Why so negative? The effect of monetary policy on bank credit supply across the euro area*

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Abstract

This paper studies different modes of monetary-policy transmission via banks' supply of credit to firms in the euro area. To assess the differential transmission in the core and the periphery, we use a unique combination of confidential credit-registry data from Germany and Portugal. Banks' cost of funding, especially the rates they pay on deposits, plays a key role. In the wake of the sovereign debt crisis, deposit rates vary substantially across the euro area, which impacts the degree to which monetary policy can stimulate bank lending. For identification, we exploit the introduction of negative monetary-policy rates in the euro area, because they may affect banks' cost of funding differentially. We find that when lower, negative policy rates do not translate into lower deposit rates, as is the case in Germany but not in Portugal, standard channels of monetary-policy transmission, such as the bank-capital channel, are dominated by the effect on high-deposit banks' cost of funding.

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1 Introduction

The Great Recession and central banks' response to it have sparked renewed interest in studying if and how monetary policy affects the economy, in particular the role of banks' supply of credit. What proves particularly challenging is the co-existence of different transmission channels, possibly exacerbated by heterogenous currency unions.

In this paper, we offer a unified view of bank lending that incorporates the role of both banks' net worth and their deposit franchise. To this end, we incorporate the potential role for deposit funding in the transmission of monetary policy (Drechsler, Savov, and Schnabl, 2017). Furthermore, with the occurrence of negative nominal interest rates, there exists growing evidence that the transmission of policy rates to deposit rates can be impaired due to a zero lower bound on (retail) deposit rates, which ultimately affects deposit-funded banks' cost of funding and, thus, their lending decisions (Heider, Saidi, and Schepens, 2019).

The impairment of the pass-through of monetary-policy rates to deposit rates motivates why economy-wide characteristics in a heterogenous currency union can affect monetary-policy transmission. In particular, the substitutability of government bonds and deposits in providing liquidity services to households (Li, Ma, and Zhao (2020)) suggests that higher sovereign risk can give rise to deposit rates that are further away from the zero lower bound.

We explore how such deposits channel of monetary policy, which has gained relevance in the aftermath of the financial and sovereign debt crises, affects and interacts with more standard channels of monetary-policy transmission, such as the bank-capital channel (Kashyap and Stein, 2000; Jiménez et al., 2012). In doing so, we account for the idea that the effectiveness of monetary policy depends also on the underlying heterogeneity of the economies within a currency area. In particular, we show that lower, negative policy rates are transmitted heterogenously to deposit rates across economies in the same currency area.

To identify if and when different modes of monetary-policy transmission are at work, we exploit the introduction of negative monetary-policy rates by the European Central Bank (ECB), which moved the deposit facility (DF) rate, its main policy rate, to negative territory in June 2014. Heider, Saidi, and Schepens (2019) show that negative policy rates affect deposit-dependent banks' lending decisions if banks are reluctant to pass on negative rates

to their depositors. This impairment in the pass-through of policy rates to deposit rates determines the strength of the deposits channel. However, if deposit rates continue to drop in response to lower, negative policy rates, other, more standard channels of monetary-policy transmission should still be at work.

By exploiting the rich heterogeneity within the euro area around the introduction of negative policy rates, we can concurrently estimate the strength of the deposits channel vis-à-vis the bank-capital channel of monetary-policy transmission. We use a unique combination of confidential credit-registry data from the Deutsche Bundesbank and Banco de Portugal to shed light on the effect of monetary policy on bank lending and risk taking in two economies representing the core and the periphery of the euro area. Two key parameters determine the nature of the channel through which negative policy rates affect bank lending and risk taking in the euro area: (i) the level of deposit rates prior to the introduction of negative rates across economies in the euro area and (ii) banks' capitalization and reliance on deposit funding within each economy in the euro area.

We find that due to the fact that deposit rates used to be already close to the zero lower bound in Germany, a core economy in the euro area, banks are unwilling, or simply unable, to reduce deposit rates further. This gives rise to the deposits channel under negative rates in Germany, affecting the lending by deposit-funded banks. In contrast, high deposit rates in Portugal allow banks to drop rates further in response to the introduction of negative monetary-policy rates in the euro area, so that Portuguese banks are not differentially exposed according to their funding structure. Instead, the introduction of negative rates affects bank lending in a similar fashion as do regular rate cuts in non-negative territory. That is, lower, negative rates relax Portuguese banks' constraints to supply credit if these banks are weakly capitalized. However, we find that the bank-capital channel is not at play in Germany. This suggests that more standard channels of monetary-policy transmission, such as the bank-capital channel, rely on the pass-through of policy rates to deposit rates.

We obtain these results using credit-registry data at the bank-firm-time level in conjunction with firm-level balance-sheet data allows us to identify changes in credit supply to firms as a function of banks' exposure to the introduction of negative monetary-policy rates in June 2014. We determine banks' exposure to monetary policy for the deposits channel by

their deposits-to-assets ratio, and for the bank-capital channel by their equity-to-assets ratio. In addition, we include bank fixed effects to control for time-invariant heterogeneity at the bank level, such as banks' different business models.

A lingering concern is that monetary policy is inherently endogenous and, thus, correlated with firm-level drivers that characterize the economic environment at the time (Nakamura and Steinsson, 2018) and that may also reflect firms' general demand for loans (irrespective of the bank providing it). To address this, we include firm-time fixed effects that absorb time-varying unobserved heterogeneity at the firm level, including but not limited to loan demand (see, for instance, Khwaja and Mian (2008) and Jiménez et al. (2012)). This implies that our estimates are identified using firms with multiple bank relationships.

We find that high-deposit banks in Germany expand their lending but only to risky firms, whereas other channels of monetary-policy transmission are muted. In contrast, weakly capitalized banks generally expand their lending in Portugal, whereas their funding structure bears no relevance for these lending decisions.

We then use firm balance-sheet data to ascertain whether firms that receive loans from differently treated banks exhibit different investment and employment. In particular, we focus on newly established lending relationships after the introduction of negative policy rates, as our results on banks' lending decisions suggest that the extensive margin is the relevant dimension along which banks adjust their lending behavior.

In this manner, we show that new loans are associated with increases in firm-level investment and employment across the board in Portugal, and equally so for both risky and safe borrowers. In contrast, deposit-funded German banks seek to establish new lending relationships with risky borrowers that are more likely to be financially constrained. As a result, we find that credit supply by high-deposit banks yields stronger investment and employment responses in Germany.

Besides allowing us to assess the relative strengths of the deposits channel in comparison to the bank-capital channel of monetary-policy transmission, our data from two extreme ends of the euro-area spectrum – the core (Germany) and the periphery (Portugal) – can be instrumental in revisiting the heterogeneity of monetary-policy pass-through across the euro area.

We take a first step in this direction by using our estimates to infer the effects of the deposits channel vs. the bank-capital channel on bank lending in the euro area. We do so by modeling each euro-area country as a convex combination of the German and the Portuguese banking system, depending on the deposit-rate pass-through of monetary policy around the introduction of negative rates, which we have identified as a key determinant of the mode of monetary-policy transmission.

We find that the deposits channel has a similar effect on lending in the euro area as does the bank-capital channel. However, the initial level of the deposit rates determines which channel dominates. If the transmission of monetary policy to deposit rates is impaired – as in Germany – this has the potential to almost entirely shut down more traditional channels such as the bank-capital channel in favor of the deposits channel, not just in Germany but also in other countries with deposit rates close to the zero lower bound at the outset, such as Finland.

Our paper is most closely related to the literature on monetary-policy transmission through banks (e.g., Gertler and Kiyotaki (2010)), and especially to the literature exploring the transmission of monetary policy when interest rates are negative (Altavilla, Giannetti, and Holton (2019), Amzallag et al. (2018), Ampudia and den Heuvel (2018), Arce et al. (2018), Bottero et al. (2019), Bubeck, Maddaloni, and Peydró (2019), Demiralp, Eisenschmidt, and Vlassopoulos (2018), Eisenschmidt and Smets (2019), Eggertsson et al. (2019), Nucera et al. (2017), Porcellacchia (2019), Ulate (2020)). We contribute to this literature by offering a unified view that encompasses underlying mechanisms of the bank lending channel (Kashyap and Stein (2000), Kishan and Opiela (2000), Jiménez et al. (2012), Gomez et al. (2020)) and the bank risk-taking channel (Jiménez et al. (2014), Ioannidou, Ongena, and Peydró (2015), Dell'Ariccia, Laeven, and Suarez (2017), Paligorova and Santos (2017), Bonfim and Soares (2018)).

To the best of our knowledge, this paper is the first comprehensive attempt to simultaneously explore multiple channels of monetary-policy transmission in a heterogenous currency union. Our insights also help to corroborate what may seem like contradictory findings in the literature on the transmission of negative monetary-policy rates. The lacking explanatory power of the deposits channel in Italy, with high deposit rates at the outset, which is pointed out by Bottero et al. (2019), chimes with our Portuguese evidence. In contrast, the

increase in risk taking by deposit-funded banks is in line with extant euro-area evidence in the literature – which is, on average, dominated by the large German banking sector – such as Heider, Saidi, and Schepens (2019) or Bubeck, Maddaloni, and Peydró (2019), but also outside the euro area, e.g., in Switzerland (Basten and Mariathasan (2018)).

2 Background and Hypothesis Development

2.1 Heterogeneity in Deposit Rates across Euro-area Countries

We seek to identify instances in which the transmission of monetary policy depends on banks' cost of funding. If monetary policy transmits to market rates and banks' deposit rates, it naturally affects banks' cost of funding. As such, lower policy rates reduce banks' cost of funding and, thus, allows them to expand their lending.

This argument hinges on a reduction in monetary-policy rates, but is not conditional on the level of such rates. When the policy rate decreases, on average, the transmission to both deposit rates and market rates tends to be strong (Hannan and Berger, 1991; Driscoll and Judson, 2013). However, in a low-rate environment, banks' funding structure starts to matter because of the zero lower bound on deposits, which is due to banks' inability or unwillingness to charge their depositors negative rates. Therefore, the differential pass-through of policy rates to deposit vs. market rates is especially pronounced once policy rates drop below zero (Heider, Saidi, and Schepens, 2019; Eggertsson et al., 2019).

After the financial and especially after the sovereign debt crisis, deposit rates (and more generally, bank funding costs) differ significantly across euro-area countries. With this, the transmission of monetary policy differs across the euro area, possibly further increasing imbalances in the euro area.

This is particularly true in 2014, just prior to the introduction of negative monetary-policy rates in the euro area. Take Portugal and Germany as an example. There is a large difference between these countries in terms of deposit rates' distance to the zero lower bound. This can be seen in Figure 1 which plots the country-level weighted deposit rate.[1] When the

[1]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 Appendix documents the evolution of

policy rate turns negative in June 2014 (vertical line), the average deposit rate in Germany is already close to the zero lower bound (around 0.5%). In contrast, the average rate in Portugal is still above 1.5%.

This implies that while German banks had limited options to further reduce deposit rates, banks in Portugal still had ample scope for a rate reduction. In other words, negative rates led to lower funding costs for Portuguese banks, but not so for German banks, thus making this unconventional monetary policy tool work to a large extent like a conventional interest-rate cut in Portugal.

Figure 2 illustrates this point in more detail and for a broader set of euro-area countries. The figure shows the percentage-point change in country-level weighted deposit rates between May 2014 and four other points in time: December 2014, June 2015, December 2015, and June 2016. The drop in deposit rates is more pronounced in Portugal than in Germany. This suggests that the pass-through of reductions in the policy rate is more limited in countries with rates that are already close to the zero lower bound.

The differential evolution of deposit rates implies that deposit-funded banks incur higher cost of funding than otherwise-funded banks in Germany, but not in Portugal. The subsequent (differential) effect on banks' net interest margins could be undone, however, if loan rates fell more in Portugal than in Germany. As can be seen in Figure 3, quite the opposite is the case. The spread between loan rates and deposit rates is constant up to the introduction of negative monetary-policy rates after which it experiences a steep decline in Germany. In contrast, the Portuguese spread has been increasing since the beginning of 2013, well ahead of the introduction of negative monetary-policy rates. This lends further support to the idea that the latter had no differential effect on the funding cost of deposit-funded banks, as opposed to banks less reliant on deposits, in Portugal.

A remaining question is why average deposit rates vary so much across countries. In the specific case of Portugal, the Troika intervention[2] during the sovereign debt crisis in 2011 had, among others, the objective of safeguarding stable deposit funding for the largest

deposit rates for a broader set of euro area countries, showing a large heterogeneity across countries.

[2]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.

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. In this regard, we exploit the interaction of the introduction of negative monetary-policy rates with previous policy interventions.

A more general explanation for the heterogeneity in deposit rates could lie in the difference in sovereign-bond yields across countries and their positive correlation with deposit rates.[3] Figure 4 illustrates this positive correlation. The figure shows the evolution of the deposit rates in four euro-area countries (France, Italy, Germany, and Portugal) together with the rates on 5-year government bonds in these countries. Government bond yields differ because of inherent/structural weaknesses that became visible after the crisis, the lack of a fiscal union, and the inability to conduct separate monetary policy.

The fact that government bond rates increased more in some countries during the sovereign debt crisis could be a potential explanation for the higher deposit rates in these countries for at least two reasons. First, government bonds might be close substitutes for deposits (Li, Ma, and Zhao (2020)). As a consequence, when bond rates increase, banks have to keep deposit rates at an elevated level in order to be able to compete with this alternative investment opportunity. This notion is in line with the model of Wang et al. (2020) in which banks set up deposit rates based on the Federal funds rate precisely to compete with depositors. We point to an important implication of this bank-sovereign competition for depositors' resources, namely its impact on how monetary policy is transmitted.

In addition, risk premia on government bonds and deposits might be closely linked. In periods of sovereign stress the (perceived) riskiness of the banking sector is likely to increase and, hence, depositors might require a higher return on their deposits during these periods. Both explanations imply that sovereign stress leads to higher deposit rates and, thus, also impacts the pass-through of negative interest rates.

We next turn to a simple model that formalizes the idea that the pass-through of monetary policy to deposit rates, which we have shown to be heterogenous across the euro area, determines the channel through which monetary policy affects bank lending.

[3]The direction of causality is not clear, however, due to a potential feedback loop: as high funding cost makes banks risky, the cost of bail-outs/or lack of demand for government bonds from banks increases government bond yields.

2.2 A Simple Model of Different Channels of Monetary-policy Transmission through Banks

The following is a simple static model of a representative bank's lending decision in reaction to a decrease in the policy rate. The essence of the model is a net-worth constraint that potentially limits bank lending. To derive the net-worth constraint, we build on the idea of a wedge between physical returns and pledgeable returns as in Holmström and Tirole (1997). Like them, we motivate the wedge with a moral-hazard problem. Outsiders cannot observe the intensity with which a bank monitors its borrowers.

Model setup

On the asset side, the bank has loans L. Each loan returns $R(L)$ with probability one when the bank monitors. More lending (weakly) lowers the loan rate, $R' \leq 0$, i.e., the bank faces a downward-sloping loan-demand curve. If the bank shirks on monitoring, a loan returns $R(L)$ only with probability $q < 1$ (and 0 with probability $1 - q$), but the bank gains a private benefit b per loan.[4] We assume $R(L) > qR + b$, i.e., monitoring is efficient.

On the liability side, the bank has deposits D, market-based debt (bonds) B, and equity E. We assume equity is fixed. It is costly to issue new equity, especially in the short run (e.g. as a reaction to monetary-policy changes). Hence, more lending goes hand in hand with more deposits and market-based debt, both of which are elastically supplied as long as depositors and bond-holders break even. The bank is protected by limited liability. When the loan return is $R(L)$, the bank pays out D and B to depositors and bond-holders. When the loan return is 0, the bank defaults and pays nothing.

The bank monitors its loans if the following incentive constraint holds:

$$(R(L) - D - B)L \geq q(R(L) - D - B)L + bL,$$

which simplifies to

$$R(L) - \frac{b}{1-q} \geq D + B \tag{1}$$

[4] As in Holmström and Tirole (1997), default is correlated across loans. Making more loans does not change the probability of default.

Following Holmström and Tirole (1997), we call $R(L) - \frac{b}{1-q} \equiv \mathcal{P}(L) > 0$ the pledgeable return, i.e., the amount per loan the bank can promise to depositors and bond-holders without jeopardizing incentives to monitor borrowers.

We assume the proportion of deposits to market-based debt is fixed. This proportion reflects the bank's intrinsic business model, which also is difficult to change in the short run. Specifically, denote d the proportion of outside funding $L - E$ that depositors contribute.

When the bank monitors, depositor are willing to contribute their funds as long as

$$DL \geq d(L - E)r_D, \tag{2}$$

where r_D is the required return on deposits. Similarly, bond-holders are willing to contribute their funds as long as

$$BL \geq (1 - d)(L - E)r_B, \tag{3}$$

where r_B is the required return on market-based debt.

The bank choses the amount of loans, deposits, and bonds to maximize profits $(R(L) - D - B)L$ subject to the incentive constraint (1) and the participation constraints (2) and (3). The participation constraints bind because it is optimal to reduce the payment to depositors and bond-holders as much as possible. Hence, the bank lends L to maximise

$$R(L)L - (L - E)\hat{r} \tag{4}$$

subject to

$$\mathcal{P}(L)L \geq (L - E)\hat{r} \tag{5}$$

where $\hat{r} = dr_D + (1 - d)r_B$ is the average required rate of return on the bank's liabilities.

The incentive constraint (5) can also be written as

$$\left(\frac{\hat{r}}{\hat{r} - \mathcal{P}(L)}\right) E \geq L. \tag{6}$$

The bank's equity (or net worth) limits lending. We assume the pledgeable return is sufficiently low, $\mathcal{P}(L) < \hat{r}$. Otherwise, the incentive constraint is redundant. The term $\frac{\hat{r}}{\hat{r} - \mathcal{P}(L)} > 1$

is the equity multiplier.[5]

Optimal lending

The optimal credit supply of the bank is given by the first-order condition with respect to L:

$$R(L)'L + R = \hat{r} + \lambda\left[\hat{r} - \mathcal{P}(L) - \mathcal{P}(L)'L\right],$$

where λ is the Lagrange multiplier on the net-worth constraint (6). The optimal credit supply of the bank equates the marginal benefit of lending (left-hand side) and the marginal cost of financing (right-hand side). The marginal cost of financing is given by the average required rate on the bank's liabilities $\hat{r}$ plus an extra term. The extra term is positive if the constraint binds, $\lambda > 0$ (note that $\hat{r} > \mathcal{P}(L)$ and $\mathcal{P}(L)' < 0$).

The fraction after λ captures how lending affects the marginal cost via the net-worth constraint. More lending tightens the constraint via the required return $\hat{r}$ but loosens the constraint via more pledgeable return (although at a decreasing rate).

It is instructive to write the first-order condition as

$$L = \frac{1}{\epsilon}\left[\frac{R(L) - \hat{r}(1+\lambda) + \lambda(\mathcal{P}(L) + \mathcal{P}(L)'L)}{R(L)}\right], \tag{7}$$

where $\epsilon = -\frac{R(L)'}{R(L)} > 0$ is the semi-elasticity of the loan return with respect to the loan volume.

To gain some intuition, assume a slack net-worth constraint ($\lambda = 0$). Then (7) becomes

$$L = \frac{1}{\epsilon}\frac{R(L) - \hat{r}}{R(L)}. \tag{8}$$

The optimal lending is given by the (relative) net interest margin times a term that has the spirit of a Lerner index.

[5] As usual, we also assume that the bank cannot operate if it does not monitor. A sufficient condition for this assumption to hold is that unmonitored loans are wasteful, $qR + b - \hat{r} < 0$, and the return on equity by itself is at least as high as $\hat{r}$.

Monetary policy

We assume the following about the pass-through of a lower policy rate r_P to other rates. First, there is a limited pass-through to the loan rate R because loans are long term and opaque. Second, there is full pass-through to the rate on market-based debt r_B. And third, the pass-through to deposit rates r_D depends on the level of deposit rates. If deposit rates are high (Portugal), then there is full pass-through. If deposit rates are low (Germany), the zero lower bound on deposits rates binds and there is no pass-through.

Standard bank-capital channel (Portugal)

A high-equity bank has a slack net-worth constraint and its lending is given by (8). A policy rate cut lowers the required rate on bank liabilities, which leads to more lending. A low-equity bank has a binding net-worth constraint. It reacts more strongly to the rate cut because the cut also relaxes the constraint. Importantly, it does not matter whether lending is financed with deposits or with market-based debt because the lower policy rate is passed through to both a lower deposit rate r_D and a lower rate on market-based debt r_B.

Deposits channel (Germany)

In Germany, there is no pass-through to lower deposit rates. For simplicity, consider unconstrained banks. Their lending is given by

$$L = \frac{1}{\epsilon} \frac{R(L) - (dr_D + (1-d)r_B)}{R(L)}.$$

For a high-deposit bank ($d \approx 1$), the lower policy rate does not lead to a lower required return on bank liabilities because r_D does not change (deposit rates are already low and do not go negative) and r_B plays no role. A low-deposit bank ($d \approx 0$) instead experiences a lower required return because the lower policy rate transmits to lower rates on market-based debt.

The lower policy rate r_P also lowers the loan rate $R(L)$ somewhat. Normally, the pass-trough to loan rates is small so that the overall interest margin $R(L) - r_D$ increases when the policy rate falls. This is the case in Portugal but not Germany (see Figure 3). In Germany,

the zero lower bound on deposit rates leads to a lower net interest margin $R(L) - r_D$.

The lower interest margin for high-deposit banks may induce them to switch to a different lending technology. In particular, high-deposit banks may chose to monitor borrowers a little less and in return, benefit from a (small) private benefit, τ. Monitoring less reduces the probability of obtaining the loan return $R(L)$ to $1 - \delta$, i.e., lending becomes riskier. Note that the bank does not choose this lending technology in the absence of lower policy rates because riskier lending reduces the pledgeable return and hence, limits profitable lending more.

Note also that when there is limited pass-trough to the required rate $\hat{r}$, because r_D does not move, then the limited pass-trough to the loan rate $R(L)$ may leave the net interest margin for the average bank $R(L) - \hat{r}$ unchanged as the policy rate changes. This means that banks with different amounts of equity react the same (i.e., not at all) to a lower policy rate and the standard bank-capital channel is not present.

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 effects of negative monetary-policy rates on bank lending in Germany and Portugal, alongside their real effects, and the importance of different transmission channels in these economies.

3.1 Data Description and Summary Statistics

We collect data on German and Portuguese banks, firms, and loans granted by the former to the latter between 2010 and 2016. Table 1 reports summary statistics on all the variables for the two countries.

The data used in this paper are based on confidential datasets available at the Deutsche Bundesbank and Banco de Portugal. This allows us to have a unique coverage of lending activities in two economies representing the core and the periphery of the euro area, which, as far as we are aware, is unprecedented in the literature. In both cases, the data can only be explored on site. All tables report simultaneously the results for Germany and Portugal.

Though there are minor differences in the data sources across the two countries, all variables are constructed in the most consistent way whenever a fully compatible definition is not available.

The bank-level data come from the BISTA dataset (Beier et al., 2017) in Germany, and from Monetary and Financial Statistics in Portugal. During part of our sample period, supervisory data were not fully harmonized across the European Monetary Union. Our definition of a bank refers to any credit institution that has a license to receive deposits from customers.

We use the German and Portuguese economies as representatives for the core and the periphery of the euro area. As such, the two countries also have different banking systems. There are three main types of banks in Germany: savings banks, cooperative banks, and commercial (universal) and private banks. The savings banks in Germany (the so-called Sparkassen) are manifold, but they are all 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 focus. The total number of branches is greater than 30,000. We focus on the bank-holding-company level for each independent bank in Germany, amounting to 1,103 banks in our data. This also matches the banking level at which credit transactions are recorded in the German credit register (Schmieder, 2006).

Similarly, we also focus on the bank-holding-company level in Portugal. However, some of these banks may be part of banking groups, which are typically functionally but not geographically diversified. As such, they match the scope of banking activities of German banks in our data. Therefore, we determine banks' exposure to negative policy rates through the main entity of a banking group if the respective bank is part of such a group. We furthermore limit our sample of banks to those financial institutions with ratios of deposits over total assets in excess of 5%. The resulting set of 47 Portuguese banks comprises 26 standalone 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.

One of the key variables of interest is the deposit ratio, defined as deposits over total

assets, which we measure in the year prior to the introduction of negative policy rates, 2013. This variable captures to what extent a given bank is exposed to the shock associated with negative rates (Heider, Saidi, and Schepens, 2019). A bank that is highly dependent on deposit funding will face a stronger pressure on its profits when rates become negative, given that the bank will want to avoid, or will not be allowed, to impose negative rates on its depositors. In Portugal, banks face a legal restriction on this, as they are not allowed to offer negative rates on bank deposits. However, as discussed above, this restriction was far from being binding when policy rates became negative (see Figure 1). Only in late 2018 did deposit rates converge to levels close to those offered in Germany. In contrast, there is no legal restriction in Germany, but deposit rates were already close to the zero lower bound.

As can be seen in Panel A of Table 1, banks in Germany are, on average, more reliant on deposit funding. Their average deposit ratio in the sample period is 53.9%, compared to 38.1% in Portugal. The sizable difference is, in part, related to the presence of many smaller banks in the German system. These banks have a more traditional intermediation structure, relying more on deposits as their primary funding source. In Portugal, some of the smaller banks are foreign-owned, thus relying more extensively on internal capital markets.

We contrast banks' exposure to the introduction of negative monetary-policy rates with another, more traditional channel of monetary-policy transmission, namely banks' capitalization (Kashyap and Stein, 2000). For this purpose, we compute equity ratios as equity over total assets in 2013. Equity refers to the accounting book value and not to regulatory capital. On average, the equity ratio is higher in Portugal, but there is significantly more dispersion. The more extreme values refer to small banks with very specific business models.

Even though the German banking system is much larger than the Portuguese one, the average bank size is larger in Portugal. This suggests that the banking system is more concentrated in Portugal. The statistics just described allow us to characterize the average bank in the two economies. However, given that the distribution of many of these variables is highly skewed, with typically a few banks having a very large market share, they offer only a partial view of the aggregate banking system.

To address this, in Panel B of Table 1, we present statistics at the bank-firm-time level, which is our unit of observation in credit-register-based regressions (Tables 2 to 6). 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, the number and duration of bank relationships, and also to identify new loans granted to each firm. In Germany data are quarterly, and in Portugal they have a monthly frequency. Both datasets allow for the link with balance-sheet data from BISTA and monetary and financial statistics, using a unique bank identifier.

It is also possible to merge the information from the credit registers with data on firms' balance sheets and profit-and-loss statements. In Germany, we collect data on firms through Bureau van Dijk's Amadeus database (see Schild, Schultz, and Wieser (2017)), and limit our sample to firms with such balance-sheet data. For Portugal, data on firms are widely available thanks to a joint initiative of Banco de Portugal, Statistics Portugal, the Ministry of Finance, and the Ministry of Justice (Informação Empresarial Simplificada).[6]

In this manner, we yield 345,180 observations in Germany and 1,529,890 observations in Portugal for the period $2013 - 2015$ around the introduction of negative monetary-policy rates. The larger sample for Portugal, even after accounting for the difference in reporting frequencies, reflects the fact that the data coverage is different in the two countries. While for Portugal there is information for the entire universe of firms in the economy, in Germany there is a reporting threshold for credit (Bundesbank) and firm-level (Amadeus) data. Focusing on reporting thresholds in the credit-register data, in Portugal the threshold is €50, while in Germany it is at least €1 million (for the size of the initial loan, not for the loan amount outstanding).[7] The latter suggests that the additional sample selection due to availability of Amadeus data for German firms is unlikely to be very restrictive.

Much like for banks' comparability across the two economies, we need to address potential concerns stemming from the different coverage in the two samples. We do so by using only the sample of Portuguese firms with at least ten employees, while acknowledging that the distribution of firms and the real economic landscape are different in Germany and Portugal.

Some of the results presented in Panel B of Table 1 differ from those presented in Panel A.

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

[7]The reporting threshold was reduced from formerly €1.5 million in January 2015.

The differences from using bank-level vs. bank-firm-level data reflect the differences in data coverage and, more importantly, the differences in the structure of the two banking systems. In Germany there are many more banks than in Portugal, but their average size in terms of total assets is smaller.

In Panel B, the bank characteristics are weighted by the number of firms each bank lends to, leading to some of these differences. For instance, the average deposit ratio of banks in the two economies becomes similar. The differences also become smaller in terms of banks' equity ratios, even though they remain higher in Portugal. The average bank size is now larger in Germany.

We also report the dependent variables from our credit-register-based regressions in Panel B. *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 $t-1$. In Germany 5.3% of the observations refer to loans obtained from a bank that a firm was not borrowing from before, in Portugal 1.6% 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 attains credit from a bank b for the first time or not. Approximately 22% of the observations refer to new bank loans in both countries. Finally, the average loan amount in Germany is €6.3 million, but only €728 thousand in Portugal, reflecting primarily the differences in reporting thresholds of the two respective credit registers.

In Panel C, we present summary statistics for our firm-level analysis (in Tables 7 and 8) of the real effects, in terms of investment and employment, of receiving loans from either existing or new bank relationships following the introduction of negative monetary-policy rates. Each observation summarizes information comparing the post-period ($2014-2016$) to the pre-period ($2011-2013$). In line with the summary statistics at the bank-firm-time level (in Panel B), Portuguese firms are much less likely to establish new lending relationships than German firms, whereas the difference is reduced strongly for increases in loan exposure stemming from existing lending relationships. Conditional on new relationships being established, however, firms' exposure to banks' equity ratios and deposit ratios – captured by *Equity exposure*$_f$ and *Deposit exposure*$_f$, respectively – is quite similar across both economies.

3.2 Identification and Empirical Specification

The level of observation in Panel B of Table 1 is the point of departure for describing our empirical strategy. In doing so, we start from the bank-firm-time level bft. Our main focus will be on the extensive margin of credit, as this is where banks can react most easily when policy rates change.

First, for each firm f that appears because it has an outstanding loan at some time t from bank b, we fill up the respective bft panel with zeros throughout. This enables us to compare credit exposure in t to credit exposure in $t-1$ in order to determine whether a firm's credit exposure to a given bank has increased due to a new bank-firm relationship.

We can then estimate the following specification:

$$New\ relationship_{bft} = \beta Exposure_b \times After(06/2014)_t + \mu_b + \theta_{ft} + \varepsilon_{bft}, \tag{9}$$

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, $After(06/2014)_t$ 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.

In addition, we also estimate a specification where the dependent variable captures the volume impact of this increase at the extensive margin, $\ln(Credit_{bft})$, conditional on $New\ relationship_{bft} = 1$.

To separately estimate the intensive margin of credit, we limit the sample to observations for which $Credit_{bft} \neq 0$, and replace the bank fixed effects by bank-firm fixed effects, so the change in the credit volume is measured within the same firm (while maintaining the within-bank approach needed for the identification).

We then estimate the following specification:

$$\ln(Credit_{bft}) = \beta Exposure_b \times After(06/2014)_t + \delta_{bf} + \theta_{ft} + \varepsilon_{bft}, \tag{10}$$

where $Credit_{bft}$ is the (non-zero) credit exposure of firm f and bank b at time t, and δ_{bf} and θ_{ft} denote bank-firm and firm-time fixed effects, respectively.

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 for the entire sample period it receives credit from only one bank b.

In (10), 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 (9), 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) credit from another bank, where the banks possibly have different exposures.

4 Empirical Results

4.1 Credit Supply

In the following, we run our specifications (9) (alongside some variants thereof) and (10), using two different bank-exposure variables, separately for Germany and Portugal.

In Table 2, we start with the bank-capital channel, which we capture by using *Equity ratio*$_b$, bank b's ratio of equity over total assets in 2013. In the top panel, we estimate (9), and use as dependent variable *New relationship*$_{bft}$ so as to capture the extensive margin of credit. The table reflects the general structure for the presentation of our results, also in the remainder of the paper. Namely, we always show the baseline results for the total regression sample of a given country, and then split up 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. We label firms as risky (safe) if they rank in the top (bottom) tercile of the latter distribution.

As in Portugal, unlike in Germany, the pass-through of lower policy rates to deposit rates is not impaired, and loan rates drop less than do deposit rates (see Figure 3), our model in Section 2.2 predicts that lower – even negative – monetary-policy rates relax Portuguese

banks' (equity) constraints to supply credit if these banks are weakly capitalized. In columns 1 to 3 of Table 2, we see that weakly capitalized Portuguese banks respond to lower, even negative monetary-policy rates by expanding their credit supply. They do so for both risky and safe firms.

In contrast, in columns 4 to 6, the bank-capital channel bears no effect at all on German banks' credit supply. Our model implies that this is a consequence of German banks' inability to adjust deposit rates below zero. Put differently, when the pass-through of monetary-policy rates to banks' funding cost (here: the cost of deposit funding) is impaired, this may trump other transmission channels, such as the bank-capital channel, that should generally be at play when monetary-policy rates drop, irrespective of whether they are negative or not.

To test the role of banks' funding structure, in particular their reliance on deposits, we replace the bank-level exposure variable by $Deposit\ ratio_b$, 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 are in the bottom panel. In columns 7 to 9, we find no significant effect at all for Portuguese banks. Conversely, in the last three columns, we see that high-deposit banks expand their credit supply, but this pertains to the establishment of new lending relationships with risky German firms (column 11). The fact that high-deposit German banks expand their lending only to some firms reflects the possibility of a reversal in our model when there is very little pass-through to the required return for debtholders. At the same time, the policy-rate cut into negative territory induces risk taking by deposit-funded German banks.

All of these findings also hold true in Table 3 where we replace the dependent variable by the actual loan amount granted whenever a new lending relationship is established. In Appendix-Table B.2, the effects become even stronger when considering combined extensive and intensive margins by using as dependent variable $Any\ new\ credit_{bft}$, which reflects any increase in loan exposure (not only the establishment of new relationships).

Finally, in Table 4, we estimate the intensive margin of credit, namely specification (10). For both the bank-capital and the deposits channel, we find no consistent or even strong results. Some estimates for the deposits channel are noteworthy. For Portugal, we find that

high-deposit banks increase their lending to risky firms (column 8), but the coefficient is not discernibly different from that in column 9 for the subsample of safe firms. For Germany, we find that high-deposit banks actually increase their exposure to safe (column 12), rather than risky, firms. This suggests that the expansion in credit to new, risky firms potentially comes at the cost of reducing credit exposure to risky firms that are standing borrowers. This is consistent with our model insofar as we characterize risk taking by a lack of monitoring by high-deposit banks, so that it operates primarily through the extensive margin of establishing new lending relationships with risky, rather than safe, borrowers.

In summary, in Germany, where deposit rates were already low and, thus, close to the zero lower bound prior to the introduction of negative policy rates, the deposits channel of monetary-policy transmission (Heider, Saidi, and Schepens, 2019) is at play, whereby deposit-funded banks focus their lending on risky firms. In contrast, whether banks rely heavily on deposit funding does not seem to be relevant at all for the risk taking of banks in Portugal, where deposit rates used to be very high and the introduction of negative monetary-policy rates has led to further reductions in deposit rates.

We next present a battery of robustness checks. First, in Table 5, we re-run all specifications from Table 2, but additionally control for the lagged exposure variable of the alternative channel. That is, we include $\textit{Deposit ratio}_{bt-1}$ in the top panel, and $\textit{Equity ratio}_{bt-1}$ in the bottom panel. The sample size drops somewhat in both countries due to the additional bank balance-sheet data requirement one year prior to time t (whereas the exposure variables are time-invariant and measured in 2013). However, all results remain robust. In particular, the coefficient on $\textit{Equity ratio}_b \times \textit{After}(06/2014)_t$ is constant across all three subsamples (all, risky, and safe borrowers) in Portugal (see columns 1 to 3). In Germany, the difference in coefficients on $\textit{Deposit ratio}_b \times \textit{After}(06/2014)_t$ for risky vs. safe borrowers (columns 11 and 12) is more emphasized than in our baseline estimation.

More generally, one may be concerned that the different exposure variables are correlated with other bank balance-sheet characteristics that affect the transmission of monetary policy, e.g., banks' liquidity and size, as suggested by Kashyap and Stein (2000). To address this concern, besides controlling for the lagged exposure variable of the alternative channel, as in Table 5, we also include $\textit{Securities ratio}_{bt-1}$, 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 6, and the coefficients of interest are virtually invariant from those in Table 5.

Finally, by including firm-time fixed effects (as in Khwaja and Mian (2008)), we identify the treatment effect off firms using multiple bank relationships. Such sample selection potentially limits the external validity of our findings. This concern may not be as severe in our sample (matched with firm balance-sheet data), 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) that allow us to identify banks' credit supply using both single-bank and multi-bank firms. The results from this procedure are in Appendix-Table B.3, and compare favorably with the respective estimates in Table 2.[8]

4.2 Real Effects

To conclude our regression-based empirical evidence, we move to a firm-level analysis to trace the real effects of the different types of monetary-policy transmission in Germany and Portugal. As we have documented, negative monetary-policy rates affect banks' lending decisions along the extensive margin. This implies that banks adjust their lending to (potential) new borrowers (which we have found to be the case in both Portugal and Germany), and seek out risky borrowers to supply more credit to them (as is the case in Germany).

In order to properly account for the fact that negative monetary-policy rates induce banks to adjust their lending to new borrowers rather than existing ones, we estimate real effects on firm-level investment and employment as a function of credit granted in the post-period, and compare the source of loans with that in the pre-period. This is in contrast to a shift-share approach (see, e.g., Greenstone, Max, and Nguyen (2020)) which implicitly assumes that firms' bank relationships from the pre-period (in our case, before the introduction of negative rates) are equal to the set of banks from which firms will (continue to) borrow in

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

the post-period.

For this analysis, 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 received credit from a new relationship by defining $\textit{New relationship}_f$ as 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 introduction of negative monetary-policy rates. As such, the probability that for a given firm $\textit{New relationship}_f = 1$ is a function of whether that firm is a beneficiary of any bank's credit supply in the post-period, as reflected by our estimates in Table 2.

Conditional on $\textit{New relationship}_f = 1$, we can further test whether a new bank relationship leads to different firm-level investment or employment outcomes as a function of that bank's equity or deposit ratio. This would be the case if a bank with a certain equity or deposit ratio was to seek new relationships with firms that are more or less financially constrained. In particular, risky firms tend to be more constrained (see, among others, Neuhann and Saidi (2018)), so that credit supply is more likely to lead to additional investment or employment by risky firms. To test this, we run the following regression specification:

$$y_f = \beta \textit{New relationship}_f + \gamma \textit{New relationship}_f \times \textit{Exposure}_f + \delta \textit{New credit}_f + \theta_j + \varepsilon_f, \quad (11)$$

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 1^{st} and 99^{th} percentiles, and $\textit{Exposure}_f$ is either $\textit{Equity exposure}_f$ or $\textit{Deposit exposure}_f$, which are defined as the average $\textit{Equity ratio}_b$ or $\textit{Deposit ratio}_b$ (measured in 2013) of all banks with which firm f contracts 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.

To exclude that our estimates of β and γ do not mirror the effects of any increases in loan exposure, rather than the establishment of new lending relationships, we also control for $\textit{New credit}_f$, which 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 introduction of negative monetary-policy rates.

Finally θ_j denotes a set of fixed effects based on firm f's industry, location, and/or decile in the firm-size distribution. As the level of observation in (11) is the result of a first difference within firms, θ_j 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 (11) for firm-level investment and employment are in Tables 7 and 8, respectively. For Portugal in the first six columns, firms with new bank relationships tend to see larger increases in investment and employment than do firms that just receive more credit from existing bank relationships. This reflects the idea that firms that (have to) establish new bank relationships to attain credit may have been previously financially constrained, which in turn implies that they should exhibit a higher marginal revenue product of capital. Most importantly, none of the interactions of $\textit{New relationship}_f$ with new relationship banks' equity and deposit ratios are significant. This reflects, firstly, the fact that deposit-funded banks are not differentially affected by negative monetary-policy rates and, secondly, the absence of any bank risk taking in Portugal. Undercapitalized Portuguese banks extend more credit, but equally so to both risky and safe borrowers.

This is not the case in Germany where deposit-funded banks seek to establish new lending relationships with risky borrowers that are more likely to be financially constrained and, thus, exhibit a(n even) higher marginal revenue product of capital (Lenzu and Manaresi (2018)). As a result, the investment and employment effects from new relationships are significantly stronger for firms attaining credit from high-deposit banks, as can be seen in columns 10 to 12 of Tables 7 and 8. Using the estimate in column 10, a one-standard-deviation increase in $\textit{Deposit exposure}_f$ (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 $2011 - 2013$.

Generally speaking, our results are robust to controlling for time-varying unobserved heterogeneity at the industry, location, and firm-size decile level. 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 Appendix-Table B.3), which in the case of Germany leads to a decline in statistical power due to a high number of singletons being dropped.

The estimates in Tables 7 and 8 point to a bright side of high-deposit banks' risk taking in Germany. As banks reliant on deposits face relatively higher cost of funding following the introduction of negative rates, and subsequently see their net-interest margins squeezed, they actively redirect their new lending to risky (high-yield) borrowers. As this group of firms tends to have worse credit access, the additional credit supply by high-deposit banks relaxes their constraints to invest and employ workers. This explains why credit supply by other banks yields weaker investment and employment responses.

5 Implications for the Euro Area

Our results document that while uniform (by definition), the ECB's negative interest-rate policy has led to a different treatment of Germany, a core economy of the euro area, and Portugal, in the periphery, in terms of how monetary policy is transmitted to the real sector via banks. If deposit rates converged across countries, the mode of transmission of monetary policy would likely be more uniform across euro-area economies.

In what follows, we predict the euro-area-wide impact of negative monetary-policy rates by combining our estimates for Portugal and Germany with bank-balance-sheet information and deposit rates for a large sample of euro-area countries. In doing so, the underlying premise is that differences in the change of deposit rates across euro-area countries and differences in deposit ratios across banks within each country are key determinants of the deposits channel when policy rates become negative, as we have shown in our analysis for Germany and Portugal.

Against this background, for each country, we calculate the change in the average weighted deposit rate between May 2014 and June 2015 (Appendix-Table B.1, column 2) and scale it by the average rate change in Germany (Table B.1, column 3). This gives us an index for the deposit-rate changes, where the index value for Germany is equal to one and the index itself can be greater than one to indicate even greater stickiness of deposit rates than in the reference economy, Germany. Next, we apply this index to the coefficient in our base-

line specification for Germany (Table 2, column 11) to yield a crude estimate of the deposits channel in each country (Appendix-Table B.1, column 4).

In Figure 5, we use these estimated country-level coefficients to illustrate the cross-country differences in the effect of negative rates on bank lending. For each country, the figure shows the impact of a ten-percentage-point increase in deposit ratios on the likelihood of observing a new relationship between a bank and a risky firm after June 2014. While a change in deposit ratios has virtually no impact on countries such as Portugal, Spain, and the Netherlands, it increases the likelihood of observing a new relationship by around 0.35 percentage points in countries such as France and Austria, and even by more than 0.5 percentage points in Finland.

We conduct a similar exercise for the bank-capital channel of monetary policy. We again calculate the expected sensitivity to monetary-policy changes for each country, this time based on the coefficient we yield for Portugal 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. Note that the coefficient is negative as the expansionary effect on lending stems from weakly, rather than strongly, capitalized banks for which the constraints on lending are relaxed thanks to lower, negative monetary-policy rates.

This channel is strong in countries such as Portugal, Spain, and the Netherlands. In contrast, it is not at work in countries that are close to the zero lower bound, such as Germany, Austria, and Finland, or in countries with limited pass-through to deposit rates due to legislation (the Livret A in France, see Duquerroy, Matray, and Saidi (2020)). Additionally, when the pass-through to deposit rates is impaired, as is the case in Germany, the effect of the bank-capital channel is drastically reduced. While it does not come as a surprise that this is (almost by design) the case for Germany, confirming our previous analysis, the relative strength of the deposits vs. bank-capital channel is similar also in other countries with low (or sticky) deposit rates at the outset, such as Finland (or France).

In Figure A.2 (A.3) in the Online Appendix, we perform a similar exercise, but now show the impact of a one-standard-deviation change in deposit (equity) ratios. These figures thus combine the impact of the deposit (bank-capital) channel with the actual distribution of the deposit (equity) ratios in the respective countries. While leading to some reshuffling in the

ranking of the countries, the main takeaway remains the same: the deposits channel is at work in countries close to the zero lower bound, while the bank-capital channel dominates in countries such as Portugal.

6 Conclusion

Our analysis offers a comprehensive view of the transmission of monetary-policy rates. If the transmission to deposit rates is impaired, as can be the case under negative monetary-policy rates, then their impact on banks' credit supply depends on banks' funding structure.

Two elements of the funding structure matter. First, the extent to which a bank's liabilities consist of deposits relative to market-based funding matters. Deposits are different because they are subject to a zero lower bound. Banks are reluctant to charge negative deposit rates, especially for deposits held by households, which form the bulk of bank deposits. In contrast, negative rates on bonds and other forms of traded debt are now widespread. And second, the level of deposit rates matters. If deposit rates are high and, thus, far from the zero lower bound, then the distinction between deposit funding and market-based funding is less relevant.

This observation has important macroeconomic consequences for the transmission of monetary policy since the sovereign debt crisis. Again, two factors are at play. First, in order to combat the sovereign debt crisis, the significant risks posed to price stability, and the ensuing fall-out, the ECB lowered the policy into negative territory. Second, the sovereign debt crisis led to vastly different yields on sovereign bonds, which, thanks to the sovereign-bank nexus, strongly correlate with deposit rates.

These forces give rise to multiple channels of monetary-policy transmission in the euro area. In core countries (e.g., Germany, Finland), the novel deposits channel is at play while the more traditional bank-capital channel is absent. The opposite is true in the periphery (e.g., Portugal, Italy). Importantly, these observations suggest that the traditional bank-capital channel – i.e., a relaxation of financial constraints for small, illiquid or undercapitalized banks – depends on the transmission of monetary-policy rates to deposit rates. If the latter transmission is impaired, as is the case in the core where the initial level of deposit

rates is already low, banks' funding structure becomes a pivotal determinant of monetary-policy transmission.

Finally, the fact that there is a link between sovereign spreads and deposit rates, and that the level of deposit rates matters for the pass-through of negative rates, has implications for the interaction of unconventional monetary policies, in particular quantitative easing, with negative rates. Namely, if central banks can use quantitative easing to push down government bond rates, they can directly affect the channel of monetary-policy transmission.

Our findings warrant further scrutiny of the euro-area heterogeneity and the distributional effects of different modes of monetary-policy transmission in currency unions. Our documented link between deposit rates and sovereign-bond yields, in conjunction with the dependence of monetary-policy effectiveness on banks' deposit funding, points to a potential stabilizing role for monetary-fiscal policy interactions.

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Figures

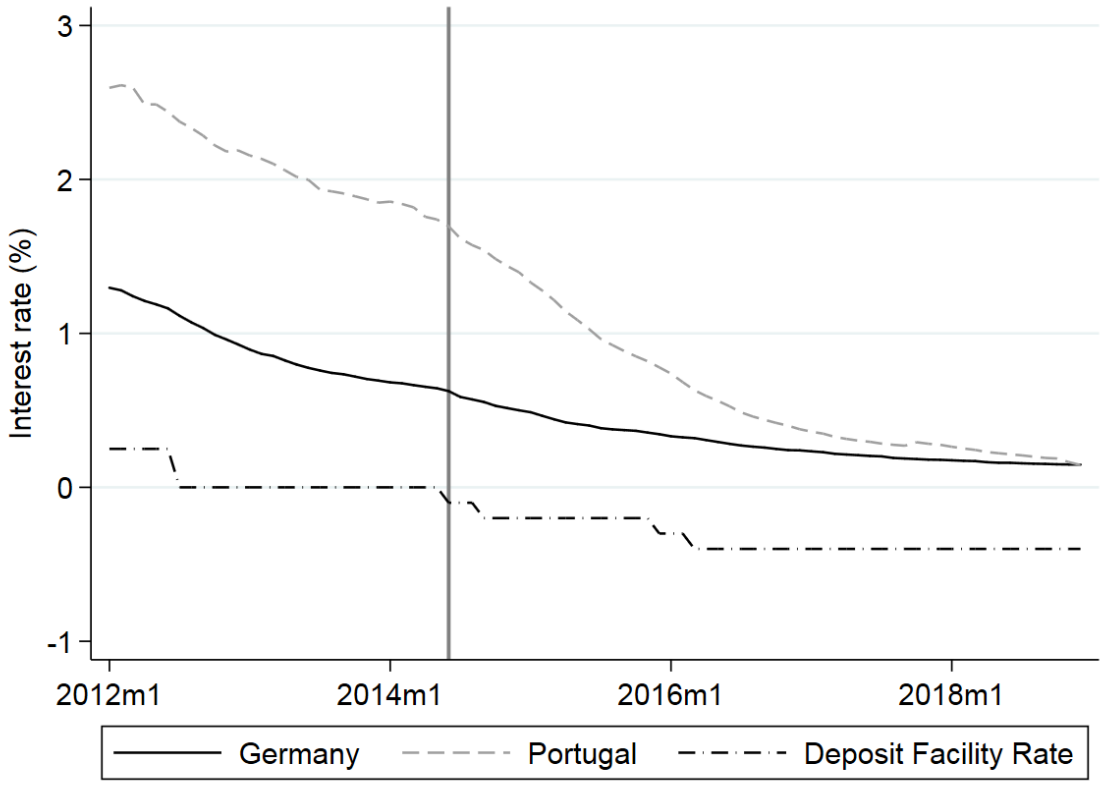


Figure 1: **Deposit Rates by Country – Weighted by Type of Deposit.** This figure shows the ECB's Deposit Facility Rate, together with the weighted, country-level deposit rates (in %, y-axis) for Germany and Portugal between January 2012 and December 2018. For each country, we calculate weighted rates, based on the rates and volumes of overnight deposits, agreed maturity deposits (all maturities), and deposits redeemable at notice. The rates are calculated using data from the MIR and BSI datasets from SDW.

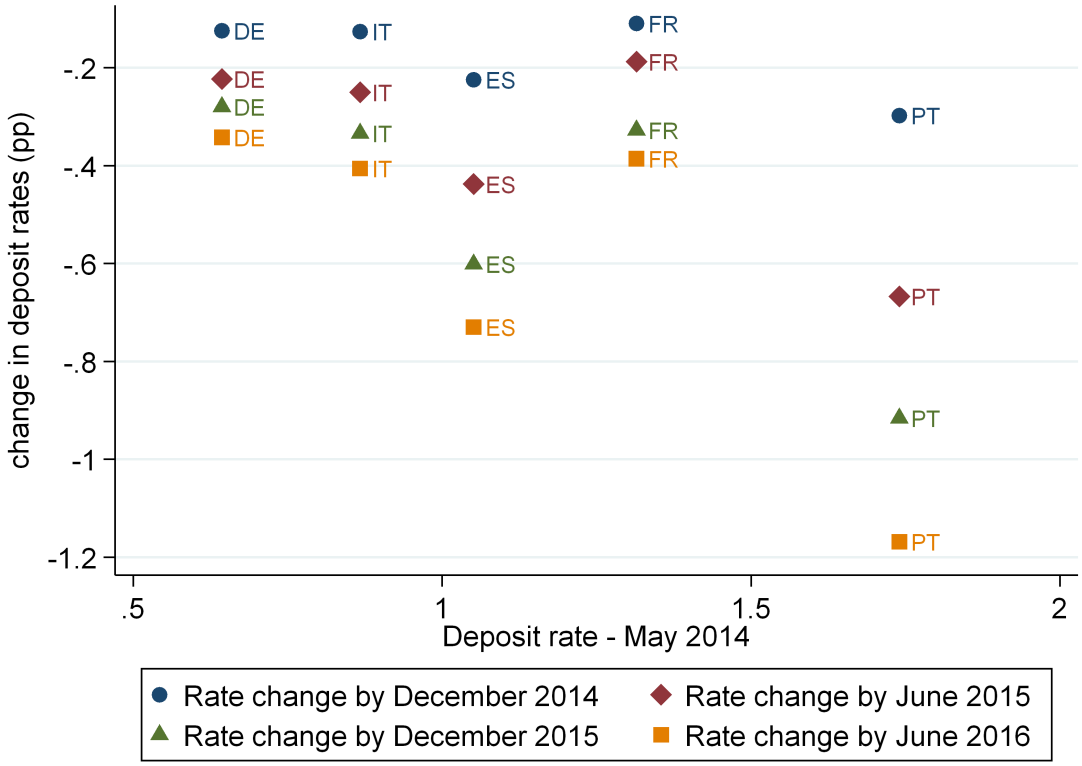


Figure 2: **Change in Deposit Rates.** This figure shows the change in country-level weighted deposit rates (in percentage points, y-axis) between May 2014 and four other points in time: December 2014, June 2015, December 2015, and June 2016. For each country, we calculate a weighted rate for each of 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 rate in May 2014. The rates are calculated using data from the MIR and BSI datasets from SDW.

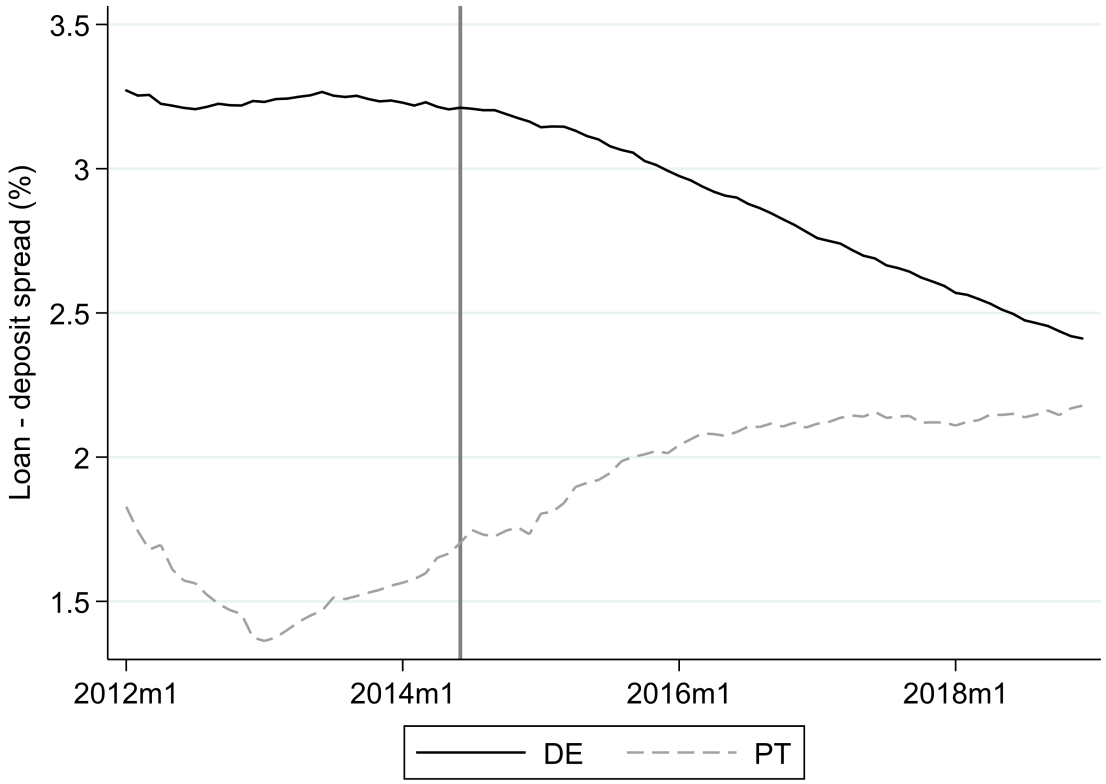
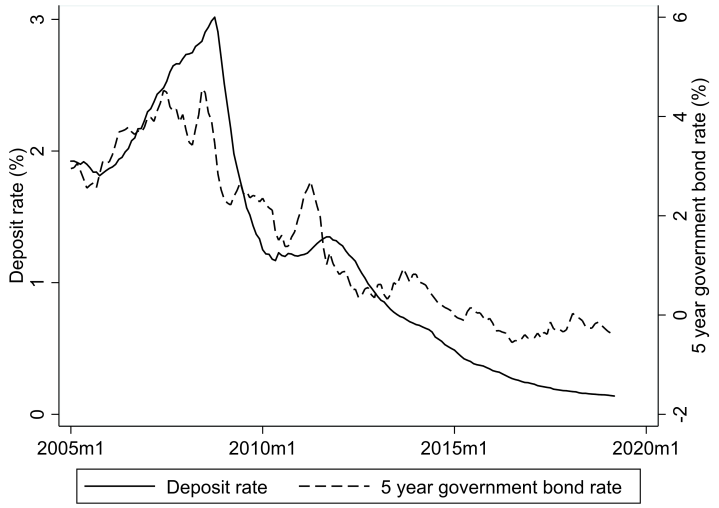
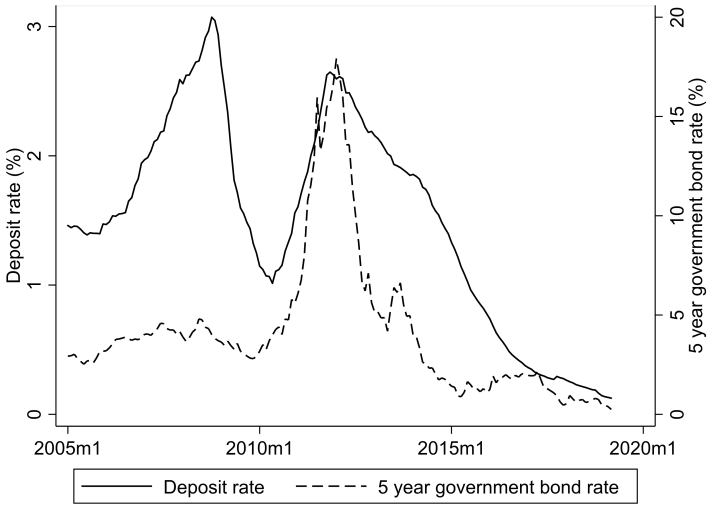


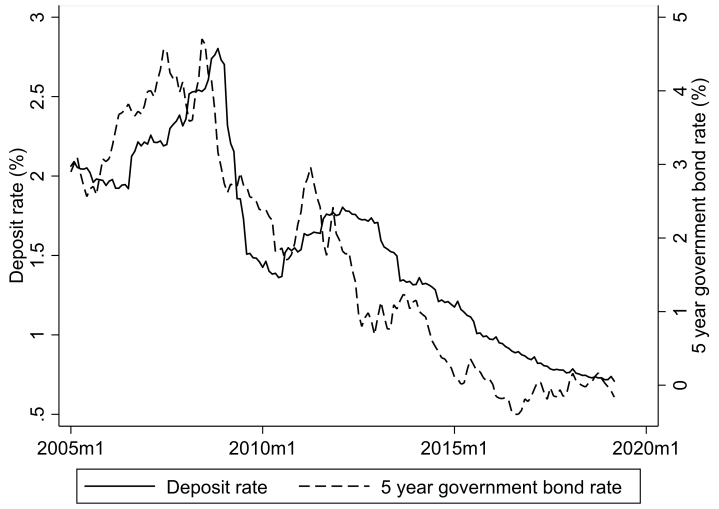
Figure 3: **Spread between Loan Rates and Deposit Rates in Germany and Portugal.** This figure shows the spread between loan rates and deposit rates (in %, y-axis) between January 2012 and December 2018 at the country level. For deposit rates in each country, we calculate weighted rates, based on the rates and volumes of overnight deposits, agreed maturity deposits (all maturities), and deposits redeemable at notice. For loan rates in each country, we calculate weighted average rates on non-financial-corporation (NFC) and household loans. Weights are calculated based on outstanding volumes of NFC and household loans. The rates are calculated using data from the MIR and BSI datasets from SDW.



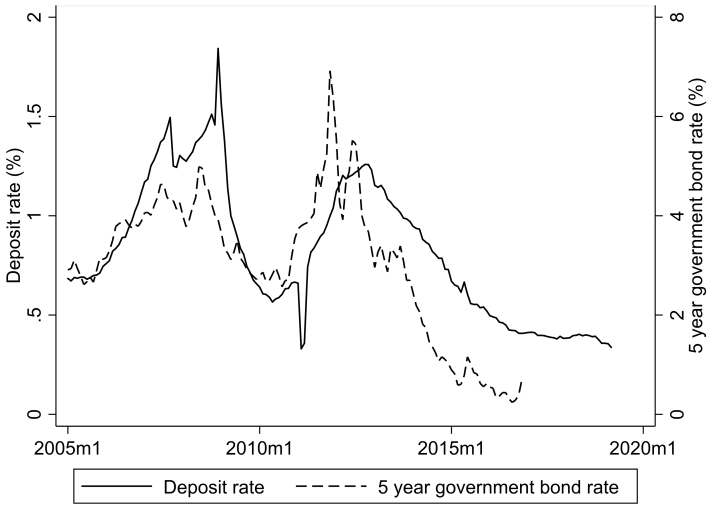
(a) Germany



(b) Portugal



(c) France



(d) Italy

Figure 4: **Deposit Rates and 5-year Government Bond Yields.** This figure shows the evolution of country-level weighted deposit rates (in %, left axis) and 5-year government bond yields (in %, right axis) for Germany, Portugal, France, and Italy. The weighted deposit rates are calculated using country-level rates and volumes of overnight deposits, agreed maturity deposits (all maturities), and deposits redeemable at notice. All underlying data are taken from SDW.

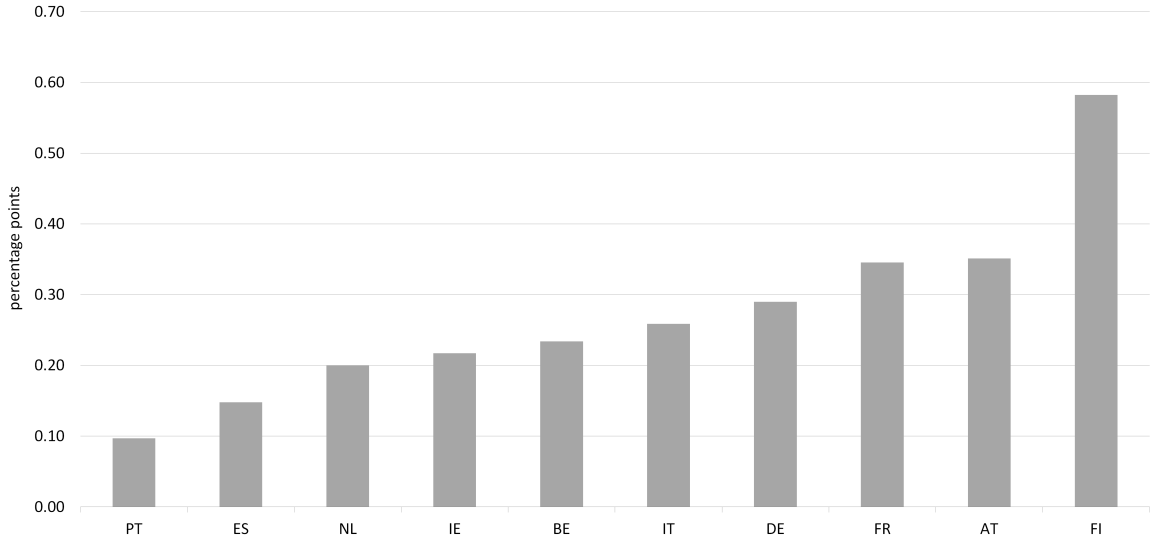


Figure 5: **Deposits Channel across Euro-area Countries.** This figure shows the estimated impact of a ten-percentage-point increase in deposit ratios on the average likelihood of a new lending relationship between a bank and a risky firm after the introduction of negative rates. For each country, we 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 Germany (Table 2, column 11) to yield an estimate of the deposits channel in each country.

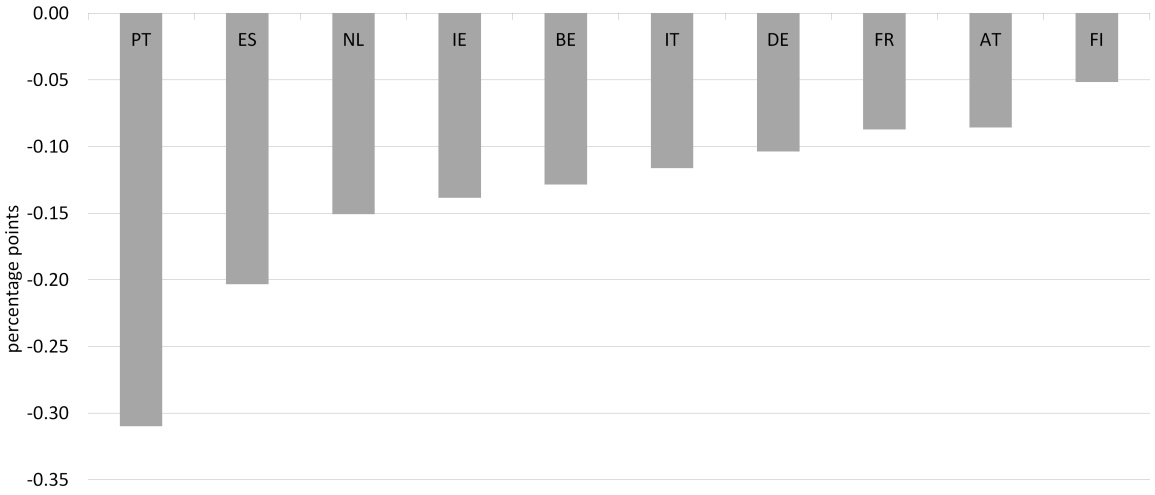


Figure 6: **Bank-capital Channel across Euro-area Countries.** This figure shows the estimated impact of a ten-percentage-point increase in equity ratios on the average likelihood of a new lending relationship between a bank and a firm after the introduction of negative rates. For each country, we calculate 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 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 bank-capital 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
Any new credit	0.222	0.416	0	1	1,529,890	0.225	0.418	0	1	345,180
New relationship	0.016	0.125	0	0	1,529,890	0.053	0.224	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 all banking groups in our German and Portuguese data. Panel B presents summary statistics at the bank-firm-time level for both credit registers in Germany (bank-firm-quarter) and Portugal (bank-firm-month); the variables correspond to those in Tables 2 to 6. Panel C presents summary statistics at the firm level, for all borrowers in our German and Portuguese data, with the variables corresponding to those in Tables 7 and 8.

Table 2: **Bank-capital vs. Deposits Channel: 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**	-0.094	0.237	-0.315
	(0.012)	(0.011)	(0.016)	(0.243)	(0.159)	(0.277)
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	0.096	0.122	0.107
N	1,491,926	472,125	490,469	303,036	86,904	99,348
Variable	(7)	(8)	(9)	(10)	(11)	(12)
Deposit ratio × After(06/2014)	-0.011	-0.009	-0.018	0.013	0.029**	-0.006
	(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	0.096	0.122	0.106
N	1,491,926	472,125	490,469	303,036	86,904	99,348

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.

Table 3: **Bank-capital vs. Deposits Channel: Effect on New-relationship Loan Volume**

	ln(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**	-0.434	0.746	-1.256
	(0.123)	(0.110)	(0.172)	(0.923)	(0.755)	(0.974)
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	0.106	0.082
N	1,491,926	472,125	490,469	303,036	86,904	99,348
Variable	(7)	(8)	(9)	(10)	(11)	(12)
Deposit ratio × After(06/2014)	-0.124	-0.102	-0.193	0.094	0.158*	0.020
	(0.089)	(0.080)	(0.129)	(0.071)	(0.086)	(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	0.106	0.082
N	1,491,926	472,125	490,469	303,036	86,904	99,348

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 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.

Table 4: **Bank-capital vs. Deposits Channel: Effect on Credit Exposure**

	ln(Credit)					
Country		Portugal			Germany	
Firms	All	Risky	Safe	All	Risky	Safe
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Equity ratio × After(06/2014)	0.801	0.772	0.993*	-1.206***	-0.489	-0.735
	(0.561)	(0.537)	(0.538)	(0.300)	(0.407)	(0.554)
Bank-firm FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.885	0.902	0.877	0.895	0.877	0.913
N	1,446,307	458,291	475,316	185,944	51,716	62,576
Variable	(7)	(8)	(9)	(10)	(11)	(12)
Deposit ratio × After(06/2014)	0.297	0.346*	0.251	0.038	-0.024	0.170**
	(0.237)	(0.200)	(0.272)	(0.062)	(0.068)	(0.083)
Bank-firm FE	Y	Y	Y	Y	Y	Y
Firm-time FE	Y	Y	Y	Y	Y	Y
Adj. R^2	0.885	0.902	0.877	0.895	0.877	0.913
N	1,446,307	458,291	475,316	185,944	51,716	62,576

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 natural logarithm of credit exposure of firm f and 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.

Table 5: **Bank-capital vs. Deposits Channel: 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)	-0.012***	-0.012***	-0.012*	-0.090	0.233	-0.312
	(0.004)	(0.004)	(0.007)	(0.237)	(0.162)	(0.285)
Deposit ratio$_{t-1}$	0.004*	-0.002	0.008	-0.009	-0.063**	0.073
	(0.002)	(0.003)	(0.006)	(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	0.056	0.075	0.052	0.097	0.124	0.107
N	1,294,342	411,798	423,776	300,588	79,752	106,320
Variable	(7)	(8)	(9)	(10)	(11)	(12)
Deposit ratio × After(06/2014)	0.001	0.000	0.001	0.011	0.033**	-0.007
	(0.001)	(0.002)	(0.002)	(0.017)	(0.015)	(0.031)
Equity ratio$_{t-1}$	-0.003	-0.002	0.004	-0.123	0.167	-0.283
	(0.008)	(0.007)	(0.012)	(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	0.056	0.075	0.052	0.097	0.124	0.106
N	1,294,342	411,798	423,776	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.

Table 6: **Bank-capital vs. Deposits Channel: 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)	-0.012***	-0.012***	-0.012*	-0.093	0.209	-0.295
	(0.004)	(0.004)	(0.007)	(0.233)	(0.154)	(0.278)
Deposit ratio$_{t-1}$	0.004	-0.003	0.009	-0.009	-0.080**	0.092
	(0.003)	(0.003)	(0.008)	(0.065)	(0.035)	(0.184)
Securities ratio$_{t-1}$	0.006*	0.005	0.003	-0.119***	-0.210***	-0.077
	(0.004)	(0.003)	(0.004)	(0.045)	(0.063)	(0.073)
ln(Assets$_{t-1}$)	-0.000	-0.001	0.000	-0.004	0.016	-0.034
	(0.001)	(0.001)	(0.002)	(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	0.056	0.075	0.052	0.097	0.125	0.107
N	1,294,342	411,798	423,776	300,588	79,752	106,320
Variable	(7)	(8)	(9)	(10)	(11)	(12)
Deposit ratio × After(06/2014)	0.000	-0.000	0.000	0.015	0.024*	0.012
	(0.001)	(0.002)	(0.002)	(0.013)	(0.013)	(0.022)
Equity ratio$_{t-1}$	0.004	0.004	0.011	-0.264	0.199	-0.616
	(0.012)	(0.011)	(0.017)	(0.391)	(0.183)	(0.594)
Securities ratio$_{t-1}$	0.008*	0.005	0.006	-0.114**	-0.193***	-0.086
	(0.004)	(0.004)	(0.005)	(0.046)	(0.058)	(0.072)
ln(Assets$_{t-1}$)	-0.001	-0.000	-0.000	-0.023	0.013	-0.075
	(0.001)	(0.001)	(0.001)	(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	0.056	0.075	0.052	0.097	0.125	0.107
N	1,294,342	411,798	423,776	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.

Table 7: **Real Effects of Bank-capital vs. Deposits Channel: 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 × 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 × 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 introduction of negative monetary-policy rates (i.e., in the last month or quarter before June 2014 for Portugal and Germany, respectively). $New\ relationship_f \times Equity\ exposure_f$ is the average $Equity\ ratio_b$ (measured in 2013) of all banks with which firm f contracts 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. $New\ relationship_f \times Deposit\ exposure_f$ is the average $Deposit\ ratio_b$ (measured in 2013) of all banks with which firm f contracts in the post-period from 2014 to 2016, weighted by the increase in credit exposure (measured as the maximum exposure in $2014 - 2016$ minus the loan exposure in the last period before the introduction of negative monetary-policy rates in June 2014) 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 introduction of negative monetary-policy rates (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.

Table 8: **Real Effects of Bank-capital vs. Deposits Channel: 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 introduction of negative monetary-policy rates (i.e., in the last month or quarter before June 2014 for Portugal and Germany, respectively). $New\ relationship_f \times Equity\ exposure_f$ is the average $Equity\ ratio_b$ (measured in 2013) of all banks with which firm f contracts 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. $New\ relationship_f \times Deposit\ exposure_f$ is the average $Deposit\ ratio_b$ (measured in 2013) of all banks with which firm f contracts in the post-period from 2014 to 2016, weighted by the increase in credit exposure (measured as the maximum exposure in $2014 - 2016$ minus the loan exposure in the last period before the introduction of negative monetary-policy rates in June 2014) 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 introduction of negative monetary-policy rates (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.

ONLINE APPENDIX

A Supplementary Figures

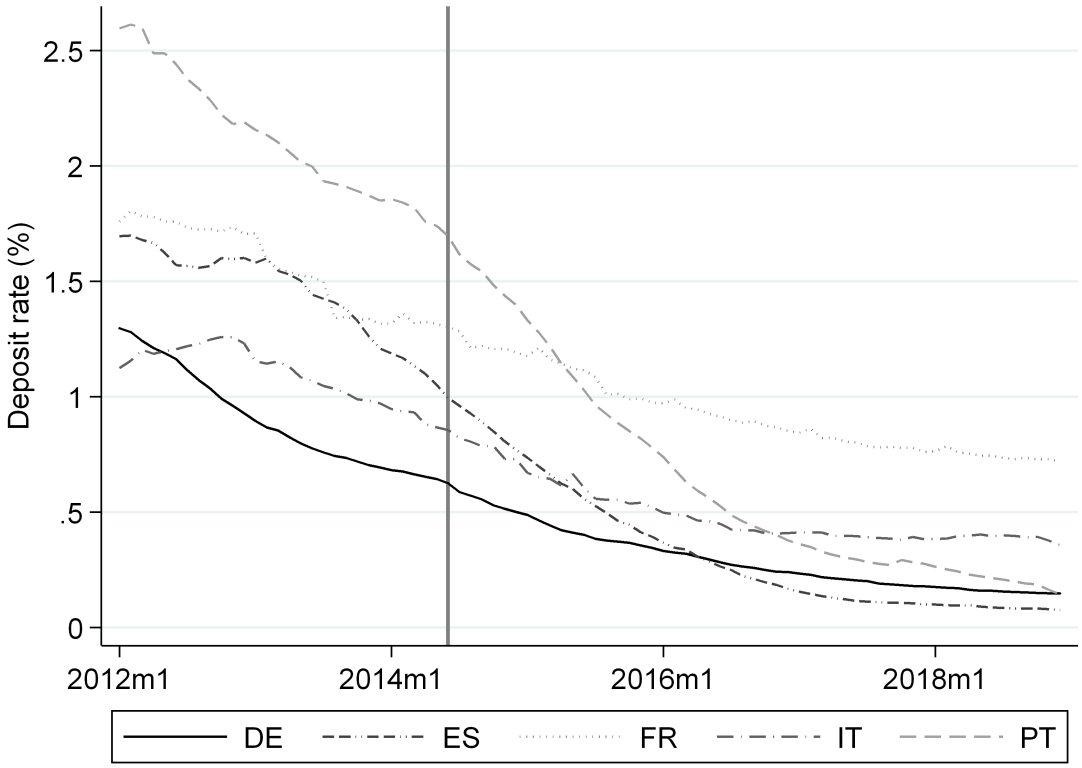


Figure A.1: **Deposit Rates by Country – Weighted by Type of Deposit.** This figure shows the ECB's Deposit Facility Rate, together with the weighted, country-level deposit rates (in %, y-axis) for a group of euro area countries between January 2012 and December 2018. For each country, we calculate weighted rates, based on the rates and volumes of overnight deposits, agreed maturity deposits (all maturities), and deposits redeemable at notice. The rates are calculated using data from the MIR and BSI datasets from SDW.

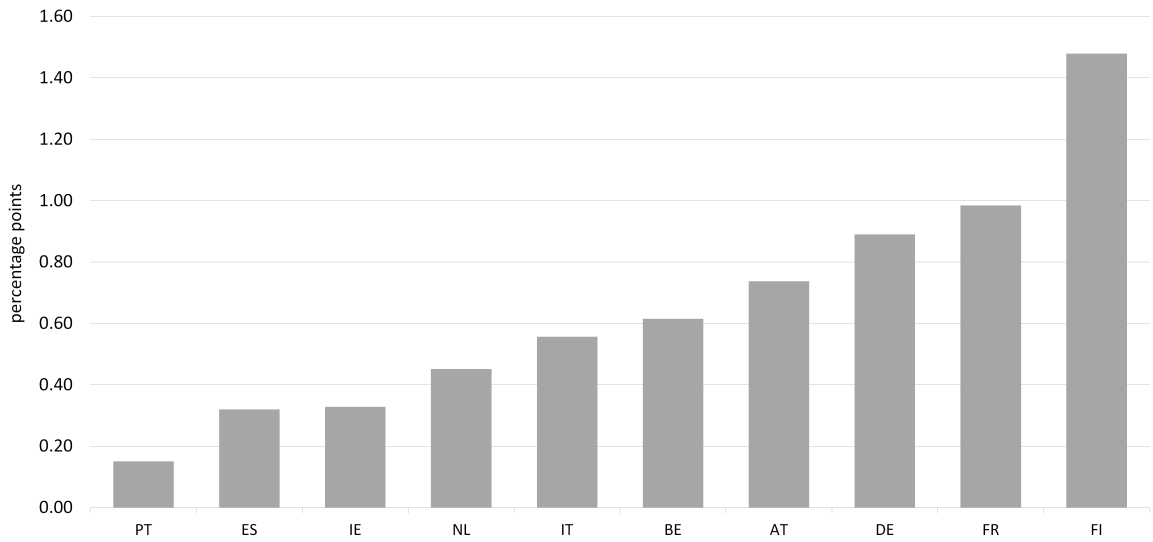


Figure A.2: **Deposits Channel across Euro-area Countries.** This figure shows the estimated impact of a one-standard-deviation increase in deposit ratios on the average likelihood of a new lending relationship between a bank and a risky firm after the introduction of negative rates. For each country, 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 Germany (Table 2, column 11) to yield an estimate of the deposits channel in each country.

Figure A.3: **Bank-capital 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 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 bank-capital channel in each country.

B Supplementary Tables

Table B.1: **Country-level Deposit Rate Changes and Expected Impact of Deposits Channel**

Country	Change in weighted deposit rate	Index	Predicted coefficient
PT	-0.667	0.335	0.010
ES	-0.438	0.510	0.015
IE	-0.298	0.749	0.022
NL	-0.325	0.688	0.020
IT	-0.250	0.892	0.026
BE	-0.277	0.807	0.023
DE	-0.223	1.000	0.029
FR	-0.188	1.191	0.035
AT	-0.184	1.211	0.035
FI	-0.111	2.008	0.058

Table B.2: **Bank-capital vs. Deposits Channel: 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*	-0.335	0.117	-0.678
	(0.098)	(0.084)	(0.118)	(0.453)	(0.278)	(0.542)
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	0.173	0.178
N	1,491,926	472,125	490,469	303,036	86,904	99,348
Variable	(7)	(8)	(9)	(10)	(11)	(12)
Deposit ratio × After(06/2014)	0.020	0.037	0.007	0.050**	0.057**	0.027
	(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	0.174	0.176
N	1,491,926	472,125	490,469	303,036	86,904	99,348

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.

Table B.3: **Bank-capital vs. Deposits Channel: 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.