Banks and Negative Interest Rates*

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Abstract

In this paper, we survey the nascent literature on the transmission of negative policy rates. We discuss the theory of how the transmission depends on bank balance sheets, and how this changes once policy rates become negative. We review the growing evidence that negative policy rates are special because the pass-through to banks' retail deposit rates is hindered by a zero lower bound. We summarize existing work on the impact of negative rates on banks' lending and securities portfolios, and the consequences for the real economy. Finally, we discuss the role of different "initial" conditions when the policy rate becomes negative, and potential interactions between negative policy rates and other unconventional monetary policies.

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

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1 Introduction

Facing a post-crisis world with low growth and low inflation, several central banks around the world have entered unchartered territory by reducing their main policy rates to below zero. Not only the European Central Bank (ECB) reduced the deposit facility (DF) rate from 0 to -0.10% in June 2014, and since then has gone progressively lower (at the time of writing this paper, the DF rate is at -0.50%), but also the central banks Denmark, Switzerland, Sweden, and Japan set negative policy rates.

The introduction of negative monetary-policy rates has sparked substantial controversy. The Federal Reserve and the Bank of England so far have refrained from setting negative policy rates, citing concerns about their effectiveness and adverse implications for financial stability.[1] The views of academics active in the public debate is no less diverse. Summers (2019) refers to negative policy rates as "black-hole economics," while Rogoff (2017) advocates going more negative as the main way forward for central banks. In the middle is Bernanke (2016) who offers a nuanced view, explains why the Federal Reverse did not resort to negative rates after the Great Financial Crisis, and finds "the anxiety about negative interest rates [...] overdone."

The discussion about negative policy rates is likely to stay. After years of unconventional monetary policy, central banks around the world are reviewing their strategy.[2] Facing the challenge of a decade-long fall in interest rates, compounded by the recent COVID-19 health and economic crisis, central banks wonder how they can still achieve their goals, what tools they need, and what side effects may occur.

In this paper, we present a comprehensive overview of how a negative monetary-policy rate transmits to the real economy. We focus on the transmission via banks for two reasons. First, the transmission via banks has a long tradition in academic research. Second, a lot of the granular data that allow to better understand the transmission come from banks (e.g., credit registers and securities-holdings statistics).

[1] See, for example, Mark Carney's remarks at the Bank of England's press conference Q&A on August 4, 2016: https://www.bankofengland.co.uk/-/media/boe/files/inflation-report/2016/press-conference-transcript-august-2016.pdf

[2] For the Federal Reserve, see https://www.federalreserve.gov/monetarypolicy/review-of-monetary-policy-strategy-tools-and-communications.htm; for the ECB's strategy review, see https://www.ecb.europa.eu/home/search/review/html/questions.en.html.

From a theoretical point of view, we discuss how the transmission of monetary-policy rates depends on bank balance sheets, and to what extent negative policy rates are "special." Building on the growing evidence of a hard zero lower bound for deposit rates but not for rates on other, market-based debt instruments, we lay out the argument for a heterogeneous transmission of negative policy rates depending on banks' funding structure. We also consider the possibility that negative rates tax banks' holdings of reserves and liquid assets.

We then provide a synthesis of the empirical evidence of how negative rates affect the behavior of banks as a function of their funding structure. We focus on the supply of bank credit and its effect on firm-level investment and employment, but we also discuss other behavior such as banks' asset holdings.

Negative policy rates transmit differently across banks not only depending on their funding structure, but also depending on their geographical location. Specifically, the sovereign-bank nexus, and the substitutability of bank deposits with government bonds, gives rise to differences in the level of deposit rates across euro-area countries. When the level is high, the zero lower bound is far and the funding structure of banks matters less.

We conclude with an outlook for future research. In our view, the important open question is how a negative policy rate interacts with other unconventional monetary policies. In particular, how does it interact with quantitative easing? Both policies affect various short-term and long-term interest rates in the economy and, thus, bank balance sheets in several ways. Disentangling the various effects and laying out the mechanisms at play poses a formidable challenge.

2 A Framework of How Policy Rates Transmit to Banks' Supply of Credit

In this section, we lay out a mechanism of how changes in a central bank's policy rate transmit to changes in the credit supply of banks. The logic of the mechanism applies to positive policy rates as well as to negative rates. In the next section, we explain what is new when the policy rate becomes negative: the rates on banks' retail deposits do not become negative.

The classic starting point for how monetary policy affects bank credit to firms is the lending channel, which operates via binding reserve requirements.[3] According to the bank lending channel, an expansionary monetary policy increases bank reserves and relaxes the reserve requirement. Banks can raise more deposits and, thus, lend more.

Since the 2008 Great Financial Crisis the banking system in most countries operates, however, with large excess reserves. The reserve requirement is not binding anymore for most banks. Nevertheless, central banks continue to use their policy rates to steer the economy.[4] A different explanation for how changes in the policy rate affect bank lending therefore is needed.

The bank capital channel instead focuses on a binding constraint for external financing. The argument has two elements. First, capital matters for banks' ability to supply credit to the economy. Second, monetary policy affects bank profitability and, thus, bank capital.[5]

A lower policy rate increases bank profits and relaxes the external-financing constraint. Lending long term while providing short-term liabilities earns banks a profitable net-interest margin. A lower policy rate increases the margin. Attracting outside financing is costly either because of regulation or because of an information problem between outsiders who provide funds and insiders who use the funds. It is easier to attract outside financing when a bank makes more profits. Higher profits lead to a larger difference between assets and liabilities, i.e., higher bank net worth/more capital. More capital relaxes a bank's regulatory financing constraint and reduces the information problem as outsiders are more likely to be paid.

The importance of an external-financing constraint for banks and the role of bank capital for lending are well documented. Negative shocks to banks' balance sheets force them to

[3]Sometimes the term "bank lending channel" is used to describe the overall impact of monetary policy on the credit supply of banks. Here we use the term in a narrow sense to describe a particular economic mechanism. For more information, see, for example, Boivin, Kiley, and Mishkin (2010). Most of the evidence on monetary policy and bank credit supply focuses on credit to firms. We therefore ignore the issue of credit to households here.

[4]In addition, central banks resort to *unconventional* monetary policy. Most notably, they undertake large-scale asset-purchase programs (quantitative easing). Less is known about how unconventional monetary policy affects bank credit supply (for a model, see Gertler and Karadi, 2011).

[5]In light of excess reserves, Drechsler, Savov, and Schnabl (2017) present another channel. A higher policy rate leads to higher market rates but not to higher deposit rates when banks have market power. Depositors withdraw to benefit from the higher market rate. With fewer deposits, banks can lend less. This stickiness of the deposit rate is different from the stickiness at the zero lower bound, which takes center stage in our narrative of why negative interest rates are special. Wang, Whited, Wu, and Xiao (2020) structurally estimate the importance of banks' market power, both on the lending and the funding side, for the transmission of monetary policy relative to financing and regulatory constraints.

lend less with adverse consequences for the real economy (Peek and Rosengren, 2000).[6] Better capitalized banks lend more while bank equity itself does not vary much over the business cycle. The variation in banks' liabilities drives variation in lending, and better capitalized banks have lower funding cost (Gambacorta and Shin, 2018).

The evidence on how policy rates interact with bank capital is also in line with the logic of the bank capital channel. When the policy rate falls, banks with less capital expand more (Jayaratne and Morgan, 2000; Kishan and Opiela, 2000; Gambacorta and Shin, 2018). Banks with less capital have a tighter external-financing constraint, which makes them more sensitive to changes in their net-interest margin and profitability.

Despite the empirical evidence, a model of how exactly the bank capital channel works is lacking. For example, where does the external-financing constraint come from, regulation or information problems? How does monetary policy affect bank profits? Does the policy rate transmit to lending rates, to the cost of funding, or does it change the value of liquid securities that banks hold (government bonds, reserves)? And how do profits affect the financing constraint?

Bittner, Bonfim, Heider, Saidi, Schepens, and Soares (2020) propose a reduced-form model to explain how a central bank's policy rate affects bank credit supply via a bank capital channel. We will use this model to structure our discussion of the empirical evidence later on.

The external-financing constraint is as in Holmström and Tirole (1997). A bank insider takes an unobservable action to monitor loans. This action is costly for the insider, but without monitoring, the bank is not viable and outsiders would not provide financing. The insider cannot be punished because of limited liability. Instead, she must obtain a rent to have the incentive to monitor. The rent reduces the per-loan amount outsiders can receive ("pledgeable return") below their required rate of return, i.e., loans are not self-financing. To overcome this problem, the insider contributes own funds to reduce the amount of outside financing. This reduces the outsiders' total opportunity cost, but does not change the per-loan pledgeable return. The insider lends as much her own funds allow. Bank lending L is given by $L = kA$, where A is the insider's own funds, and $k > 1$ is a multiplier that describes

[6] Kashyap and Stein (2000) also note that a negative shock to banks' capital increases their cost of external financing.

how much outside financing the insider can raise per unit of own funds.

The policy rate r_p affects the multiplier $k(r_p)$ in two opposing ways. First, a lower policy rate reduces the required rate of return of outsiders. This makes it cheaper to obtain funding from outsiders because it lowers their opportunity cost. Second, a lower policy rate reduces loan rates. This reduces the amount outsiders can receive – the insider's rent must stay constant, otherwise she would not monitor – and makes it more expensive to obtain funding.[7]

In normal times, away from the zero lower bound, a lower policy rate should lead to more bank credit supply. In the context of the above logic, this requires an increase in the multiplier k as the policy rate falls, $\frac{dk}{dr_p} < 0$. When this condition holds, lower cost of funding outweighs the decrease in the pledgeable return. More precisely, Bittner et al. (2020) show $\frac{dk}{dr_p} < 0$ when the elasticity of the loan rate with respect to the policy rate is smaller than the elasticity of banks' cost of funding with respect to the policy rate. This formalizes the notion of a higher net-interest margin for banks and, thus, more credit supply when the central bank lowers the policy rate.

In normal times, the condition for a lower policy rate to expand bank credit likely holds because a lower policy rate transmits more strongly to short-term rates, relevant for banks' cost of funding, than to long-term loan rates. Away from the zero lower bound, deposit rates co-move with rates on short-term debt, which in turn closely follow the policy rate. The reason for the close link is the possibility for outside investors to substitute bank deposits with other forms of short-term debt.

The policy rate also transmits to loan rates, but imperfectly so.[8] Like outside investors, firms have alternatives to transacting with banks. Firms can issue bonds in the market in-

[7]Some refer to capital regulation to derive a financing constraint: $L \leq \mu E$, where E is the bank's outside equity and μ^{-1} is the regulatory capital ratio. Because regulatory risk weights do not depend on the policy rate, monetary policy must work through the amount of equity. In Van den Heuvel (2002), the bank retains profits from intermediation over time to increase equity. In Bolton and Freixas (2006), the bank issues new equity. Macroeconomic models with a banking sector often derive a financing constraint from the banker's ability to divert funds (see Gertler and Kiyotaki, 2011). The banker either diverts a fraction λ^{-1} of current bank assets (loans) L or continues for another period. This yields $L \leq \lambda V$, where V is the present value of the banker's future claim on the bank. The diversion parameter λ does not depend on the policy rate, so monetary policy works via the value of the bank V (and the price of loans as the constraint is in market-value terms). A constant multiplier (μ, λ) is, however, at odds with the evidence that the variation in liabilities, and not equity, drives the variation in bank lending.

[8]For evidence, see, for example, Gambacorta, Illes, and Lombardi (2014) and Mojon (2000).

stead of relying on bank loans. As monetary policy affects short-term market rates, there should be some link between bond market rates and loan rates. The link is less tight than the link between the different rates on short-term debt instruments because firms' ability to substitute bonds for loans is limited.[9]

3 Monetary-policy Transmission under Negative Rates: Mechanism

3.1 The Zero Lower Bound on Deposit Rates

What is special about policy-rate cuts into negative territory is that, unlike rate cuts above zero, they do not lower all short-term rates alike. Lower, negative policy rates transmit to lower, negative market rates on short-term debt (e.g., interbank market rates), but they do not transmit to lower, negative rates on retail deposits. While in general, banks are eager to lower the rates on retail deposits in times of positive rates (see, for instance, Hannan and Berger, 1991), they are reluctant, and sometimes unable, to charge negative deposit rates.

Figure 1 illustrates this unequal pass-through of negative policy rates to deposit and short-term market rates in the euro area. It shows the ECB's main policy rate, the 3-month Euribor (a benchmark for the market rate of unsecured short-term debt), and the average rate on overnight household and corporate deposits of euro-area banks between January 2003 and May 2020.[10] As long as the policy rate is in positive territory, both deposit rates and the 3-month Euribor move in tandem with the policy rate. When the policy rate is lowered below zero in June 2014, the paths of the 3-month Euribor and the deposit rate diverge: the 3-month Euribor decreases in line with the lower policy rate, while the deposit

[9] Bolton and Freixas (2006) model the transmission of monetary policy to loan rates and banks' cost of funding. Firms can finance investments with bank loans or bonds. Because banks can restructure loans, riskier firms prefer loans. Households can save using bank deposits, corporate bonds, or government bonds. Tighter monetary policy increases the market rate, i.e., the rate on instruments households can use to save, but decreases the spread banks earn. The market rate increases because bank deposits and corporate bonds compete with government bonds for the savings of households. The spread decreases because banks are mindful of losing borrowers to the bond market where rates have gone up.

[10] Note that the main ECB policy rate was the main refinancing operations (MRO) rate until September 2008. In October 2008, the ECB switched to fixed-rate full allotment, making the deposit facility (DF) rate the key policy rate. For a review of how the ECB implements monetary policy before and after the Great Financial Crisis, see Garcia-de-Andoain, Heider, Hoerova, and Manganelli (2016).

rate remains fairly stable. Bech and Malkhozov (2016) provide similar evidence for other countries with negative policy rates.

Little is known why the rates on retail deposits face a hard zero lower bound. One possibility is the zero nominal return on physical cash. Depositors would withdraw their funds and hold cash instead if the deposit rate became negative. This argument does not take into account the cost of holding cash and using it for transactions, however. Another reason could be that zero is a focal point for banks and depositors. If a bank offers a negative deposit rate, this is more noticeable than if it lowers the deposit rate in positive territory. If a rate cut is more salient, depositors could be more likely to withdraw. If, additionally, other banks still offer positive deposit rates, depositors would simply switch deposit accounts and would not have to hold cash.

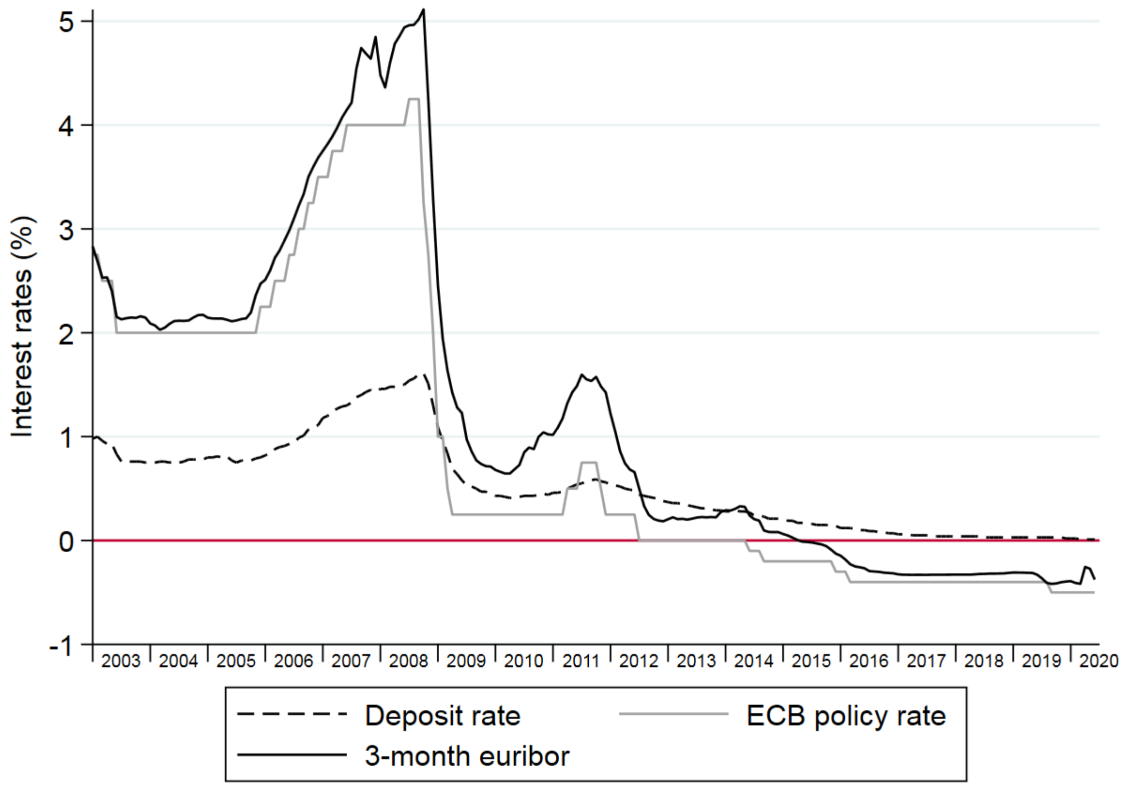
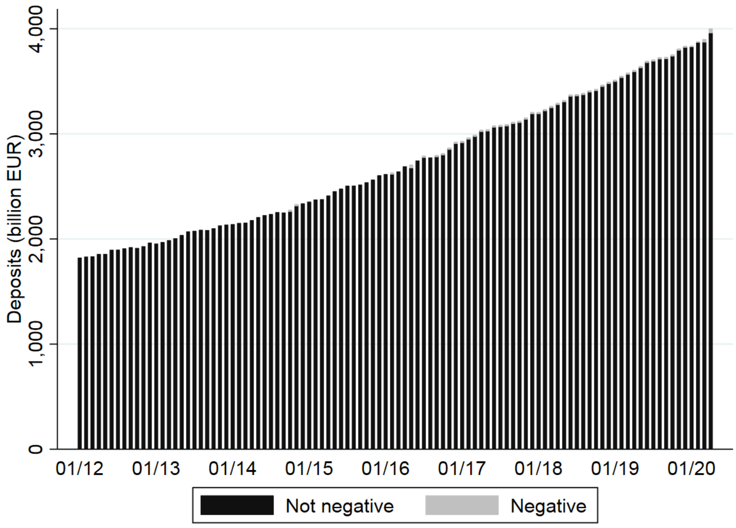
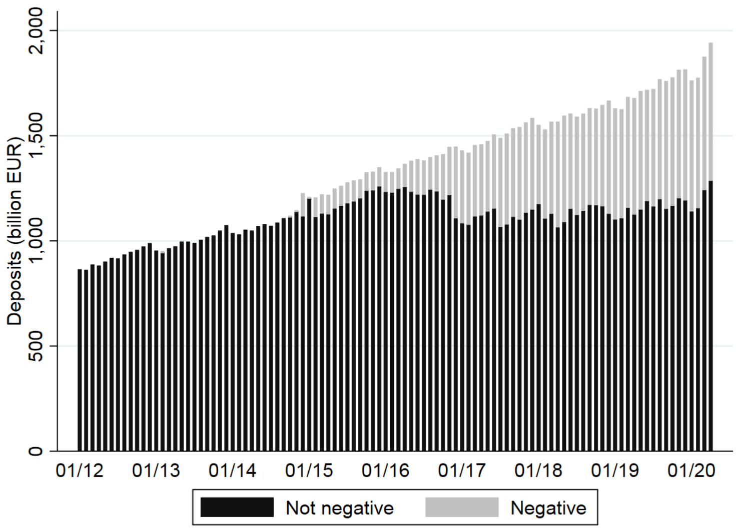


Figure 1: **The ECB Policy Rate, the 3-month Euribor, and the Overnight Deposit Rate.** This figure shows the evolution of the average overnight deposit rate at euro-area banks between January 2003 and May 2020, in comparison to the 3-month Euro Interbank Offered Rate (Euribor) and the ECB policy rate. The ECB policy rate is the main refinancing operations (MRO) rate until September 2008, and the deposit facility rate (DFR) from October 2008 onwards. The ECB switched to fixed-rate full allotment that month, making the DFR the key policy rate. All series are taken from the ECB Statistical Data Warehouse.

Rates on household deposits face a harder zero lower bound than those on non-financial corporations' deposits. This reflects the idea that switching costs are lower for households than for non-financial firms. While households, on average, hold fewer deposit accounts from which they can readily withdraw their funds and move to a competitor bank or hold cash, non-financial firms are more likely to be held up by banks as they rely on multiple financial services and have much larger deposit accounts.



(a) Households



(b) Non-financial corporations

Figure 2: **Volume of Overnight Deposits with Negative and Non-negative Rates.** The top panel of this figure shows the monthly volume of euro-area overnight household deposits with a negative rate (in gray) and a non-negative rate (in black) attached to them for the period from January 2012 to April 2020. The bottom panel shows the same statistics for overnight deposits of non-financial corporations. All underlying data are taken from the ECB's iMIR and iBSI datasets.

Heider, Saidi, and Schepens (2019) document that shortly after the introduction of negative monetary-policy rates in the euro area, not a single monetary financial institution (MFI) has charged its household depositors negative rates, whereas a few banks have done so for their non-financial-corporation depositors. Figure 2 indicates that this differential treatment persists in the longer run (see also Altavilla, Giannetti, and Holton, 2019).

3.2 Deposits and Bank Net Worth at the Zero Lower Bound

Banks that rely heavily on deposit funding experience a negative shock to their net-interest margin when the policy rate becomes negative. The zero lower bound for deposit rates implies that deposit-reliant banks do not benefit from the typical drop in the cost of funding that occurs when the policy rate is lowered in positive territory. At the same time, loan rates still continue to drop together with the reduction in market rates. Loan rates are much further away from the zero lower bound because of premia for credit risk and illiquidity.

A policy-rate cut into negative territory is less expansionary in terms of the mechanism laid out in Section 2. The multiplier k increases less when the policy rate becomes negative the more a bank relies on deposit funding. The reason is the lower elasticity of a bank's cost of funding with respect to the policy rate when the bank relies more on deposit funding.[11,12]

A useful statistic for the impact of policy rates on banks' net-interest margin is their market value,[13] and a number of papers examine the reaction of bank stock prices to policy-rate announcements. Lower policy rates in positive territory increase bank stock prices (Flannery and James, 1984; English, Van den Heuvel, and Zakrajšek, 2018). In negative territory, the opposite holds: bank stock prices react negatively (Hong and Kandrac, 2018; Eggertsson,

[11] Using a calibrated DSGE model where banks intermediate the transmission of monetary policy, and building on the same hard zero lower bound for banks' retail deposits, Ulate (Forthcoming) estimates that monetary policy in negative territory is about two-thirds as effective as in positive territory. In Wang (2020), a lower policy rate transmits imperfectly in a low-rate environment because banks earn less income from deposit taking and are, thus, reluctant to reduce loan rates. In Kumhof and Wang (2020), less lending in a low-rate environment goes hand in hand with less deposit taking, which hurts the economy because deposits are essential for making payments. Rognlie (2016) offers a different perspective that does not rely on banks: negative rates are costly for the economy because they inefficiently subsidize cash.

[12] It could be possible that the multiplier k *decreases* as the policy rate falls. Such "reversal" is proposed by Brunnermeier and Koby (2019), although without explicit reference to negative policy rates. Repullo (2020) reviews the theoretical possibility of a reversal rate.

[13] In the framework laid out in Section 2, the value of a bank is the per-loan rent for the bank's insider times the lending volume. The lending volume depends on the multiplier and hence, the sensitivity of the multiplier to the policy rate translates into a sensitivity of bank value to the policy rate.

Juelsrud, Summers, and Wold, 2020).

The stock price of banks with a lot of deposit funding reacts particularly negatively to a negative policy rate. Heider, Saidi, and Schepens (2019) examine euro-area banks around the introduction of negative rates by the ECB in June 2014. Banks with considerable deposit funding lose market value relative to banks with more market-based funding. Ampudia and Van den Heuvel (2018) conduct a high-frequency event study to disentangle the effect of the rate announcement on banks' stock prices from other economic news. In normal times, a policy-rate cut of 25 basis points increases bank stock prices by 1%. This is consistent with the mechanism of a bank capital channel in Section 2: a lower policy rate increases banks' net-interest margin, and leads to more lending and higher bank value. Conversely, a policy-rate cut of 25 basis points in negative territory decreases bank stock prices by 2% on average. Importantly, the stock price of banks with more deposit funding reacts more negatively.

Apart from stock prices, one can also study accounting-based measures such as profitability, even though they tend to be more backward looking and are available only at lower frequency. Molyneux, Reghezza, and Xie (2019) use yearly bank-level data for a sample of banks from 33 OECD countries, and show that net-interest margins and overall profitability fell in countries that introduced negative rates. Lopez, Rose, and Spiegel (2020) analyze banks in 27 European and Asian countries. Negative rates lead to a substantial drop in net interest income, but banks are able to offset these losses via increases in non-interest income. Deposit-reliant banks fare worse under negative rates, consistent with a hard zero lower bound on deposit rates. Similarly, Urbschat (2018) documents that deposit-reliant banks in Germany have lower net-interest margins when policy rates become negative.

The adverse effect of negative rates on bank value opens up the possibility for bank risk taking.[14] If screening loans is costly, then banks may screen less in order to preserve bank value. To illustrate risk taking in the bank capital channel, consider the framework in Section 2 with an ex-ante possibility for banks to screen loans (in addition to ex-post monitoring). When a bank screens more, loans become less risky. This increases the per-loan pledgeable return for outside investors and makes it easier to attract outside funding.

[14] Several papers examine whether a lower policy rate in normal times, away from the zero lower bound, leads to more bank risk taking (Maddaloni and Peydró, 2011; Jiménez, Ongena, Peydró, and Saurina, 2014; Dell'Ariccia, Laeven, and Marquez, 2014; Dell'Ariccia, Laeven, and Suarez, 2017).

Screening increases the multiplier, $\frac{dk(r_p,p)}{dp} > 0$, where p denotes the screening effort. The optimal screening effort p^* balances the benefit of more profitable lending, given by $L = k(r_p, p)A$, and the cost of screening. When a lower policy rate increases bank risk taking, this means $\frac{dp*}{dr_p} > 0$. Bittner et al. (2020) examine this condition, and show it holds when the elasticity of a bank's funding cost with respect to the policy rate is low. This is the case for banks with considerable deposit funding when deposit rates no longer follow the policy rate because of the hard lower bound at zero.

3.3 Other Bank Characteristics that Impact Pass-through of Negative Rates

Thus far, we mainly focused on the role of deposits for the pass-through of negative rates, given the importance of funding costs in the traditional bank credit channel, and the differential pass-through of negative policy rates to deposit and wholesale funding rates. A number of studies have explored the role that other bank characteristics may play in how negative policy rates transmit to credit supply. They mainly focus on the role of banks' excess reserves and bank liquidity.

Excess reserves are a natural place to look when wondering how negative rates affect banks. When there is a negative policy rate, it typically applies to those reserves that banks hold, on their accounts at the central bank, in excess of the regulatory reserve requirement (Bech and Malkhozov, 2016). At the ECB this rate is the deposit facility (DF) rate, which became negative in June 2014. With a negative deposit facility rate, holding more reserves is more costly. It is not entirely clear, though, that the overall cost of holding reserves increases when the deposit facility rate becomes negative. A bank can only hold reserves if it first borrows them from the ECB at the main refinancing operations (MRO) rate, which is higher than the DF rate. Thus, it is the difference between the MRO and the DF rate that determines the overall cost of holding reserves, and not the level of the DF rate alone.

A bank's excess reserves are, however, endogenous. They reflect a trade-off between a bank's benefits and costs of holding large amounts of central bank reserves. Each bank can decide how much to borrow from the central bank (or decide how many assets to sell to the central bank) and then decide how many reserves it trades in the interbank market. Moreover, several central banks have implemented a "tiering" mechanism for excess reserves. Tiering remunerates excess reserves below a certain threshold more than those above it.[15]

Demiralp, Eisenschmidt, and Vlassopoulos (2019) consider the combined impact of euro-area banks' excess reserves and deposit reliance. They find that banks that rely more on retail deposits and that hold more excess reserves significantly increase their lending to households and firms. They interpret this as evidence that deposit-dependent banks have problems maintaining their interest margins, especially when they hold many excess reserves. As a consequence, they attempt to improve their margins by increasing interest income. Banks operationalize this by shifting from reserves to loans on their asset side. Basten and Mariathasan (2018) focus on the differences in the cost of holding excess reserves induced by a tiering mechanism in Switzerland (at the same time as the policy rate becomes negative), and uncover similar portfolio-rebalancing effects.

Bottero, Minoiu, Peydró, Polo, Presbitero, and Sette (2019) and Arseneau (2020) focus on the role of bank liquidity more generally in the transmission of negative policy rates. Bottero et al. (2019) find that banks that hold more liquid assets ex ante rebalance their portfolio towards (illiquid) loans once policy rates become negative. This is different from what one observes in positive territory, where liquid banks typically react less to monetary-policy changes (see, e.g., Kashyap and Stein, 2000). Bottero et al. (2019) explain this finding by the observation that negative rates widened the spread between the yields of safer, liquid assets and those of corporate loans. As a consequence, banks holding a lot of low-yielding liquid assets shifted their portfolios towards higher-yielding assets such as loans.

Evidence provided by Arseneau (2020) also suggests that bank liquidity could play a role for the pass-through of negative rates. He uses data provided by U.S. banks in the context of the Comprehensive Capital Analysis and Review (CCAR) stress tests. Part of the review consists of a stress test where banks are asked to project their profitability over a nine-quarter forward horizon conditional on a negative policy-rate scenario. He finds that banks with a lot of short-term liquid assets expect to experience a sharp drop in profitability if rates were to become negative.

[15] At the ECB this threshold currently stands at six times a bank's reserve requirement.

4 Monetary-policy Transmission under Negative Rates: Consequences for Bank Balance Sheets and the Real Economy

4.1 Bank Balance Sheets

The mechanism discussed in Section 3 explains how a negative policy rate leads to less lending and more risk taking by banks with a lot of deposit funding. At the heart of the mechanism is the zero lower bound on retail deposit rates and the lower elasticity of the cost of funding with respect to the policy rate for a bank that relies on deposits rather than on wholesale market funding.

Banks' predominant asset-side activity is lending, both to non-financial firms and households. As such, the bulk of existing empirical evidence builds on respective lending data to ascertain the effects of negative monetary-policy rates on banks' balance sheets. In doing so, this empirical research generally faces a trade-off between capturing as many different bank activities on the asset side as possible and the granularity of the data, with the latter enabling research designs that may allow for causal inference.

While the granularity of data employed ranges from the aggregate bank to the transaction level, the source of identifying variation stems from banks' funding structure and the latter's interaction with monetary policy. Given the zero lower bound on retail deposit rates, an important empirical determinant of banks' treatment is their reliance on deposit vs. other sources of funding, such as interbank lending. By interacting banks' reliance on deposits with the introduction of negative monetary-policy rates, one tests whether deposit-funded banks react differently than do otherwise-funded banks.

This difference-in-differences test is at the core of many papers in this literature. Heider, Saidi, and Schepens (2019) use transaction-level data from syndicated loans in the euro area, and show that deposit-dependent banks start lending to (ex-ante) riskier firms only after the introduction of negative monetary-policy rates, but not when rates are lowered in non-negative territory. To demonstrate that the increase in risk taking is prompted by high-deposit banks incurring higher funding costs, they exploit the fact that the rates on household deposits face a harder zero lower bound than do those on non-financial corporations' deposits.[16] Indeed, they find that among deposit-dependent banks, those funded by household rather than non-financial-corporation deposits are more likely to lend to riskier firms. This comparison holds constant any confounds that are correlated with banks' reliance on deposits in general and may simultaneously govern bank lending. Furthermore, they show that banks' reliance on deposit funding is unrelated to deposit growth after the introduction of negative monetary-policy rates. Therefore, bank lending decisions should be due to the subsequent variation in funding costs, but not due to changes in banks' leverage ratios.

Heider, Saidi, and Schepens (2019) also present evidence that high-deposit banks reduce their total syndicated lending pursuant to the introduction of negative monetary-policy rates. This suggests that high-deposit banks take risk by concentrating their lending on risky firms, and potentially rationing other borrowers. Eggertsson et al. (2020) document a similar contractionary effect using bank-level data from Sweden. Once the Swedish repo rate becomes negative, deposit-dependent banks experience lower loan growth because they do not lower lending rates in order to preserve their interest margin. Arce, García-Posada, Mayordomo, and Ongena (2020) confirm these results using Spanish banks' response to a question in the ECB's Bank Lending Survey on how the negative DF rate affects their net interest income. More adversely affected banks reduce credit, increase loan rates, and lend to riskier firms.

Bittner et al. (2020) attempt to dissect high-deposit banks' risk taking in response to negative policy rates by zooming in on their lending relationships with both existing borrowers and new ones. In particular, they use credit-register data in an economy where the zero lower bound on retail deposits is sure to be binding – namely Germany – and as such can identify the effect of squeezed net-interest margins on German banks' lending behavior following the introduction of negative monetary-policy rates.

One possibility for banks to take risk is to reduce the loan exposure to safe firms and to increase it to risky firms. The reduction of the loan exposure to safe firms must take place at the intensive margin. An increase in lending to risky firms can take place either

[16] Grandi and Guille (2020) apply this rationale to overnight vs. term deposits, as the former are more short term and as such are more susceptible to being withdrawn.

at the intensive or the extensive margin. A bank can increase the loan volume to existing risky borrowers or establish new lending relationships with risky firms. Bittner et al. (2020) show evidence in favor of the latter, which is consistent with the logic that once high-deposit banks' net-interest margins are squeezed, they perform less costly screening.

A number of papers examine the impact of negative rates on other bank assets than corporate loans. Following the same logic of how negative rates adversely affect the net-interest margins of high-deposit banks, these papers document how banks counteract the squeeze. Using loan-level data from Italy, Amzallag, Calza, Georgarakos, and Sousa (2018) show that high-deposit banks charge more on new fixed-rate mortgages after the introduction of negative monetary-policy rates in the euro area. Using bank-level data from Switzerland, Basten and Mariathasan (2018) exploit the differential cost of holding reserves induced by "tiering" (see Section 3.3), and also find that more exposed banks increase their mortgage rates. Moreover, more exposed banks take on more credit and interest rate risk. Using a securities register for a sample of euro-area banking groups, Bubeck, Maddaloni, and Peydró (2020) provide further support for the idea that banks with costlier customer deposits after the introduction of negative monetary-policy rates search for yield. In this case, affected banks respond by tilting their security portfolios towards higher-yielding securities.

This characterization of bank risk taking in response to the introduction of negative monetary-policy rates may hint at a potential source of financial fragility, by encouraging risk taking by those (high-deposit) banks typically thought to follow the most traditional banking model.[17] This depends on whether affected banks supply credit disproportionately to excessively risky firms, typically culminating in firm defaults. Given the recency of negative monetary-policy rates, the jury is still out.[18]

However, more lending to risky borrowers need not be harmful for financial stability. A firm with risky operations and uncertain cash flows can be small or highly innovative. In general, these are likely more credit-constrained firms, so the introduction of negative rates may have led to a relaxation of credit constraints for these firms which, in turn, use bank

[17]The market perceives a higher likelihood of becoming undercapitalized in case of a financial crisis for banks with a traditional business model (i.e., making loans and issuing deposits) once rates become negative (Nucera, Lucas, Schaumburg, and Schwaab, 2017).

[18]Porcellacchia (2019) proposes a model of banks with deposits at the zero lower bound, where financial fragility comes from banks no longer offering liquidity services if their interest margin is squeezed.

credit to fund (possibly productivity-enhancing) investments. We next discuss the evidence of real economic effects of bank risk taking in the negative-rate environment.

4.2 Real Economy

Does the change in bank credit supply in response to negative policy rates lead to changes in the real economy? To answer this question, one needs to pin down at least two parameters. First, what is the distribution of bank credit across firms, and how is it affected by changes in credit supply? And second, how constrained are firms when raising external capital, so that a change in bank credit affects their non-financial operations?

Bittner et al. (2020) examine the real consequences of the risk taking by high-deposit banks in Germany in response to the ECB's decision to lower the deposit facility rate to negative in June 2014. As high-deposit banks establish new relationships with risky firms, one would expect to detect real effects for these firms. Specifically, Bittner et al. (2020) shed light on the consequences in terms of firm-level investment and employment (Chodorow-Reich, 2014). Riskier firms are more likely to be rationed by banks and should therefore exhibit a higher marginal revenue product of capital and labor. Holding constant the impact of a new relationship with a bank on a firm's real decisions, those firms that form a new relationship with a high-deposit bank – i.e., risky firms – indeed invest more and increase their employment.

Bottero et al. (2019) also document positive effects on firm-level investment and employment in Italy. Instead of the extent of deposit funding, they use liquid asset holdings as a measure of a bank's exposure to the ECB's negative interest-rate policy (see Section 3.3). More liquid banks rebalance their asset portfolio towards more lending to ex-ante riskier and smaller firms.

The positive real effects from more bank credit to constrained firms is maybe counterbalanced by less credit overall. For the case of Germany, Moser, Saidi, Wirth, and Wolter (2020) show that firms in pre-existing relationships with high-deposit banks do not only receive less credit (in the form of syndicated loans, as in Heider, Saidi, and Schepens, 2019) after the introduction of negative policy rates than do firms in pre-existing relationships with low-deposit banks, but they also reduce their overall leverage by more. This suggests that firms cannot readily substitute credit across banks or substitute bank credit for bonds.

Negative policy rates induce banks to extend credit to financially constrained firms. The positive real effects in Bottero et al. (2019) are at the intensive lending margin. Firms in a pre-existing relationship with their bank obtain more and also cheaper credit when the bank is more liquid. The positive real effects in Bittner et al. (2020) are at the extensive margin. Firms with a new banking relationship receive more credit when the bank relies more on deposits. In both cases, the evidence speaks against inefficient lending, although there may be distributional effects across borrowers within a bank as well as across banks.

For the labor market, Moser et al. (2020) document distributional effects of negative policy rates using administrative employer-employee linked data in Germany. Firms that are in relationships with high-deposit banks reduce wages at the top of their within-firm wage distribution, e.g., through adjusting variable compensation, while laying off workers at the bottom of the distribution. This implies an overall reduction in the average wage paid by affected firms and a decline in within-firm wage inequality. Between-firm wage inequality also decreases because the reduction in firm-level average wages is concentrated among initially higher-paying firms.

5 Importance of Heterogeneity in Initial Economic Conditions

While the vast majority of the literature on both conventional and unconventional monetary policy pass-through emphasizes the importance of bank-level characteristics (see Sections 2 and 3), heterogeneity in market conditions also matters. In the euro area, for example, the ECB decides on a single policy rate for a diverse set of 19 countries, even though the business cycles and financial cycles across euro-area countries are not necessarily perfectly synchronized. The ECB's single monetary policy may therefore transmit differently across member countries.[19]

The heterogeneity in the euro area matters for how setting a negative policy rate in June

[19] Dell'Ariccia, Laeven, and Suarez (2017) exploit the heterogeneity of business cycles across regions in the U.S. to identify the causal effect of monetary policy on bank risk taking.

2014 transmits to banks and their borrowers. In some euro-area countries deposit rates are far away from the zero lower bound prior to June 2014. As such, a lower policy rate can still transmit to lower deposit rates. In other countries deposit rates are close to the zero lower bound prior to June 2014. In those countries a lower policy rate does not transmit to lower deposit rates.

Figure 3 shows the different pass-through of setting a negative policy rate to deposit rates in the euro area. The figure shows the average deposit rate (weighted across different maturities) for five euro-area countries (France, Italy, Germany, Portugal, and Spain). In Germany, the average deposit rate was low in early 2014 and has not come down much since then. In contrast, the average rate in Portugal was high in early 2014 and has come down a lot.

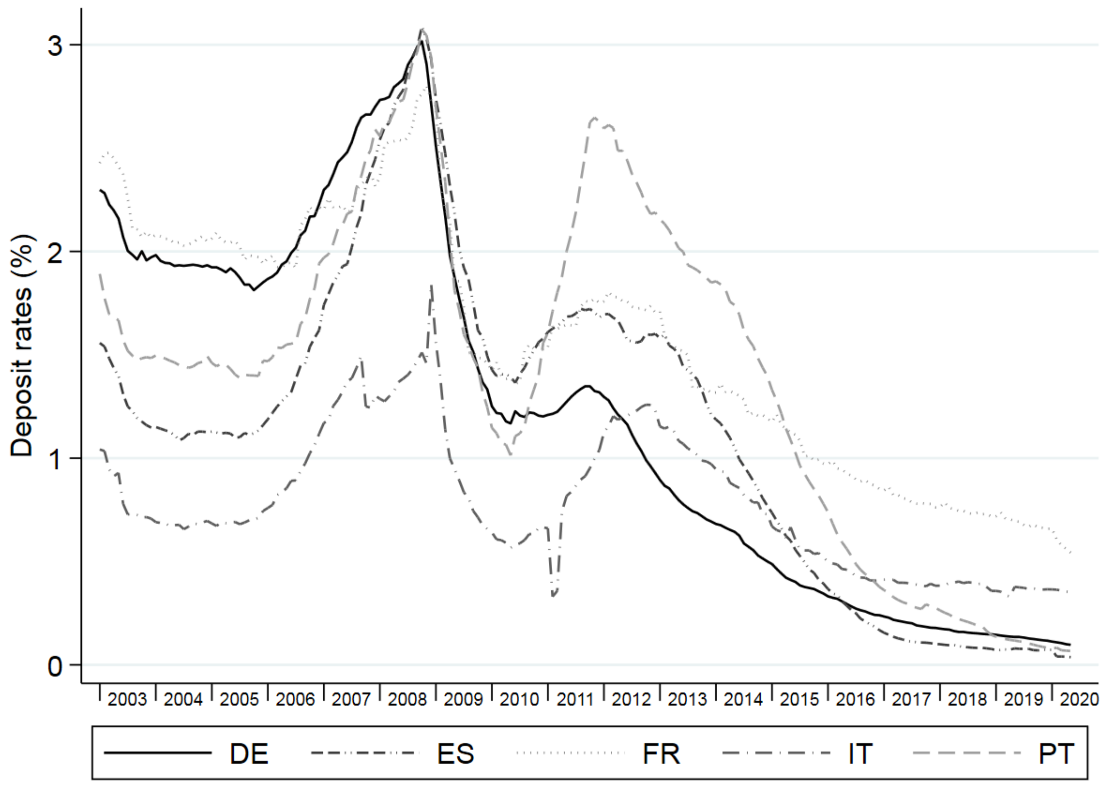


Figure 3: **Deposit Rates by Country – Weighted by Type of Deposits.** This figure shows the weighted, country-level deposit rates (in %) for France, Italy, Germany, Portugal, and Spain between January 2003 and May 2020. For each country, we calculate weighted rates, based on the rates and volumes of overnight deposits, agreed-maturity deposits (all maturities), and deposits redeemable at notice. We include deposits held by both households and non-financial corporations. The rates are calculated using data from the MIR and BSI datasets from the ECB Statistical Data Warehouse.

Lowering the policy rate to below zero transmits like a standard rate cut when deposit rates are high, but transmits differently when deposit rates are low. When deposit rates are high initially and then drop, the rate cut reduces a bank's cost of funding irrespective of whether the bank relies on deposits or wholesale market funding. In this case, the normal bank capital channel is at play. When deposit rates are low and do not drop, the rate cut affects the funding costs of high-deposit and low-deposit banks differentially. Then, a modified bank capital channel, where a bank's funding structure matters, explains bank behavior.

In line with this reasoning, Bittner et al. (2020) document a different transmission of the ECB's decision to set a negative policy rate in June 2014 across the euro area. In Portugal, where deposit rates were high, banks' funding structure does not matter and weakly capitalized banks expand their lending. This indicates a transmission according to the standard bank capital channel. In Germany, where deposit rates were low, high-deposit banks expand their lending only to risky firms. This reflects a transmission according to the modified bank capital channel.

Bittner et al. (2020) combine their estimates for the transmission in Portugal and in Germany with information about bank balance sheets and deposit rates for a large sample of euro-area countries to predict the euro-area-wide impact of negative rates. This exercise reveals strong cross-country heterogeneity in the transmission of the rate cut, both in terms of which channel is at work and in terms of the strength of each channel.

An important question is why average deposit rates vary so much across countries. A potential reason is the difference in sovereign-bond yields because they correlate strongly with deposit rates. One explanation for this is that sovereign bonds are substitutes for deposits in providing liquidity services to households and corporations (see, for instance, Krishnamurthy and Vissing-Jorgensen, 2015; Li, Ma, and Zhao, 2020). Another explanation is the sovereign-bank nexus. Banks typically hold the bonds of their sovereigns. Sovereign stress increases the riskiness of banks, and depositors require a higher return on their deposits in order not to withdraw. Moreover, riskier banks feed back to sovereign stress as governments typically bail out their banking system. This explanation for the variation in deposit rates across euro-area countries in 2014 carries weight because the euro area was still reeling from the shock of the $2011 - 2012$ sovereign debt crisis.

6 Conclusion

In our review, we focus mainly on policy rates, bank lending, and the role of banks' net-interest margin. A negative policy rate is a standard monetary policy instrument applied in an unconventional way. Central banks use a number of other unconventional policy instruments, mostly notably large-scale asset purchases, also known as quantitative easing (QE).

An important open issue is how negative policy rates interact with QE. Are they substitutes or complements? They could be substitutes because they both flatten the yield curve. Breaking through the zero lower bound removes an upward bias in expectations about future policy rates. Once a central bank goes negative, future rate cuts become more likely and long-term interest rates fall accordingly. QE directly lowers long-term rates by increasing the demand for long-term bonds. Or maybe QE hinders the transmission of negative policy rates because it lowers government-bond yields and brings deposit rates closer to the zero lower bound?

Negative rates and QE could be complements because they affect different parts of banks' balance sheets. QE makes it more expensive to hold liquid assets, which induces banks with more liquid assets to lend more instead (Rodnyansky and Darmouni, 2017; Chakraborty, Goldstein, and MacKinlay, 2020). Negative rates reduce the cost of funding for low-deposit banks and make lending cheaper. Or QE transmits to lower loan rates and together with negative rates provides a double-squeeze on the net-interest margin of high-deposit banks.

Disentangling the different effects of negative rates and QE is a challenge, both empirically and theoretically. The empirical challenge is to find variation in the data specific to the proposed mechanism. For example, the ECB engaged in large-scale asset purchases (its public sector purchase program, PSPP) in March 2015 shortly after setting a negative policy rate in June 2014. To address this, Heider, Saidi, and Schepens (2019) narrow the estimation window and also exploit variation in who holds a bank's deposits, households or firms. Because the zero lower bound on deposit rates is harder for household deposits, QE is unlikely to explain the lending behavior across the different banks.

The theoretical challenge is to integrate the role of liquid assets into a model of bank lending. Holding liquid assets and trading them in interbank markets is essential for lending because it allows banks to manage liquidity risk, i.e., the risk of borrowers using their deposits to make payments. Macroeconomic models with a banking sector, however, tend to abstract from banks' liquidity-management problem (for recent exceptions, see De Fiore, Hoerova, and Uhlig, 2019; Bianchi and Bigio, 2020).

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