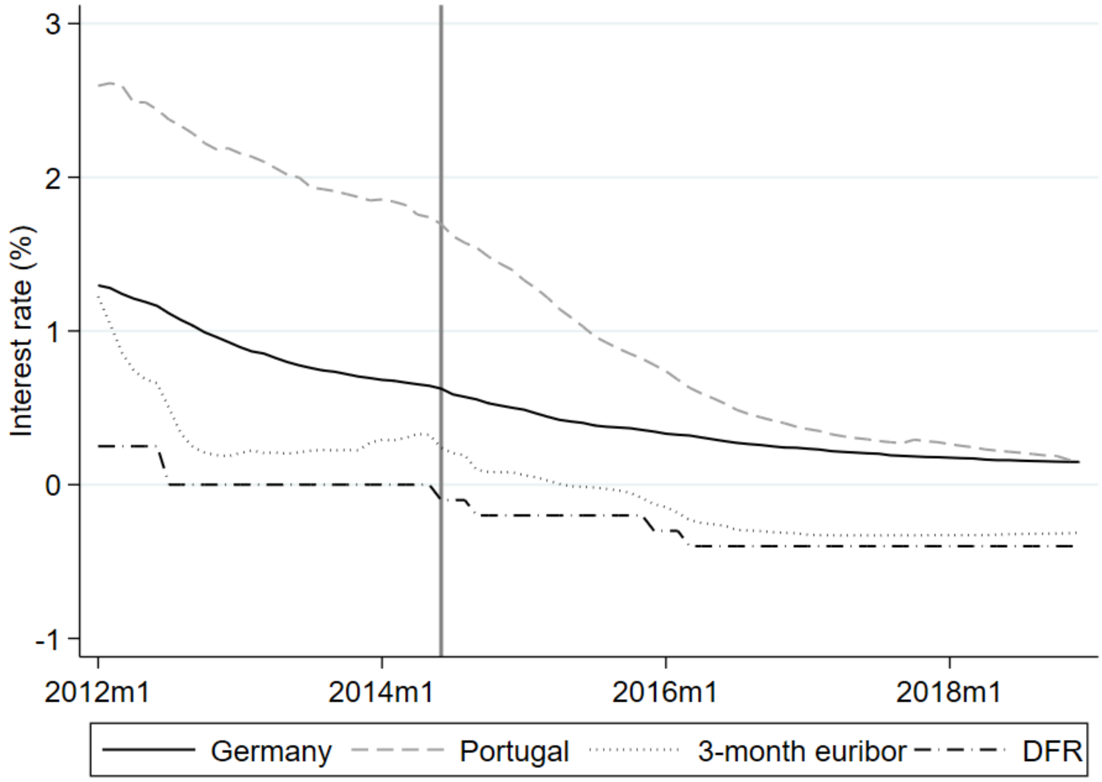

Figure 1: **Monetary Policy, Interbank Rates, and Deposit Rates in Germany and Portugal.** This figure shows the ECB's Deposit Facility Rate (DFR), the 3-month Euro Interbank Offered Rate (Euribor), and country-level weighted deposit rates (in %, y-axis) for Germany and Portugal between January 2012 and December 2018. For each country, we calculate weighted average deposit rates, based on the rates and volumes of overnight deposits, agreed-maturity deposits (all maturities), and deposits redeemable at notice. All data series are taken from the Statistical Data Warehouse (SDW).

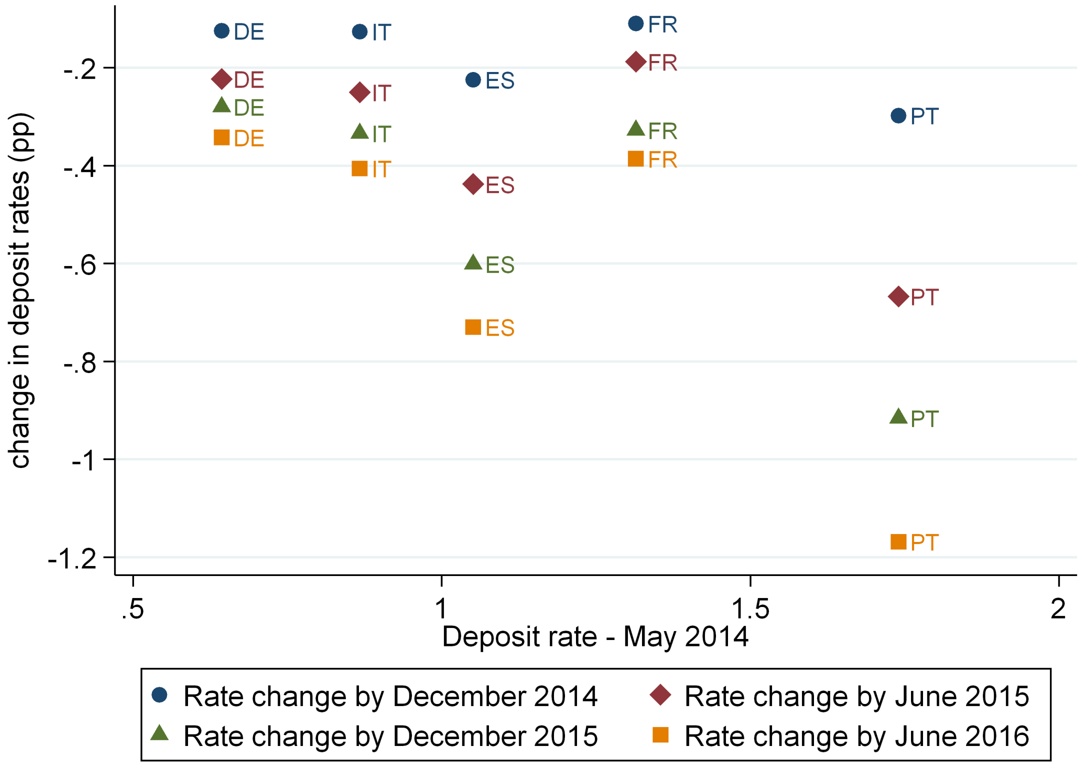

Figure 2: **Change in Deposit Rates across Countries.** This figure shows the change in country-level weighted deposit rates (in percentage points, y-axis) between May 2014 and four other points in time: December 2014, June 2015, December 2015, and June 2016. For each country, we calculate a weighted rate at each of these points in time, based on the rates and volumes of overnight deposits, agreed-maturity deposits (all maturities), and deposits redeemable at notice. We then calculate the difference with the weighted average rate in the respective country in May 2014. All rates are calculated using data from the MIR and BSI datasets from the SDW.

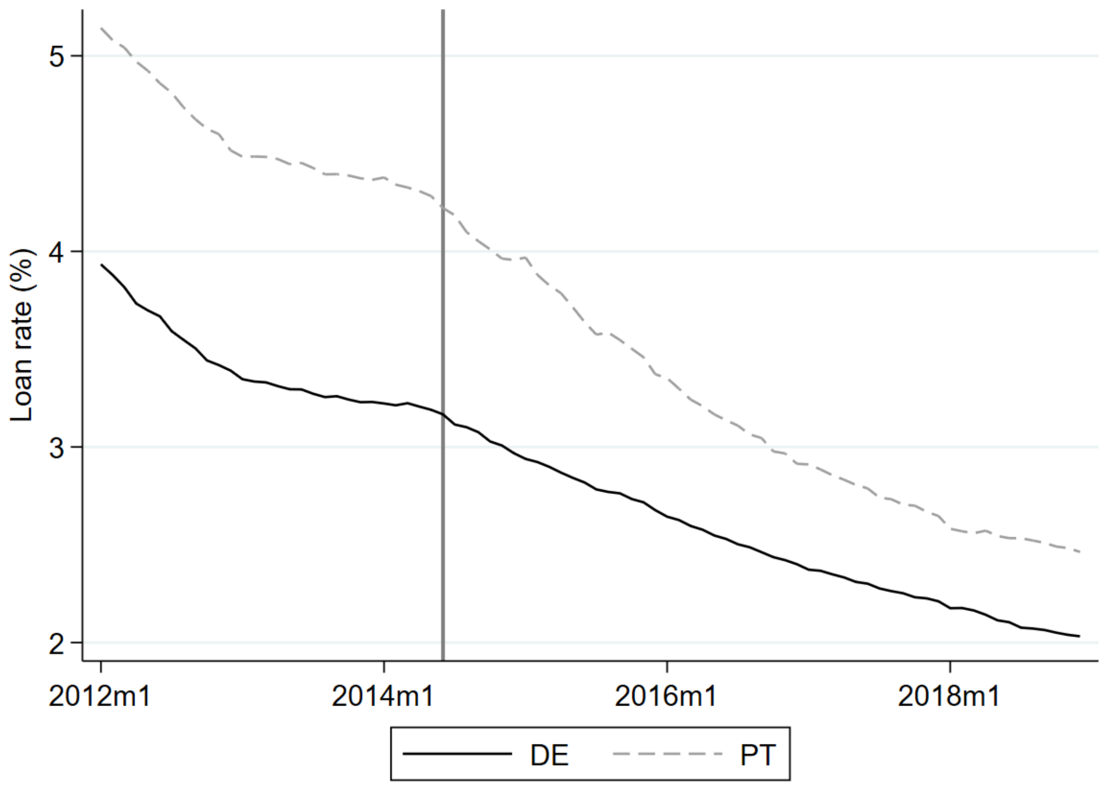

Figure 3: **Loan Rates in Germany and Portugal.** This figure shows country-level non-financial-corporation loan rates (in %, y-axis) for Germany and Portugal between January 2012 and December 2018. Both data series are taken from the SDW.

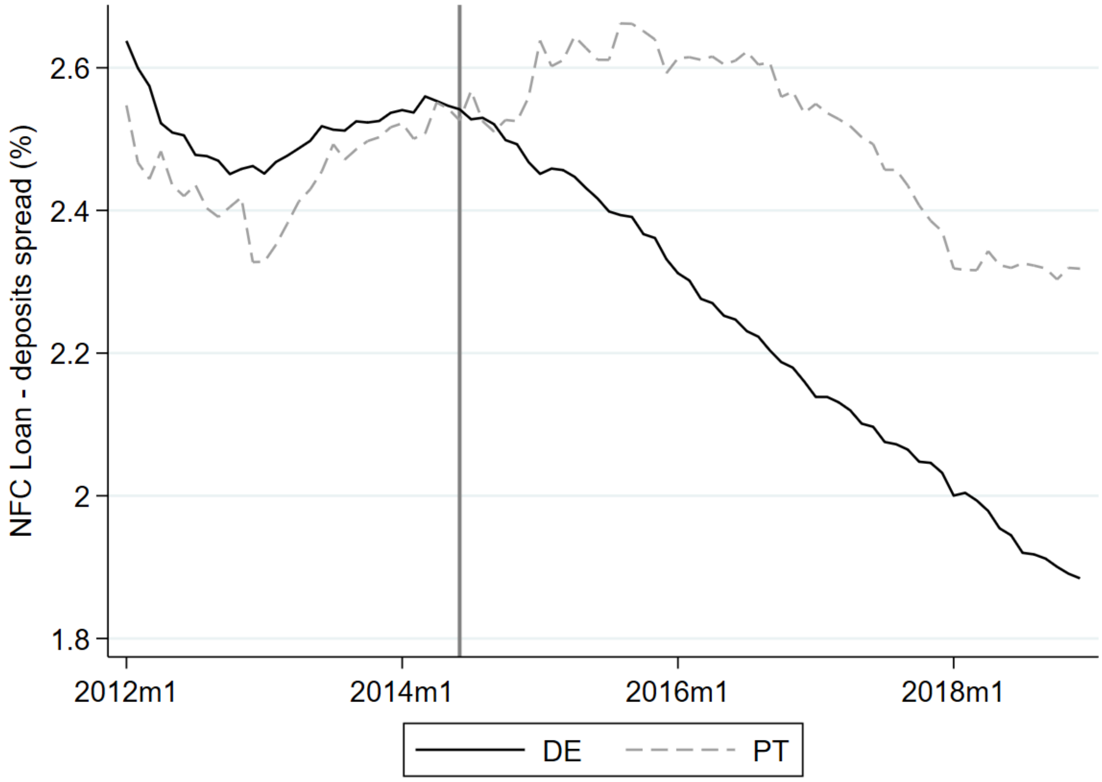

Figure 4: **Spread between Loan Rates and Deposit Rates in Germany and Portugal.** This figure shows the spread between country-level non-financial-corporation loan rates and weighted deposit rates (in %, y-axis) for Germany and Portugal between January 2012 and December 2018. For deposit rates in each country, we calculate weighted average rates, based on the rates and volumes of overnight deposits, agreed-maturity deposits (all maturities), and deposits redeemable at notice. All rates are calculated using data from the MIR and BSI datasets from the SDW.

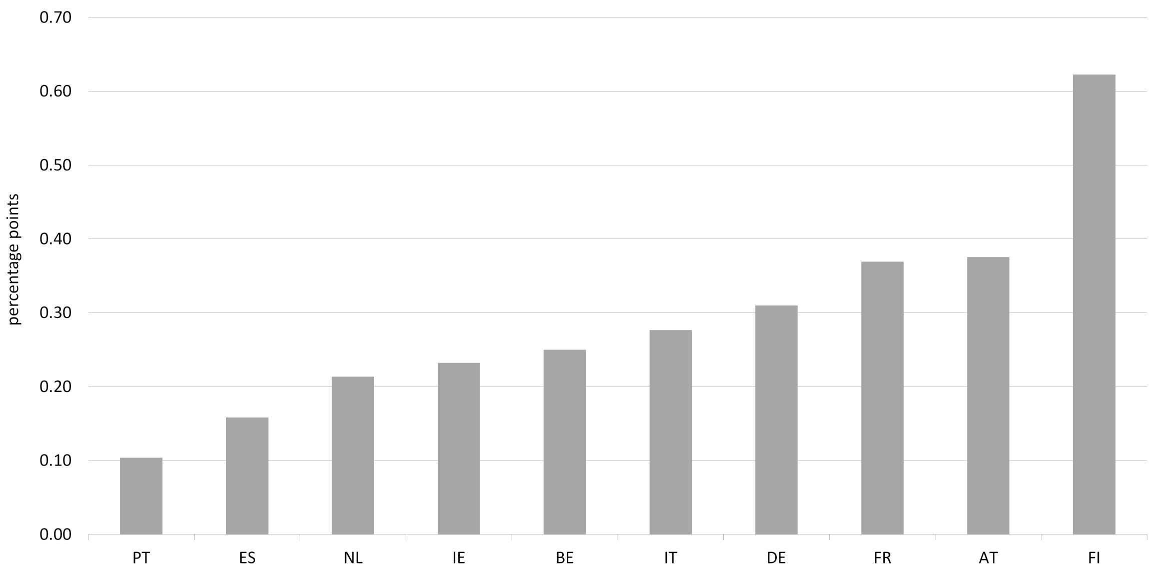

Figure 5: **The Role of Banks' Funding Structure across Euro-area Countries.** This figure shows the estimated impact of a ten-percentage-point increase in deposit ratios on the average likelihood of a new lending relationship between a bank and a risky firm after the mid-2014 rate cut. For each country, we calculate the decline in the average weighted deposit rate between May 2014 and June 2015, and scale it by the average decline in Germany. This gives us an index for the change in deposit rates, where the index value for Germany is equal to one. Next, we combine this index with the coefficient from our new-relationship specification for risky firms in Germany (Table 2, column 11) to yield an estimate of bank risk taking in each country.

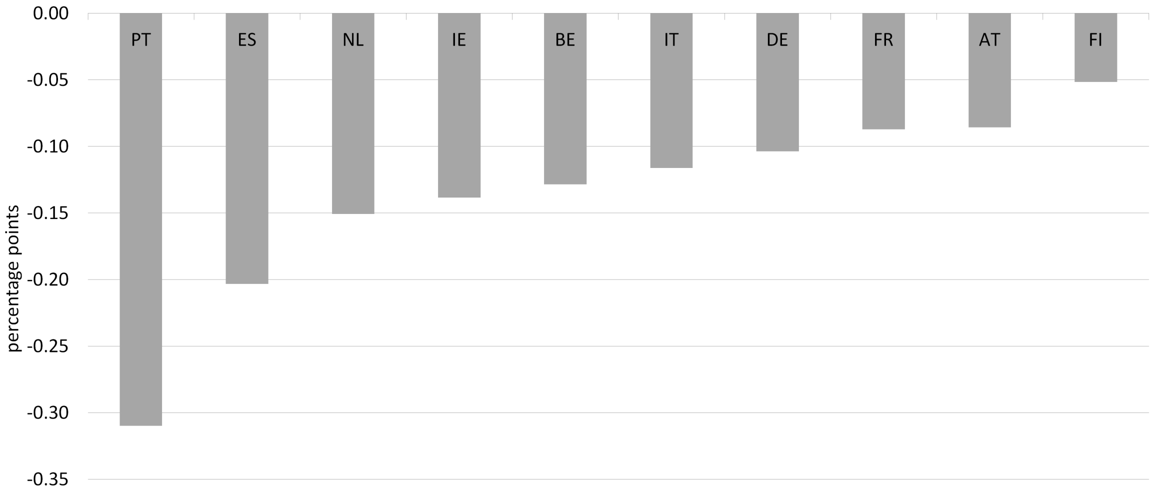

Figure 6: **The Role of the Bank Balance-sheet Channel across Euro-area Countries.** This figure shows the estimated impact of a ten-percentage-point increase in equity ratios on the average likelihood of a new lending relationship between a bank and a firm after the mid-2014 rate cut. For each country, we calculate the decline in the average weighted deposit rate between May 2014 and June 2015, and scale it by the average decline in Portugal. This gives us an index for the change in deposit rates, where the index value for Portugal is equal to one. Next, we combine this index with the coefficient from our new-relationship specification for Portugal (Table 2, column 1) to yield an estimate of the strength of the bank balance-sheet channel in each country.

Tables

Table 1: **Summary Statistics**

Variable	Portugal					Germany				
Panel A: Bank level	Mean	Std. dev.	p5	p95	*N*	Mean	Std. dev.	p5	p95	*N*
Equity ratio	0.135	0.119	0.000	0.313	37	0.060	0.029	0.036	0.088	1,103
Deposit ratio	0.381	0.247	0.056	0.800	37	0.539	0.160	0.130	0.726	1,103
Securities ratio	0.189	0.198	0.000	0.509	37	0.207	0.120	0.023	0.424	1,103
Bank assets in million €	12,805	28,080	5.000	105,505	37	4,781	32,724	219.437	8,377	1,103
Panel B: Bank-firm-time level (2013 – 2015)	Mean	Std. dev.	p5	p95	*N*	Mean	Std. dev.	p5	p95	*N*
Equity ratio	0.097	0.034	0.046	0.154	1,529,890	0.060	0.037	0.030	0.158	345,180
Deposit ratio	0.318	0.103	0.145	0.567	1,529,890	0.367	0.224	0.044	0.694	345,180
New relationship	0.016	0.125	0	0	1,529,890	0.053	0.224	0	1	345,180
Any new credit	0.222	0.416	0	1	1,529,890	0.225	0.418	0	1	345,180
Credit ($\neq 0$) in thousand €	727.736	5,420	2.500	2,111	1,486,216	6,276	26,447	22.000	21,053	228,655
Panel C: Firm level	Mean	Std. dev.	p5	p95	*N*	Mean	Std. dev.	p5	p95	*N*
Δln(Tangible fixed assets)	-0.016	0.561	-0.870	0.957	16,476	0.070	0.377	-0.527	0.714	4,628
Δln(No. of employees)	0.017	0.215	-0.343	0.380	16,541	0.037	0.189	-0.259	0.336	4,628
New relationship	0.034	0.181	0	0	16,541	0.521	0.500	0	1	4,628
New credit	0.174	0.379	0	1	16,541	0.656	0.475	0	1	4,628
Equity exposure if New relationship = 1	0.057	0.049	0.000	0.149	559	0.063	0.037	0.030	0.158	2,411
Deposit exposure if New relationship = 1	0.211	0.186	0.000	0.567	559	0.306	0.200	0.024	0.641	2,411

Panel A presents summary statistics at the bank level for Portugal and Germany (in 2013). Panel B presents summary statistics at the bank-firm-time level for both credit registers in Portugal (bank-firm-month) and Germany (bank-firm-quarter); the variables correspond to those in Tables 2 to 7 (and Table B.1 of the Supplementary Appendix). Panel C presents summary statistics at the firm level, for all borrowers in our Portuguese and German data, with the variables corresponding to those in Tables 9 and 10. Exact source for German portion: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), monthly balance-sheet statistics (BISTA), from 2011Q1 to 2016Q4, own calculations.

Table 2: **The Bank Balance-sheet Channel and Risk Taking: Effect on New Relationships**

	New relationship $\in \{0,1\}$					
Country	Portugal			Germany		
Firms	All	Risky	Safe	All	Risky	Safe
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Equity ratio × After(06/2014)	-0.031**	-0.024**	-0.038**	-0.089	0.251	-0.314
	(0.012)	(0.011)	(0.016)	(0.245)	(0.164)	(0.278)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.052	0.062	0.047	0.097	0.124	0.107
N	1,491,926	472,125	490,469	300,588	79,752	106,320
Variable	(7)	(8)	(9)	(10)	(11)	(12)
Deposit ratio × After(06/2014)	-0.011	-0.009	-0.018	0.013	0.031**	-0.004
	(0.008)	(0.008)	(0.012)	(0.015)	(0.014)	(0.028)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.052	0.062	0.047	0.097	0.124	0.106
N	1,491,926	472,125	490,469	300,588	79,752	106,320

In the first three columns of each panel, the sample consists of monthly observations on credit to firms, with available balance-sheet data and at least ten employees, from the Portuguese credit register. In the last three columns of each panel, the sample consists of quarterly observations on credit to firms, with available balance-sheet data, from the German credit register. The sample period is January 2013 to December 2015. In the second and fifth (third and sixth) column of each panel, the sample is furthermore limited to firms in the top (bottom) tercile of the distribution of (five-year) sales-growth volatility, calculated using annual data from 2009 to 2013. The dependent variable is an indicator for any increase in credit of firm f granted by bank b at time t (month t for Portugal and quarter t for Germany), conditional on zero credit in $t-1$. *Equity ratio*$_b$ is bank b's ratio of equity over total assets in 2013. *Deposit ratio*$_b$ is bank b's ratio of deposits over total assets in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. Robust standard errors (clustered at the bank level) are in parentheses. Exact source for German portion: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), monthly balance-sheet statistics (BISTA), from 2013Q1 to 2015Q4, own calculations.

Table 3: **The Bank Balance-sheet Channel and Risk Taking: Effect on New-relationship Loan Volume**

	$\ln(1+\text{Credit}\times\mathbb{1}\{\text{New relationship}=1\})$					
Country	Portugal			Germany		
Firms	All	Risky	Safe	All	Risky	Safe
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Equity ratio × After(06/2014)	-0.327**	-0.270**	-0.357**	-0.414	0.806	-1.297
	(0.123)	(0.110)	(0.172)	(0.929)	(0.769)	(0.977)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.033	0.041	0.028	0.072	0.109	0.082
N	1,491,926	472,125	490,469	300,588	79,752	106,320
Variable	(7)	(8)	(9)	(10)	(11)	(12)
Deposit ratio × After(06/2014)	-0.124	-0.102	-0.193	0.089	0.174**	0.031
	(0.089)	(0.080)	(0.129)	(0.072)	(0.084)	(0.110)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.033	0.041	0.028	0.072	0.110	0.082
N	1,491,926	472,125	490,469	300,588	79,752	106,320

In the first three columns of each panel, the sample consists of monthly observations on credit to firms, with available balance-sheet data and at least ten employees, from the Portuguese credit register. In the last three columns of each panel, the sample consists of quarterly observations on credit to firms, with available balance-sheet data, from the German credit register. The sample period is January 2013 to December 2015. In the second and fifth (third and sixth) column of each panel, the sample is furthermore limited to firms in the top (bottom) tercile of the distribution of (five-year) sales-growth volatility, calculated using annual data from 2009 to 2013. The dependent variable is the natural logarithm of one plus the credit exposure of firm f and bank b at time t (month t for Portugal and quarter t for Germany) multiplied by an indicator for any increase in credit of firm f granted by bank b at time t, conditional on zero credit in $t-1$. *Equity ratio*$_b$ is bank b's ratio of equity over total assets in 2013. *Deposit ratio*$_b$ is bank b's ratio of deposits over total assets in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. Robust standard errors (clustered at the bank level) are in parentheses. Exact source for German portion: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), monthly balance-sheet statistics (BISTA), from 2013Q1 to 2015Q4, own calculations.

Table 4: **The Bank Balance-sheet Channel and Risk Taking: Effect on Credit Exposure**

			Δln(Credit)			
Country		Portugal			Germany	
Firms	All	Risky	Safe	All	Risky	Safe
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Equity ratio × After(06/2014)	-0.040	-0.042	-0.039	-0.256	-0.148	-0.368
	(0.053)	(0.046)	(0.068)	(0.302)	(0.270)	(0.470)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	-0.014	-0.007	-0.020	0.121	0.097	0.118
N	1,336,871	422,702	438,822	169,391	43,218	61,808
Variable	(7)	(8)	(9)	(10)	(11)	(12)
Deposit ratio × After(06/2014)	-0.001	-0.002	-0.005	0.010	0.002	0.010
	(0.017)	(0.012)	(0.019)	(0.018)	(0.027)	(0.028)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	-0.014	-0.007	-0.020	0.121	0.097	0.118
N	1,336,871	422,702	438,822	169,391	43,218	61,808

In the first three columns of each panel, the sample consists of monthly observations conditional on non-zero credit to firms, with available balance-sheet data and at least ten employees, from the Portuguese credit register. In the last three columns of each panel, the sample consists of quarterly observations conditional on non-zero credit to firms, with available balance-sheet data, from the German credit register. The sample period is January 2013 to December 2015. In the second and fifth (third and sixth) column of each panel, the sample is furthermore limited to firms in the top (bottom) tercile of the distribution of (five-year) sales-growth volatility, calculated using annual data from 2009 to 2013. The dependent variable is the difference in the natural logarithm of credit exposure of firm f and bank b between time t (month t for Portugal and quarter t for Germany) and $t-1$. *Equity ratio*$_b$ is bank b's ratio of equity over total assets in 2013. *Deposit ratio*$_b$ is bank b's ratio of deposits over total assets in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. Robust standard errors (clustered at the bank level) are in parentheses. Exact source for German portion: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), monthly balance-sheet statistics (BISTA), from 2013Q1 to 2015Q4, own calculations.

Table 5: **The Bank Balance-sheet Channel and Risk Taking: Effect on New Relationships—Robustness**

	New relationship $\in \{0,1\}$					
Country		Portugal			Germany	
Firms	All	Risky	Safe	All	Risky	Safe
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Equity ratio × After(06/2014)	-0.026**	-0.021	-0.032*	-0.090	0.233	-0.312
	(0.012)	(0.013)	(0.017)	(0.237)	(0.162)	(0.285)
Deposit ratio$_{t-1}$	-0.008	-0.011	-0.007	-0.009	-0.063**	0.073
	(0.023)	(0.016)	(0.035)	(0.067)	(0.032)	(0.189)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.050	0.061	0.045	0.097	0.124	0.107
N	1,428,574	451,230	470,329	300,588	79,752	106,320
Variable	(7)	(8)	(9)	(10)	(11)	(12)
Deposit ratio × After(06/2014)	-0.004	-0.004	-0.009	0.011	0.033**	-0.007
	(0.005)	(0.006)	(0.007)	(0.017)	(0.015)	(0.031)
Equity ratio$_{t-1}$	0.105**	0.077***	0.147**	-0.123	0.167	-0.283
	(0.040)	(0.026)	(0.054)	(0.360)	(0.169)	(0.560)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.050	0.061	0.045	0.097	0.124	0.106
N	1,428,574	451,230	470,329	300,588	79,752	106,320

In the first three columns of each panel, the sample consists of monthly observations on credit to firms, with available balance-sheet data and at least ten employees, from the Portuguese credit register. In the last three columns of each panel, the sample consists of quarterly observations on credit to firms, with available balance-sheet data, from the German credit register. The sample period is January 2013 to December 2015. In the second and fifth (third and sixth) column of each panel, the sample is furthermore limited to firms in the top (bottom) tercile of the distribution of (five-year) sales-growth volatility, calculated using annual data from 2009 to 2013. The dependent variable is an indicator for any increase in credit of firm f granted by bank b at time t (month t for Portugal and quarter t for Germany), conditional on zero credit in $t-1$. *Equity ratio*$_b$ is bank b's ratio of equity over total assets in 2013, and *Equity ratio*$_{bt-1}$ is bank b's ratio of equity over total assets one year prior to time t (month t for Portugal and quarter t for Germany). *Deposit ratio*$_b$ is bank b's ratio of deposits over total assets in 2013, and *Deposit ratio*$_{bt-1}$ is bank b's ratio of deposits over total assets one year prior to time t (month t for Portugal and quarter t for Germany). $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. Robust standard errors (clustered at the bank level) are in parentheses. Exact source for German portion: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), monthly balance-sheet statistics (BISTA), from 2013Q1 to 2015Q4, own calculations.

Table 6: **The Bank Balance-sheet Channel and Risk Taking: Effect on New Relationships—Alternative Risk Measure**

	New relationship $\in \{0,1\}$					
Country		Portugal			Germany	
Firms	All	Risky	Safe	All	Risky	Safe
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Equity ratio × After(06/2014)	-0.031**	-0.012	-0.036**	-0.089	0.174	-0.268
	(0.012)	(0.009)	(0.016)	(0.245)	(0.125)	(0.295)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.052	0.068	0.040	0.097	0.083	0.099
N	1,453,978	444,810	549,785	300,588	85,752	107,424
Variable	(7)	(8)	(9)	(10)	(11)	(12)
Deposit ratio × After(06/2014)	-0.011	-0.005	-0.017	0.013	0.026**	-0.006
	(0.008)	(0.005)	(0.013)	(0.015)	(0.012)	(0.026)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.052	0.068	0.040	0.097	0.083	0.098
N	1,453,978	444,810	549,785	300,588	85,752	107,424

In the first three columns of each panel, the sample consists of monthly observations on credit to firms, with available balance-sheet data and at least ten employees, from the Portuguese credit register. In the last three columns of each panel, the sample consists of quarterly observations on credit to firms, with available balance-sheet data, from the German credit register. The sample period is January 2013 to December 2015. In the second and fifth (third and sixth) column of each panel, the sample is furthermore limited to firms in the top (bottom) tercile of the distribution of (five-year) EBITDA margin, calculated using annual data from 2009 to 2013. The dependent variable is an indicator for any increase in credit of firm f granted by bank b at time t (month t for Portugal and quarter t for Germany), conditional on zero credit in $t-1$. *Equity ratio*$_b$ is bank b's ratio of equity over total assets in 2013. *Deposit ratio*$_b$ is bank b's ratio of deposits over total assets in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. Robust standard errors (clustered at the bank level) are in parentheses. Exact source for German portion: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), monthly balance-sheet statistics (BISTA), from 2013Q1 to 2015Q4, own calculations.

Table 7: **The Bank Balance-sheet Channel and Risk Taking: Effect on New Relationships—Additional Bank Controls**

	New relationship $\in \{0,1\}$					
Country		Portugal			Germany	
Firms	All	Risky	Safe	All	Risky	Safe
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Equity ratio × After(06/2014)	-0.025**	-0.020*	-0.032*	-0.093	0.209	-0.295
	(0.012)	(0.011)	(0.016)	(0.233)	(0.154)	(0.278)
Deposit ratio$_{t-1}$	-0.026*	-0.025***	-0.028	-0.009	-0.080**	0.092
	(0.013)	(0.009)	(0.019)	(0.065)	(0.035)	(0.184)
Securities ratio$_{t-1}$	0.006	0.003	-0.002	-0.119***	-0.210***	-0.077
	(0.014)	(0.012)	(0.018)	(0.045)	(0.063)	(0.073)
ln(Assets$_{t-1}$)	-0.020***	-0.015***	-0.024**	-0.004	0.016	-0.034
	(0.007)	(0.005)	(0.009)	(0.019)	(0.010)	(0.045)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.050	0.062	0.046	0.097	0.125	0.107
N	1,428,574	451,230	470,329	300,588	79,752	106,320
Variable	(7)	(8)	(9)	(10)	(11)	(12)
Deposit ratio × After(06/2014)	-0.001	-0.001	-0.005	0.015	0.024*	0.012
	(0.004)	(0.006)	(0.005)	(0.013)	(0.013)	(0.022)
Equity ratio$_{t-1}$	0.044	0.029	0.075	-0.264	0.199	-0.616
	(0.034)	(0.019)	(0.048)	(0.391)	(0.183)	(0.594)
Securities ratio$_{t-1}$	0.006	0.001	0.002	-0.114**	-0.193***	-0.086
	(0.013)	(0.012)	(0.015)	(0.046)	(0.058)	(0.072)
ln(Assets$_{t-1}$)	-0.014**	-0.010**	-0.015*	-0.023	0.013	-0.075
	(0.005)	(0.004)	(0.008)	(0.021)	(0.013)	(0.049)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.050	0.061	0.046	0.097	0.125	0.107
N	1,428,574	451,230	470,329	300,588	79,752	106,320

In the first three columns of each panel, the sample consists of monthly observations on credit to firms, with available balance-sheet data and at least ten employees, from the Portuguese credit register. In the last three columns of each panel, the sample consists of quarterly observations on credit to firms, with available balance-sheet data, from the German credit register. The sample period is January 2013 to December 2015. In the second and fifth (third and sixth) column of each panel, the sample is furthermore limited to firms in the top (bottom) tercile of the distribution of (five-year) sales-growth volatility, calculated using annual data from 2009 to 2013. The dependent variable is an indicator for any increase in credit of firm f granted by bank b at time t (month t for Portugal and quarter t for Germany), conditional on zero credit in $t-1$. *Equity ratio*$_b$ is bank b's ratio of equity over total assets in 2013. *Deposit ratio*$_b$ is bank b's ratio of deposits over total assets in 2013. All other bank-level control variables are measured one year prior to time t (month t for Portugal and quarter t for Germany); in particular, *Securities ratio*$_{bt-1}$ is defined as bank b's ratio of cash and securities over total assets one year prior to time t. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. Robust standard errors (clustered at the bank level) are in parentheses. Exact source for German portion: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), monthly balance-sheet statistics (BISTA), from 2013Q1 to 2015Q4, own calculations.

Table 8: **The Bank Balance-sheet Channel and Risk Taking: Effect on New Relationships—Portugal in a Low-rate Environment 2019**

	New relationship $\in \{0,1\}$					
Country	Portugal					
Firms	All	Risky	Safe	All	Risky	Safe
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Equity ratio × After(10/2019)	-0.021	-0.024	-0.026	-0.031	-0.039	-0.034
	(0.021)	(0.026)	(0.024)	(0.020)	(0.025)	(0.026)
Deposit ratio$_{t-1}$	-0.042	-0.035	-0.047	-0.043	-0.030	-0.045*
	(0.032)	(0.038)	(0.029)	(0.026)	(0.037)	(0.025)
Securities ratio$_{t-1}$				0.017	0.029*	0.016
				(0.014)	(0.017)	(0.019)
ln(Assets$_{t-1}$)				-0.015**	-0.015*	-0.010
				(0.006)	(0.007)	(0.007)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.029	0.023	0.038	0.030	0.023	0.038
N	898,114	312,961	280,851	898,114	312,961	280,851
Variable	(7)	(8)	(9)	(10)	(11)	(12)
Deposit ratio × After(10/2019)	0.015**	0.023**	0.019**	0.015***	0.025***	0.017***
	(0.007)	(0.010)	(0.007)	(0.005)	(0.009)	(0.005)
Equity ratio$_{t-1}$	0.092**	0.055	0.110***	0.095**	0.058	0.130***
	(0.043)	(0.050)	(0.030)	(0.036)	(0.042)	(0.041)
Securities ratio$_{t-1}$				0.029**	0.032**	0.031**
				(0.011)	(0.013)	(0.015)
ln(Assets$_{t-1}$)				-0.007	-0.009	0.001
				(0.004)	(0.006)	(0.005)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.030	0.023	0.038	0.030	0.023	0.038
N	898,114	312,961	280,851	898,114	312,961	280,851

The sample consists of monthly observations on credit to firms, with available balance-sheet data and at least ten employees, from the Portuguese credit register. The sample period is September 2018 to August 2020. In the second and fifth (third and sixth) column of each panel, the sample is furthermore limited to firms in the top (bottom) tercile of the distribution of (five-year) sales-growth volatility, calculated using annual data from 2014 to 2018. The dependent variable is an indicator for any increase in credit of firm f granted by bank b in month t, conditional on zero credit in $t-1$. *Equity ratio*$_b$ is bank b's ratio of equity over total assets in 2018. *Deposit ratio*$_b$ is bank b's ratio of deposits over total assets in 2018. All other bank-level control variables are measured one year prior to month t; in particular, *Securities ratio*$_{bt-1}$ is defined as bank b's ratio of cash and securities over total assets one year prior to month t. $After(10/2019)_t$ is a dummy variable for the period from October 2019 onwards. Robust standard errors (clustered at the bank level) are in parentheses.

Table 9: **Real Effects of Bank Credit Supply: Investment**

	Δln(Tangible fixed assets)											
Country	Portugal						Germany					
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
New relationship	0.087**	0.086**	0.079*	0.110***	0.108***	0.107***	0.059***	0.060**	0.046	0.026	0.009	-0.004
	(0.035)	(0.037)	(0.041)	(0.035)	(0.036)	(0.041)	(0.019)	(0.026)	(0.038)	(0.017)	(0.025)	(0.038)
New relationship $\times$ Equity exposure	0.157	0.097	0.246				0.072	-0.057	-0.266			
	(0.468)	(0.483)	(0.535)				(0.238)	(0.342)	(0.510)			
New relationship $\times$ Deposit exposure				-0.067	-0.075	-0.062				0.121***	0.154***	0.114
				(0.124)	(0.127)	(0.142)				(0.040)	(0.058)	(0.092)
New credit	0.058***	0.052***	0.045***	0.059***	0.052***	0.045***	0.039***	0.037**	0.015	0.040***	0.038**	0.017
	(0.011)	(0.012)	(0.013)	(0.011)	(0.012)	(0.013)	(0.013)	(0.018)	(0.027)	(0.013)	(0.018)	(0.027)
Industry FE	Y	N	N	Y	N	N	Y	N	N	Y	N	N
Location FE	Y	N	N	Y	N	N	Y	N	N	Y	N	N
Size FE	Y	N	N	Y	N	N	Y	N	N	Y	N	N
Industry-location FE	N	Y	N	N	Y	N	N	Y	N	N	Y	N
Industry-size FE	N	Y	N	N	Y	N	N	Y	N	N	Y	N
Industry-location-size FE	N	N	Y	N	N	Y	N	N	Y	N	N	Y
Adj. R^2	0.049	0.049	0.049	0.049	0.049	0.049	0.029	0.042	0.026	0.031	0.044	0.027
N	15,778	15,618	13,711	15,778	15,618	13,711	4,698	3,594	1,870	4,698	3,594	1,870

In the first six columns, we use annual data from the balance sheets of firms, with at least ten employees, that occur in the Portuguese credit register. In the last six columns, we use annual data from the balance sheets of firms that occur in the German credit register. We collapse information from the pre-period $(2011-2013)$ and the post-period $(2014-2016)$ to a single observation for each firm f. The dependent variable is the first difference in the natural logarithm of firm f's tangible fixed assets in year t, winsorized at the 1^{st} and 99^{th} percentiles. *New relationship*$_f$ is an indicator variable for whether anytime from 2014 to 2016, firm f increased its loan exposure to any given bank from which it had zero credit outstanding as of the last period before the mid-2014 rate cuts (i.e., in the last month or quarter before June 2014 for Portugal and Germany, respectively). *New relationship*$_f$ $\times$ *Equity exposure*$_f$ and *New relationship*$_f$ $\times$ *Deposit exposure*$_f$ are, respectively, the average *Equity ratio*$_b$ and *Deposit ratio*$_b$ (both measured in 2013) of all banks with which firm f establishes a new lending relationship in the post-period from 2014 to 2016, weighted by the increase in credit exposure (measured as the maximum exposure in $2014-2016$) to each bank b. *New credit*$_f$ is an indicator variable for whether anytime from 2014 to 2016, firm f increased its loan exposure to any given bank from which it had non-zero credit outstanding as of the last period before the mid-2014 rate cuts (i.e., in the last month or quarter before June 2014 for Portugal and Germany, respectively). Industry-location-size fixed effects are based on two-digit industry codes, districts (in Portugal), NUTS-3 regions (in Germany), and firm-size deciles. Robust standard errors (clustered at the firm level) are in parentheses. Exact source for German portion: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), monthly balance-sheet statistics (BISTA), from 2011Q1 to 2016Q4, own calculations.

Table 10: **Real Effects of Bank Credit Supply: Employment**

	Δln(No. of employees)											
Country	Portugal						Germany					
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
New relationship	0.027**	0.027*	0.016	0.035**	0.034**	0.028*	0.018*	0.023*	0.032*	-0.011	-0.005	-0.014
	(0.014)	(0.014)	(0.015)	(0.014)	(0.014)	(0.015)	(0.009)	(0.013)	(0.019)	(0.009)	(0.012)	(0.018)
New relationship × Equity exposure	0.264	0.292	0.375*				-0.041	-0.052	-0.166			
	(0.183)	(0.187)	(0.201)				(0.118)	(0.168)	(0.271)			
New relationship × Deposit exposure				0.035	0.045	0.043				0.085***	0.080***	0.121***
				(0.048)	(0.049)	(0.053)				(0.020)	(0.030)	(0.045)
New credit	0.014***	0.012***	0.009*	0.014***	0.012***	0.009*	0.021***	0.025***	0.029**	0.023***	0.026***	0.031**
	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.005)	(0.007)	(0.009)	(0.013)	(0.007)	(0.009)	(0.013)
Industry FE	Y	N	N	Y	N	N	Y	N	N	Y	N	N
Location FE	Y	N	N	Y	N	N	Y	N	N	Y	N	N
Size FE	Y	N	N	Y	N	N	Y	N	N	Y	N	N
Industry-location FE	N	Y	N	N	Y	N	N	Y	N	N	Y	N
Industry-size FE	N	Y	N	N	Y	N	N	Y	N	N	Y	N
Industry-location-size FE	N	N	Y	N	N	Y	N	N	Y	N	N	Y
Adj. R^2	0.043	0.057	0.081	0.043	0.057	0.081	0.025	0.044	0.028	0.029	0.047	0.034
N	15,831	15,674	13,747	15,831	15,674	13,747	4,737	3,623	1,900	4,737	3,623	1,900

In the first six columns, we use annual data from the balance sheets of firms, with at least ten employees, that occur in the Portuguese credit register. In the last six columns, we use annual data from the balance sheets of firms that occur in the German credit register. We collapse information from the pre-period $(2011 - 2013)$ and the post-period $(2014 - 2016)$ to a single observation for each firm f. The dependent variable is the first difference in the natural logarithm of firm f's number of employees in year t, winsorized at the 1^{st} and 99^{th} percentiles. *New relationship*$_f$ is an indicator variable for whether anytime from 2014 to 2016, firm f increased its loan exposure to any given bank from which it had zero credit outstanding as of the last period before the mid-2014 rate cuts (i.e., in the last month or quarter before June 2014 for Portugal and Germany, respectively). *New relationship*$_f$ × *Equity exposure*$_f$ and *New relationship*$_f$ × *Deposit exposure*$_f$ are, respectively, the average *Equity ratio*$_b$ and *Deposit ratio*$_b$ (both measured in 2013) of all banks with which firm f establishes a new lending relationship in the post-period from 2014 to 2016, weighted by the increase in credit exposure (measured as the maximum exposure in $2014 - 2016$) to each bank b. *New credit*$_f$ is an indicator variable for whether anytime from 2014 to 2016, firm f increased its loan exposure to any given bank from which it had non-zero credit outstanding as of the last period before the mid-2014 rate cuts (i.e., in the last month or quarter before June 2014 for Portugal and Germany, respectively). Industry-location-size fixed effects are based on two-digit industry codes, districts (in Portugal), NUTS-3 regions (in Germany), and firm-size deciles. Robust standard errors (clustered at the firm level) are in parentheses. Exact source for German portion: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), monthly balance-sheet statistics (BISTA), from 2011Q1 to 2016Q4, own calculations.

SUPPLEMENTARY APPENDIX—NOT FOR PUBLICATION

A Supplementary Figures

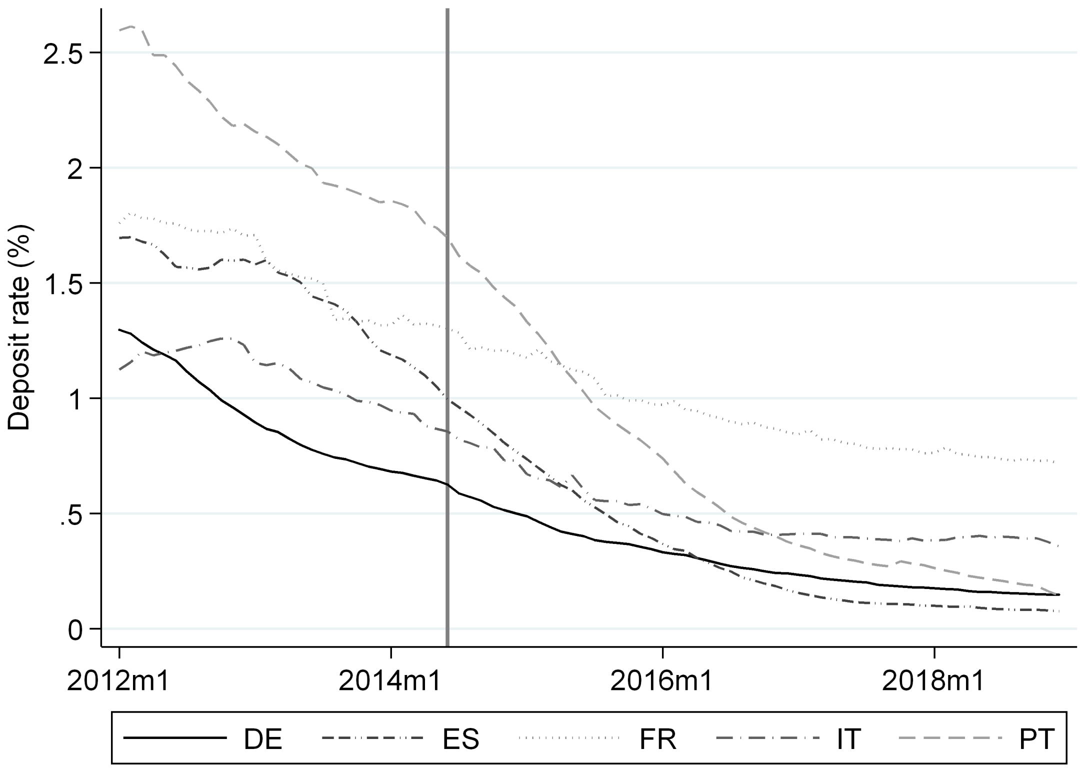

Figure A.1: **Deposit Rates across the Euro Area.** This figure shows the country-level weighted deposit rates (in %, y-axis) for a group of euro-area countries between January 2012 and December 2018. For each country, we calculate weighted rates, based on the rates and volumes of overnight deposits, agreed-maturity deposits (all maturities), and deposits redeemable at notice. All rates are calculated using data from the MIR and BSI datasets from the Statistical Data Warehouse (SDW).

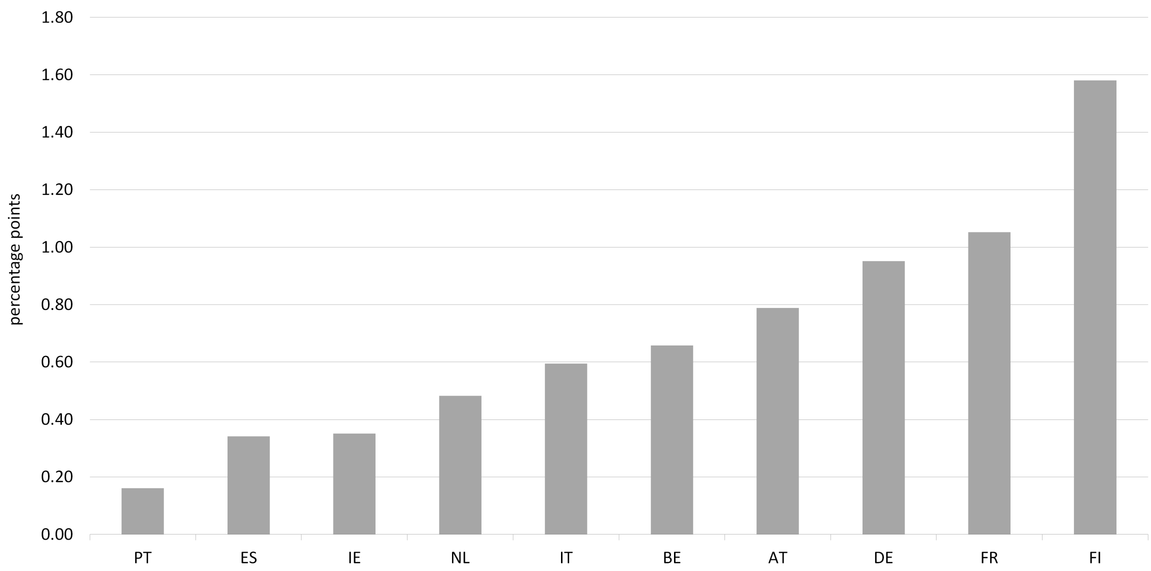

Figure A.2: **The Role of Banks' Funding Structure across Euro-area Countries.** This figure shows the estimated impact of a one-standard-deviation increase in deposit ratios on the average likelihood of a new lending relationship between a bank and a risky firm after the introduction of negative rates. For each country, we calculate the decline in the average weighted deposit rate between May 2014 and June 2015, and scale it by the average decline in Germany. This gives us an index for the change in deposit rates, where the index value for Germany is equal to one. Next, we combine this index with the coefficient from our new-relationship specification for risky firms in Germany (Table 2, column 11) to yield an estimate of bank risk taking in each country.

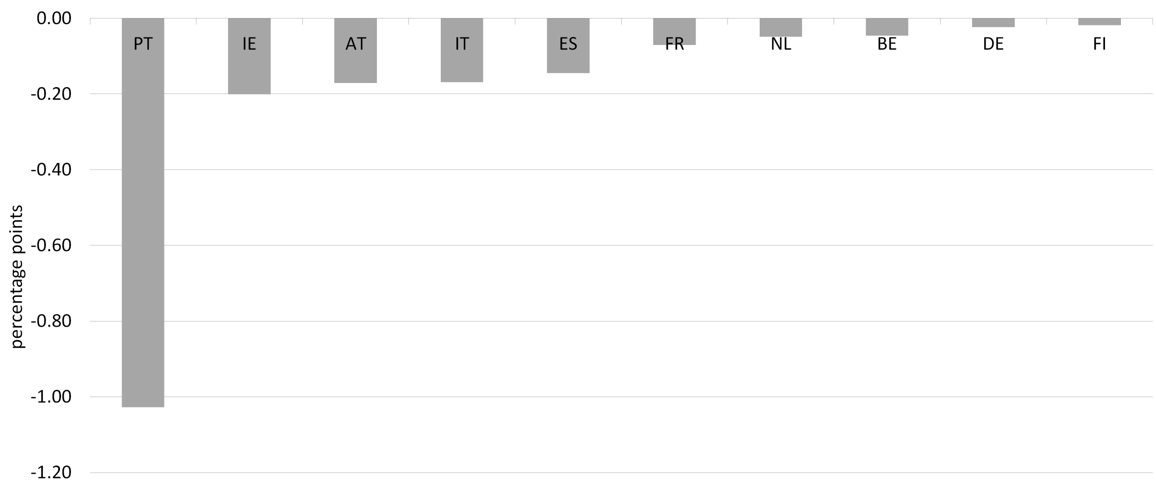

Figure A.3: **The Role of the Bank Balance-sheet Channel across Euro-area Countries.** This figure shows the estimated impact of a one-standard-deviation increase in equity ratios on the average likelihood of a new lending relationship between a bank and a firm after the introduction of negative rates. For each country, we calculate the decline in the average weighted deposit rate between May 2014 and June 2015, and scale it by the average decline in Portugal. This gives us an index for the change in deposit rates, where the index value for Portugal is equal to one. Next, we combine this index with the coefficient from our new-relationship specification for Portugal (Table 2, column 1) to yield an estimate of the strength of the bank balance-sheet channel in each country.

B Supplementary Tables

Table B.1: **The Bank Balance-sheet Channel and Risk Taking: Effect on Any New Credit**

	Any new credit $\in \{0,1\}$					
Country		Portugal			Germany	
Firms	All	Risky	Safe	All	Risky	Safe
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Equity ratio × After(06/2014)	-0.162*	-0.154*	-0.198*	-0.316	0.143	-0.642
	(0.098)	(0.084)	(0.118)	(0.451)	(0.281)	(0.540)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.094	0.106	0.085	0.164	0.176	0.175
N	1,491,926	472,125	490,469	300,588	79,752	106,320
Variable	(7)	(8)	(9)	(10)	(11)	(12)
Deposit ratio × After(06/2014)	0.020	0.037	0.007	0.051**	0.055**	0.033
	(0.027)	(0.023)	(0.028)	(0.020)	(0.023)	(0.035)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.094	0.106	0.085	0.164	0.176	0.174
N	1,491,926	472,125	490,469	300,588	79,752	106,320

In the first three columns of each panel, the sample consists of monthly observations on credit to firms, with available balance-sheet data and at least ten employees, from the Portuguese credit register. In the last three columns of each panel, the sample consists of quarterly observations on credit to firms, with available balance-sheet data, from the German credit register. The sample period is January 2013 to December 2015. In the second and fifth (third and sixth) column of each panel, the sample is furthermore limited to firms in the top (bottom) tercile of the distribution of (five-year) sales-growth volatility, calculated using annual data from 2009 to 2013. The dependent variable is an indicator for any increase in credit of firm f granted by bank b at time t (month t for Portugal and quarter t for Germany). *Equity ratio*$_b$ is bank b's ratio of equity over total assets in 2013. *Deposit ratio*$_b$ is bank b's ratio of deposits over total assets in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. Robust standard errors (clustered at the bank level) are in parentheses. Exact source for German portion: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), monthly balance-sheet statistics (BISTA), from 2011Q1 to 2016Q4, own calculations.

Table B.2: **The Bank Balance-sheet Channel and Risk Taking: Effect on New Relationships—Alternative Risk Measure II**

	New relationship $\in \{0,1\}$					
Country		Portugal			Germany	
Firms	All	Risky	Safe	All	Risky	Safe
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Equity ratio × After(06/2014)	-0.038***	-0.015	-0.042***	-0.089	-0.106	-0.092
	(0.013)	(0.011)	(0.014)	(0.245)	(0.106)	(0.262)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.066	0.070	0.063	0.097	0.069	0.095
N	1,917,310	384,411	1,532,899	300,588	31,620	261,840
Variable	(7)	(8)	(9)	(10)	(11)	(12)
Deposit ratio × After(06/2014)	-0.010	-0.002	-0.012	0.013	0.026*	0.009
	(0.008)	(0.003)	(0.010)	(0.015)	(0.014)	(0.017)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.066	0.070	0.063	0.097	0.069	0.095
N	1,917,310	384,411	1,532,899	300,588	31,620	261,840

In the first three columns of each panel, the sample consists of monthly observations on credit to firms, with available balance-sheet data and at least ten employees, from the Portuguese credit register. In the last three columns of each panel, the sample consists of quarterly observations on credit to firms, with available balance-sheet data, from the German credit register. The sample period is January 2013 to December 2015. In the second and fifth (third and sixth) column of each panel, the sample is furthermore limited to firms that defaulted (did not default) on their loans (repayment >3 months overdue) at least once in $2011-2013$. The dependent variable is an indicator for any increase in credit of firm f granted by bank b at time t (month t for Portugal and quarter t for Germany), conditional on zero credit in $t-1$. *Equity ratio*$_b$ is bank b's ratio of equity over total assets in 2013. *Deposit ratio*$_b$ is bank b's ratio of deposits over total assets in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. Robust standard errors (clustered at the bank level) are in parentheses. Exact source for German portion: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), monthly balance-sheet statistics (BISTA), from 2013Q1 to 2015Q4, own calculations.

Table B.3: **The Bank Balance-sheet Channel and Risk Taking: Effect on New Relationships—Alternative Risk Measure III**

	New relationship $\in \{0,1\}$					
Country	Portugal			Germany		
Firms	All	Risky	Safe	All	Risky	Safe
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Equity ratio × After(06/2014)	-0.039**	-0.023	-0.037***	-0.089	0.153	-0.277
	(0.015)	(0.023)	(0.013)	(0.245)	(0.153)	(0.289)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.047	0.053	0.046	0.097	0.080	0.111
N	1,060,215	299,657	404,749	300,588	93,156	117,504
Variable	(7)	(8)	(9)	(10)	(11)	(12)
Deposit ratio × After(06/2014)	-0.011	-0.009	-0.014	0.013	0.025*	0.002
	(0.010)	(0.011)	(0.012)	(0.015)	(0.013)	(0.023)
Bank FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.047	0.053	0.046	0.097	0.080	0.111
N	1,060,215	299,657	404,749	300,588	93,156	117,504

In the first three columns of each panel, the sample consists of monthly observations on credit to firms, with available balance-sheet data and at least ten employees, from the Portuguese credit register. In the last three columns of each panel, the sample consists of quarterly observations on credit to firms, with available balance-sheet data, from the German credit register. The sample period is January 2013 to December 2015. In the second and fifth (third and sixth) column of each panel, the sample is furthermore limited to firms in the top (bottom) tercile of the distribution of (five-year) operating-profit growth, calculated using annual data from 2009 to 2013. The dependent variable is an indicator for any increase in credit of firm f granted by bank b at time t (month t for Portugal and quarter t for Germany), conditional on zero credit in $t-1$. *Equity ratio*$_b$ is bank b's ratio of equity over total assets in 2013. *Deposit ratio*$_b$ is bank b's ratio of deposits over total assets in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. Robust standard errors (clustered at the bank level) are in parentheses. Exact source for German portion: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), monthly balance-sheet statistics (BISTA), from 2013Q1 to 2015Q4, own calculations.

Table B.4: **The Bank Balance-sheet Channel and Risk Taking: Effect on New Relationships—ILST instead of Firm-time Fixed Effects**

	New relationship $\in \{0,1\}$					
Country	Portugal			Germany		
Firms	All	Risky	Safe	All	Risky	Safe
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Equity ratio × After(06/2014)	-0.033***	-0.024*	-0.036**	-0.086	0.242	-0.312
	(0.012)	(0.012)	(0.017)	(0.230)	(0.151)	(0.251)
Bank FE	Y	Y	Y	Y	Y	Y
ILST FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.051	0.063	0.045	0.079	0.098	0.093
N	1,375,694	413,857	468,093	324,420	85,896	110,028
Variable	(7)	(8)	(9)	(10)	(11)	(12)
Deposit ratio × After(06/2014)	-0.006	-0.005	-0.013*	0.013	0.029**	-0.003
	(0.004)	(0.004)	(0.007)	(0.013)	(0.014)	(0.026)
Bank FE	Y	Y	Y	Y	Y	Y
ILST FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.009	0.021	0.015	0.079	0.098	0.092
N	1,375,551	410,072	474,304	324,420	85,896	110,028

In the first three columns of each panel, the sample consists of monthly observations on credit to firms, with available balance-sheet data and at least ten employees, from the Portuguese credit register. In the last three columns of each panel, the sample consists of quarterly observations on credit to firms, with available balance-sheet data, from the German credit register. The sample period is January 2013 to December 2015. In the second and fifth (third and sixth) column of each panel, the sample is furthermore limited to firms in the top (bottom) tercile of the distribution of (five-year) sales-growth volatility, calculated using annual data from 2009 to 2013. The dependent variable is an indicator for any increase in credit of firm f granted by bank b at time t (month t for Portugal and quarter t for Germany), conditional on zero credit in $t-1$. *Equity ratio*$_b$ is bank b's ratio of equity over total assets in 2013. *Deposit ratio*$_b$ is bank b's ratio of deposits over total assets in 2013. $After(06/2014)_t$ is a dummy variable for the period from June 2014 onwards. Industry-location-size-time (ILST) fixed effects are based on two-digit industry codes, districts (in Portugal), NUTS-3 regions (in Germany), and firm-size deciles. Robust standard errors (clustered at the bank level) are in parentheses. Exact source for German portion: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, German credit register (BAKIS-M), monthly balance-sheet statistics (BISTA), from 2011Q1 to 2016Q4, own calculations.

Table B.5: **Country-level Deposit-rate Changes and Expected Impact of Banks' Funding Structure**

Country	Change in weighted deposit rate	Index	Predicted coefficient
PT	-0.667	0.335	0.010
ES	-0.438	0.510	0.016
NL	-0.325	0.688	0.021
IE	-0.298	0.749	0.023
BE	-0.277	0.807	0.025
IT	-0.250	0.892	0.028
DE	-0.223	1.000	0.031
FR	-0.188	1.191	0.037
AT	-0.184	1.211	0.038
FI	-0.111	2.008	0.062