The Upside Down: Banks, Deposits and Negative Rates*

Pietro Grandi† and Marianne Guille‡

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Abstract

Using confidential bank-firm level data on France, we show that the introduction of negative rates is associated with an increase in lending by banks with greater reliance on deposits, especially by those with lower capital and larger shares of liquid and households deposits. Consistent with portfolio rebalancing, negative rates elicit reallocation toward riskier and long-term assets, as banks shrink their share of interbank liquidity and grow that of corporate loans and debt securities. These results suggest that negative rates encourage banks most reliant on deposits to engage in riskier activities to restore profitability and confirm that deposits play a key role in the transmission of monetary policy rates below the zero lower bound.

Keywords: Monetary Policy, Negative Rates, Deposits, Banks, Risk Taking, Credit.

JEL classification: E43, E44, E52, E58, G21.

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†Boston College and LEMMA, Université Panthéon Assas (Paris II). LEMMA, 4 Rue Blaise Desgoffe, 75006 Paris (France). Contact: grandip@bc.edu.

‡LEMMA, Université Panthéon Assas (Paris II) and Labex MME-DII. LEMMA, 4 Rue Blaise Desgoffe, 75006 Paris (France). Contact: marianne.guille@u-paris2.fr.

1 Introduction

Since 2012, central banks around the world have gradually pushed interest rates below zero. Once an intellectual curiosity, rates are today negative in countries accounting for one quarter of world GDP and $17 trillion worth of debt securities now offer a negative yield.[1] Negative rates turn the principles of finance upside down: commercial banks are charged to hold reserves at the central bank, while some companies and sovereigns are paid to borrow. Going negative constitutes a radical innovation in monetary policy as much as a challenge to conventional economic thinking, as the mere notion of negative nominal rates was traditionally jarring to most economists due to the existence of cash (Black, 1995). Yet, negative rates are now regarded as a potential instrument when policy rates reach the zero lower bound (ZLB). Given the historical decline in nominal interest rates (Figure 1) (Caballero and Farhi, 2018; Jordà and Taylor, 2019) and concerns about secular stagnation (Summers, 2014), advanced economies are likely to spend long periods at the ZLB in the future (Kiley and Roberts, 2017). The ability to lower real interest rates by cutting policy rates below zero may hence become an important resource in responding to future economic downturns (Rogoff, 2016, 2017; Lilley and Rogoff, 2019).

However, the wider financial ramifications of negative rates are still not well understood, nor is it clear how they transmit to real economic activity through the banking system.[2] On the one hand, negative rates may stimulate aggregate demand by removing the zero bound on short-term interest rates (Buiter, 2009; Agarwal and Kimball, 2015) and thus achieve their intended purpose in complementarity with other monetary measures (Draghi, 2016; Bernanke, 2017). On the other, long spells of sub-zero rates could increase the risk of financial disruptions (Carney, 2016). The existence of cash makes banks reluctant to pass negative rates onto retail depositors, so that the ZLB is likely to remain in place for deposits at least in the short-term (Eisenschmidt and Smets, 2019). Due to this nominal rigidity, a protracted period of negative rates may squeeze banks' net interest margins, erode equity, the value of the deposits franchise, and ultimately have contractionary effects on credit supply (Brunnermeier and Koby, 2018; Eggertsson et al., 2019). The importance of understanding the transmission of negative rates is also underscored by the little consensus on the efficacy of other unconventional monetary policies – e.g. quantitative easing and forward guidance – in supporting lending and aggregate demand (Greenlaw et al., 2018; Swanson, 2017; Krishnamurthy et al., 2018). Finally, negative rates are politically sensitive. Five years after

[1] BIS Quarterly Review, International banking and financial market developments, September 2019

[2] See Arteta et al. (2018) and IMF (2018) for early appraisals of negative interest rate policies.

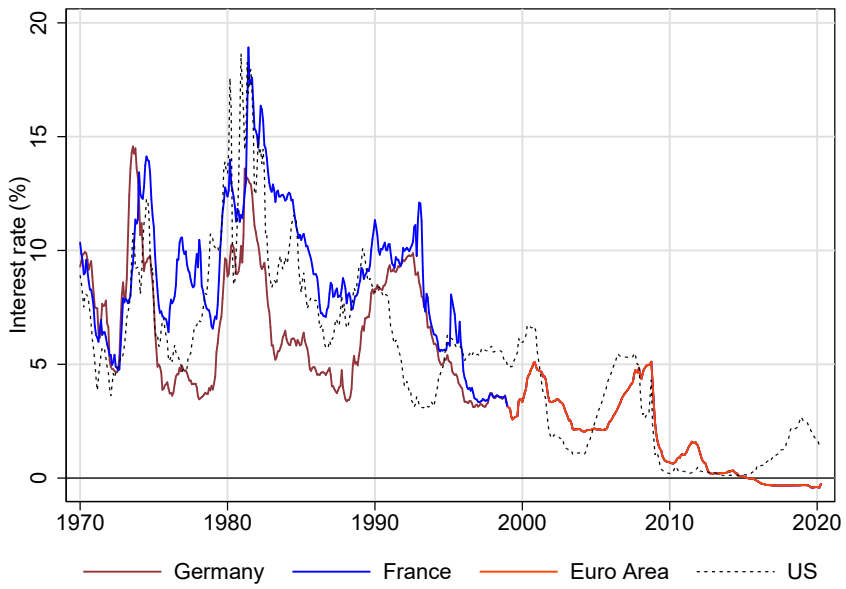


Figure 1: 50 years of nominal interest rates. 3-months interbank rates (%) in the US, France, Germany and the Euro Area, 1970-2020. Source: OECD (2020).

their introduction, the decision by the European Central Bank (ECB) in September 2019 to further lower the Deposit Facility Rate to –0.50% caused a public uproar in Germany where negative rates are seen as an unfair tax on personal savings. The controversial nature of negative rates is also reflected in the growing rift in the governing council of the ECB between representatives of national central banks.[3]

In this paper we study the transmission of negative rates to French banks using confidential data owned by the Banque de France. We document that banks most reliant on deposit funding extend more loans relatively to other banks after the ECB lowers the Deposit Facility Rate below zero. Results obtained from balance sheets and credit register data are both qualitatively and quantitatively consistent: after the introduction of negative rates, a one-standard-deviation increase in banks' deposits to assets ratio is associated to a 13% increase in loans to non-financial corporations and households and to a 12% increase in loans supplied via credit lines to firms and entrepreneurs. This finding is robust to controlling for bank-specific credit demand and for other simultaneous policy measures. More generally, negative rates induce a shift toward high-yielding assets by banks more heavily reliant on deposits. After the implementation of the policy, a one-standard-deviation increase in banks' deposits ratio is associated to a 1.9% decrease in their share of interbank loans and to a 0.9% and 1.2% increase in the shares of corporate loans and privately

[3]The Financial Times, "Can further monetary policy stimulus still be effective?", Martin Sandbu, October 3, 2019.

issued debt securities, respectively. We also find some evidence that banks with large fractions of deposits increase fee and commission income by more than other banks after the introduction of negative rates.

Our results support a transmission mechanism of negative rates that reconciles the contradictory findings of previous contributions (Heider et al., 2019; Bottero et al., 2019; Bubeck et al., 2020). Negative rates disproportionally reduce the net interest margin and net worth of banks that rely on deposits funding. At the same time, negative rates flatten and shift down the yield curve, which accentuates yield-seeking behaviour and induces investors to climb up the maturity ladder to preserve the same portfolio income (Hanson and Stein, 2015; Lane, 2019). High deposits banks have therefore a strong incentive to restore profitability by increasing lending and taking additional risk. We refer to this mechanism as the *Portfolio Rebalancing Hypothesis*. By contrast, our findings are incompatible with the view that negative rates have a contractionary effect on credit supply through the erosion of bank equity (Brunnermeier and Koby, 2018; Eggertsson et al., 2019).

Additional evidence supports this interpretation. First, within banks more reliant on deposits, the increase in corporate lending associated with negative rates is larger for banks with weak ex-ante capitalization. Negative rates appear to elicit stronger rebalancing by banks more susceptible to take risks because of their low equity and limited "skin in the game" (Holmstrom and Tirole, 1997; Hellmann et al., 2000). Second, the increase in lending associated with negative rates is relatively stronger for banks with larger shares of households and liquid deposits. Because negative rates intensify the competition between deposits and physical currency, the zero bound should be harder for deposits that offer near-zero remuneration and that can be readily withdrawn were they charged a negative rate. As a result, banks that rely on these types of deposits would be under even stronger pressure to find avenues to rebalance their portfolio in order to restore profitability.

This paper directly relates to the growing literature on the transmission of negative rates. Empirical work provides contrasting indications as to the effectiveness of this new policy instrument. For instance, Heider et al. (2019) use Euro Area syndicated loan data and document that banks with high shares of deposits cut lending by more relatively to other banks after the introduction of negative rates. The authors also find that high deposits banks take on more risk in the form of increased lending to firms exhibiting higher return-on-assets volatility. Similarly, Eggertsson et al. (2019) use Swedish data and find that the introduction of negative rates had a limited pass-through to lending rates, with banks with larger shares of deposits reducing lending relatively to other banks. By contrast, employing bank level data on, respectively, Swiss and Euro Area

banks, Schelling and Towbin (2018) and Tan (2019) find that banks most reliant on deposits loosen lending spreads and lend out more than other banks as policy rates move below zero. In the same vein, Bubeck et al. (2020) show that the introduction of negative rates induces banks more reliant on deposits to increase holdings of higher yielding securities with respect to other lenders. A number of studies on Italian (Bottero et al., 2019), Swiss (Basten and Mariathasan, 2018) and Euro Area data (Demiralp et al., 2019) also conclude that negative rates have expansionary effects through stimulating lending by banks with high amounts of reserves and excess liquidity. In the same vein, Hong and Kandrac (2018) show that Japanese banks whose share price fell the most upon the announcement of negative rates by the Bank of Japan increase credit supply and take on more risk relatively to other banks. By contrast, Arce et al. (2018) show that Spanish banks declaring their net interest income to be negatively affected by negative rates do not adjust their lending differently with respect to other banks. Finally, Altavilla et al. (2019) document that negative rates are expansionary in the sense that firms linked to banks that charge negative rates on corporate deposits tend to increase investment and decrease cash holdings in order to avoid the costs associated with negative rates.

We make three distinct contributions to this literature. First, to the best of our knowledge this is the first study that provides evidence on the transmission of negative rates via retail deposits for an entire national banking system. In doing so, our analysis expands the focus from the securities market (Bubeck et al., 2020) or the mortgage (Eggertsson et al., 2019) and syndicated lending segment (Heider et al., 2019) to an entire credit market, accounting for the universe of domestic banks' activities. This increase in scope is particularly important because it allows to capture the full extent of bank risk-taking triggered by negative rates which may be otherwise missed in studies that focus on low-risk lending to large corporations and households. Combining balance sheet, income statement and credit register data we offer coherent evidence that banks seek to offset negative rates by increasing non-interest income and adjusting their balance sheets in terms of lending to various counterparts at different maturities, as well as in terms of securities holdings.

Second, we document that the transmission of negative rates varies depends upon term structure of deposits. The differential pass-through on liquid deposits that we uncover is consequential because of the outsize role of checking deposits in banking (Drechsler et al., 2017). As of January 2019, overnight deposits by households and non-financial corporations was the largest class of deposit liabilities, accounting for 46% of total deposits in France.[4] Overnight deposits also rep-

[4]Overnight deposits by non-financial customers over total deposits by non-financial customers. Authors' calculations based on data from the Banque de France (2020).

resent 42.5% of all deposits for the average bank in our sample. In addition, since banks reliant on retail deposits are more likely to lend to non-financial borrowers — their asset share of loans to households and non-financial corporations is 42%, more than twice that of banks less reliant on deposits (see Table A3) – our results have direct implications for the transmission of monetary policy to the real economy and for its macroeconomic impact when nominal rates are at or below the zero lower bound.

Third, this is the first study on the transmission of negative rates in France, the second biggest economy and largest banking system in the Euro Area in terms of assets size. The high-frequency and extensive coverage of the data provided by the Banque de France – including 63% of all domestic loans to households and non-financial corporations – allows us to reliably test for the transmission of negative rates via French banks at different levels of granularity. Providing external validity on the effectiveness of negative rates appears to be particularly important because of their unprecedented nature and the potential heterogeneity of their transmission across countries in the Euro Area (Bittner et al., 2019; Bottero et al., 2019; Arce et al., 2018).

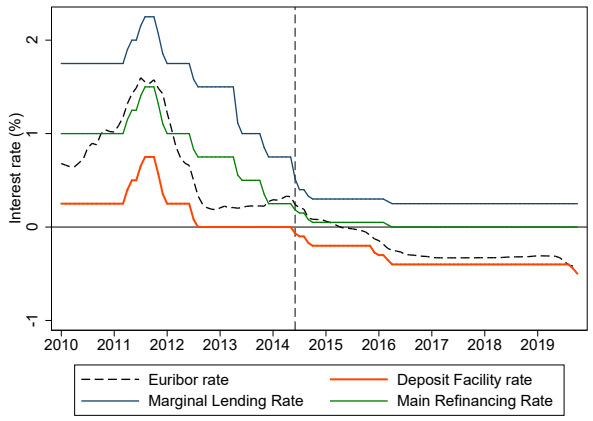
The remainder of the paper is structured as follows. Section 2 offers background information on the implementation of negative rates by the ECB and discusses the possible transmission channels working through the banking sector. Section 3 presents the data and descriptive statistics, discusses the identification strategy and outlines the econometric models. Section 4 reports the results and Section 4.5 offers concluding remarks.

2 Institutional background and hypotheses

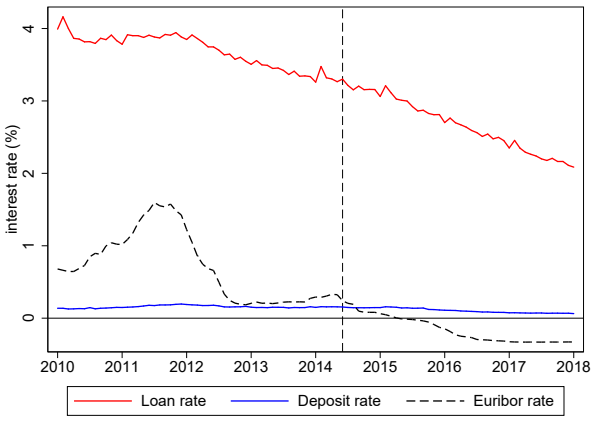
On June 11, 2014, the European Central Bank lowered the Deposit Facility Rate (DFR henceforth) to -10 basis points. As the DFR is the rate on commercial banks' reserves above the regulatory minimum held at the central bank, the move effectively charged banks' excess liquidity. On September 4, 2014, the same rate was lowered to -0.20% and was since lowered three more times: on December 9, 2015 to-0.30%, on March 6, 2016 to -0.40% and on September 12, 2019 to -0.50%, where it currently stands. While some central banks introduced negative rates in the attempt to stabilize the exchange rate (e.g. Denmark and Switzerland), the stated goal of the ECB was to provide additional monetary accommodation in the face of lingering deflation risks (Praet, 2014; Eisenschmidt and Smets, 2019).

As in Heider et al. (2019) and Eggertsson et al. (2019), our study exploits the imperfect transmission of negative rates to retail deposits. When monetary policy rates are above zero, cutting

Figure 2: The imperfect pass-through of negative rates



(a) ECB policy rates and Euribor rate (3 months). Source: ECB (2019).



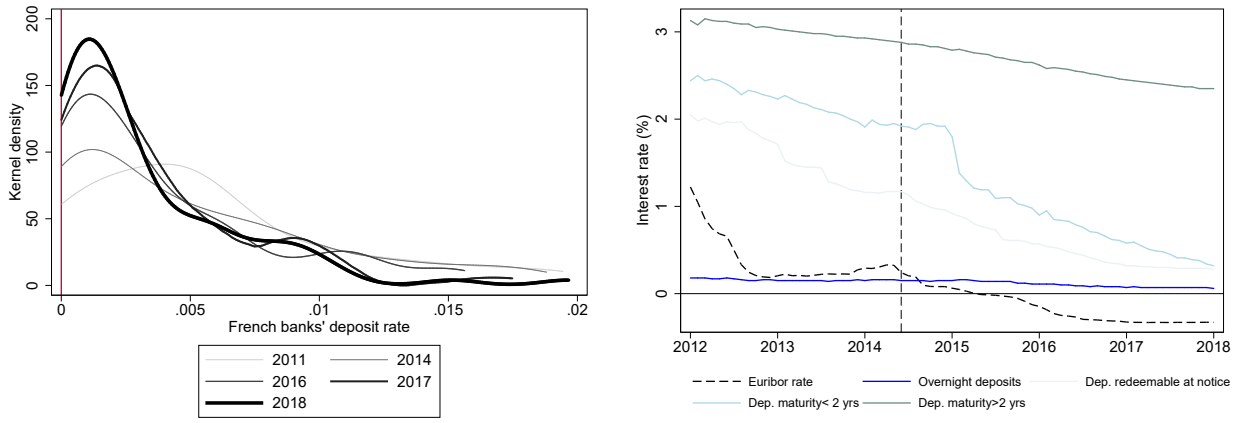
(b) Loan rate and overnight deposits rate offered to French households and non-financial corporations (weighted average) and Euribor rate (3 months). Source: ECB and Banque de France (2019).

the DFR immediately lowers both deposits and money markets rates, thus reducing banks' funding costs. Below zero, however, DFR cuts affect the cost of deposit and market-based funding differently. As illustrated in Figure 2a, DFR cuts into negative territory succeeded in bringing short-term rates below zero, implying a complete pass-through to money market rates. Similarly, loan rates to households and non-financial corporations adjusted downward over time, consistent with a compression of risk spreads brought about by the lower level of short-term interest rates. For instance, the average loan rate for French firms fell from 4% to 2.5% between June 2014 and January 2019. By contrast, the transmission to retail deposit rates was incomplete, as deposit rates remained bounded at just above zero (Figure 2b). Equivalently, Figure 3a shows that the distribution mass of deposits rates in France has progressively bunched at zero, rather than entering negative territory. This phenomenon goes beyond France: evidence suggests that banks across the Euro Area have not yet imposed negative rates on retail depositors (ECB, 2020).

The zero bound on deposits rates is a nominal friction that stems from the existence of cash and from banks' reluctance to pass negative rates to retail depositors (Eisenschmidt and Smets, 2019; Eggertsson et al., 2019). Since cash offers a zero nominal return and deposits are seen as equivalent to currency – i.e. convertible at par – lowering deposits rates below zero may induce a dramatic rise in the supply elasticity of deposits. That is, negative nominal rates may prompt retail depositors to swap checking accounts for cash (or for accounts at competitor banks that do not charge negative rates) as alternative store of value and means of payment.[5] In turn, banks are wary

[5] According to a survey by ING (2015) more than 60% of French depositors would withdraw their deposits if charged

Figure 3: Negative rates and French deposits



(a) Distribution of deposits rates (computed as interest expenses over total deposits) offered by French banks over time. Source: Orbis Bank Focus (2019).

(b) Euribor rate (3 months) and interest rates on main French deposits and savings accounts. Source: ECB and Banque de France (2020).

of losing deposits given their value as a stable source of funding and preferred treatment under Basel III liquidity provisions (Drechsler et al., 2018). Credit institutions also derive substantial market power from deposits which compensates the large operating costs of maintaining a deposit franchise (Drechsler et al., 2017; Li et al., 2019). In addition, legislators and courts in the Euro Area have so far maintained a framework that could pose legal hurdles or litigation risks related to imposing negative rates on retail customers (ECB, 2020). For all these reasons, banks appear to be wary to pass negative rates onto depositors.

Banks would therefore be exposed to negative rates according to their reliance on deposits. Because of the zero bound on deposits, after a rate cut in negative territory banks with large shares of deposits (high deposits banks) would experience a lower reduction in funding costs relative to banks with lower shares of deposits (low deposits banks). At the same time, since the cut in the DFR also lowers the average loan rate, high deposits banks experience a compression of their net interest margin — i.e. the spread between the rate earned on loans and that paid on deposits. Because this margin represents a large share of banks' net income, its compression reduces profits and, ultimately, net worth.

In principle, the compression in net interest margins could have different implications for bank lending. First, high deposits banks may engage in activities aimed at restoring profitability, such as

a negative rate. Note that this reasoning applies strictly to nominal rates since the real (inflation-adjusted) rates had already been negative in the past (see Figure B2). Eggertsson et al. (2019) suggest that, given the storage costs of holding cash, the effective lower bound may be below zero. Alternatively, banks may be willing to charge negative rates in principle, but hesitant to be the first to do so given concerns about reputational costs and competition over deposits associated with a "first-mover curse" (IMF, 2018).

lending to riskier borrowers (Heider et al., 2019) or investing in higher-yielding securities (Bubeck et al., 2020). Search-for-yield incentives may have been particularly strong since negative rates were also associated with a flatter and lower yield curve which increased the wedge between safe and risky assets for a given return (Hanson and Stein, 2015; Lane, 2019). Much like standard monetary policy, negative rates may then induce banks to rebalance their portfolios toward higher-yielding assets such as corporate loans (IMF, 2018; Bottero et al., 2019; ECB, 2020). Indeed, monetary policy works through a risk taking channel even when interest rates are above zero (Adrian and Shin, 2010; Borio and Zhu, 2012; Jiménez et al., 2014; Ioannidou et al., 2015).[6] Negative rates are special in that they concentrate risk-taking incentives in banks more reliant on deposit funding. In other words, because of the zero bound on deposits, negative rates create search-for-yield incentives for banks that would have not otherwise had reason to alter their asset structure. Therefore, the *Portfolio Rebalancing Hypothesis (H1)* predicts that high deposits banks increase lending and exposure to higher-yield assets following the introduction of negative rates. High deposits banks may also restore profitability through non-interest income, for instance by charging higher fees, in a surreptitious application of negative rates (Basten and Mariathasan, 2018). Higher fees may nonetheless be more appealing to banks because customers are already used to accounting and transactions commissions. The scope for raising fees could yet be limited by explicit government regulation aimed at consumer protection and by bank competition for deposits (IMF, 2018).[7]

A second possibility is that, if capital constraints bind, the erosion of equity caused by negative rates forces high deposits banks to deleverage in order to restore regulatory ratios (Eggertsson et al., 2019; Wang, 2019; Campos, 2019). Since banks face an external finance premium that is inversely related to their financial health, lower net worth should limit their ability to perform intermediation and supply credit (Van den Heuvel, 2002; Gertler and Kiyotaki, 2010; Disyatat, 2011). A sufficiently low negative rate may thus correspond to a "reversal rate", that is, a level of the monetary policy rate below which further reductions become contractionary because the compression in net interest income outweighs the capital gains on securities held on banks' balance

[6] This outcome is also in line with the stated aim of the policy – i.e. inducing banks to swap reserves and liquid assets for loans (Rostagno et al., 2016). In general, these predictions are consistent with the notion that financial institutions are expected to search for yield in a low interest rate environment in order to cover their fixed-rate liabilities (Rajan, 2005). Banks facing adverse profit shocks also tend to grow their assets (Capie and Wood, 1991; Beck and Casu, 2017) and engage in practices aimed at offsetting losses by taking additional risk (Beatty et al., 2002; Willman et al., 2002; Pennacchi and Santos, 2018).

[7] The widespread use of online fees comparators (such as the one provided by the Comité consultatif du secteur financier in France) are also likely to reduce the extent to which banks can increase fees without losing market shares.

sheets (Brunnermeier and Koby, 2018). Hence, for the *Reversal Rate Hypothesis* banks most reliant on deposits should contract lending following the introduction of negative rates.

While offering opposite predictions, both hypotheses identify the transmission of negative rates by looking at banks with different shares of deposits. Their discrepancy stems instead from assumptions about bank capital. While *H2* assumes that, by eroding equity, negative rates necessarily force banks to reduce lending, *H1* implies that the same adverse impact on equity should strengthen banks' incentives to increase profitability by searching for yield. These considerations suggest an additional cross-sectional test that conditions on bank capital. If the *Reversal Rate Hypothesis* were correct, one would expect that, among banks reliant on deposits, low capital banks would be under even stronger pressure to deleverage, because they are relative closer to the regulatory floor (Van den Heuvel, 2002). Conversely, under the *Portfolio Rebalancing Channel* high deposits/low capital banks should have stronger incentives to take additional risks and expand lending, notably because of lower "skin in the game" and the potential for moral hazard and risk-shifting (Holmstrom and Tirole, 1997; Allen and Gale, 2000; Hellmann et al., 2000).

Another way of sharpening the empirical test is to exploit heterogeneities in the pass-through of negative rates *across deposits*. Not all deposits are alike: notably, some are more susceptible than others to downward rigidity at zero because of their low rates and inherent withdrawal risk. For instance, banks may be willing to charge negative interest rates on large corporate deposits but not on small households deposits (Heider et al., 2019; Basten and Mariathasan, 2018). The reason may be that large deposits cannot realistically be readily withdrawn and stored in cash given the presence of storage costs (Eggertsson et al., 2019). In this sense, evidence indicates that French and Euro Area banks have passed negative rates on some corporate deposits and large retail deposits. However, some degree of downward rigidity in smaller deposits to households and SMEs remains, thus limiting the scope to reduction in funding costs without changes to banks' liability structure (ECB, 2020; Altavilla et al., 2019).[8] Furthermore, while long-term savings accounts bear relatively high interest rates and cannot be costlessly withdrawn, overnight checking accounts offer almost no return to holders and are readily and freely convertible to cash. In this regard, Figure 3b shows that the rate on overnight checking deposits in France was already close to zero when the DFR and the Euribor rate went negative. By contrast, rates on savings accounts with longer maturities were well above zero and had ample room to fall in absolute terms after June 2014. To sum up, the hypotheses delineated above should apply in the cross-section of deposits.

[8] Le Figaro, "Taux bas: pas de frais sur les dépôts des particuliers habituels et PME, promet la Banque de France", 18 septembre 2019

Specifically, after the introduction of negative rates banks reliant on households and liquid deposits should expand (*H1*) or contract (*H2*) lending by more relative to banks funded by corporate and less liquid deposits, respectively.

3 Empirical strategy

Given the contrasting theoretical predictions outlined in Section 2, understanding the transmission of negative rates remains an empirical question. In this section we lay out the framework of our empirical analysis. First, we provide background information on France (Section 3.1) and present the data (Section 3.2). Second, we detail our identification strategy and provide descriptive evidence on the differential effect of negative rates across banks with different reliance on deposit funding (Section 3.3). Finally, we introduce a series of econometric models designed to test for the transmission of negative rates (Section 3.4).

3.1 France as a case study

France provides a good testing ground for the transmission of negative rates to bank lending. The largest banking system in the Euro Area in terms of total assets, France is home to some of the largest European banking groups.[9] While capital markets are relatively well developed, France remains a bank-based system. As of 2018 bank credit to domestic non-financial agents accounted for 105% of Gross Domestic Product and banks remain the main funding source for most domestic firms, especially small and medium-sized enterprises (SMEs henceforth).[10] Because of the importance of banks, the transmission of monetary policy to lending has significant economic implications in France (Andrade et al., 2018; Cahn et al., 2017).

Another appealing feature is that deposits rates in France were low with respect to other members of the Euro Area upon the introduction of negative rates (Figure B1). Specifically, in June 2014 the interest rate on overnight deposits from households was 0.07% in France, 0.19% in Spain, 0.27% in Italy and 0.31% in Germany. This feature may render French banks more exposed to negative rates: while German, Italian and Spanish banks had ample room to lower deposit rates, this option was not open to French banks. Based on the hypotheses discussed above, one would expect a stronger transmission – stemming from a stronger compression of net interest margins –

[9] Data refers to January 2014. The asset share of French banks is 26%. By comparison, the share of German banks is 25%, while those of Italian and Spanish banks are, respectively, 13% and 10%. Source: ECB Statistical Data Warehouse (2019).

[10] As of end-2016 bank loans and advances represented 53% of all external debt of French SMEs. Source: Centre de Documentation Economie-Finances (2016).

at work in a country like France (Eisenschmidt and Smets, 2019).[11]

3.2 Data

We use data on French banks and firms owned by the Banque de France. We combine two databases on banks' balance sheets and income statements, the Individual Balance Sheet Items (IBSI) and Compte de Resultat (CR) datasets, with the Fichier Central des Risques (FCR) – the French Credit Register.[12]

The IBSI contains balance sheet information on 40 credit institutions operating in France. Observations are at monthly frequency and at the bank group level. While we do not have access to granular information at the individual bank level, the reprentativeness of the sample is quite satisfactory since our banking groups represent 62% of assets and 63% of loans in France as of January 2016 (see Table A1). We extract series on banks' assets (cash, loans and securities holdings) and liabilities (deposits, securities issued, capital and reserves). The data is granular along several dimensions, including maturity of balance sheet items as well as sector and geography of the counterpart. This database is supplemented with income statement data available in the CR database. Income statement information is semi-annual and available for only 20 banking groups.

We combine these sources with the FCR. As explained by Andrade et al. (2018), the registry collects almost exhaustively the bilateral credit exposures of resident credit institutions to individual resident firms on a monthly basis. Specifically, French banks must report all credit exposures larger than €25,000. Such exposures include loaned funds (drawn credit), commitment on credit lines (undrawn credit) as well as guarantees and specific operations such as long-term leases, factoring and securitized loans. In the FCR firms are defined as legal units, i.e. they are not consolidated under the parent company if they belong to a corporate group. The population of firms then include single businesses, corporations and sole proprietors engaged in professional activities. This database also contains information on firms such as their credit rating internally estimated by the Banque de France, geographical location, industrial sector and a size indicator.

We extract from the FCR all loans supplied by the banking groups for which we have balance sheet data and obtain a sample consisting of 33 bank groups lending to 3889 firms between January 2012 and January 2017. Descriptive statistics on key variables are provided in Table A2.

[11] Incidentally, this could also explain why studies on Italian and Spanish banks do not find evidence on the transmission of negative rates via bank deposits (Bottero et al., 2019; Arce et al., 2018).

[12] Data is accessed through the Banque de France's Open Data Room, a facility providing researchers access to confidential granular data on French credit institutions, financial intermediaries, non-financial corporations and households.

3.3 Identification

To test the hypotheses outlined in Section 2, we exploit cross-sectional variation in reliance on deposits to identify bank-specific exposure to negative rates. We follow Heider et al. (2019) and adopt a differences-in-differences approach. The "policy" corresponds to the lowering of the DFR below zero by the ECB in June 2014. The share of households and corporate deposits to total assets as of January 2014 measures the bank-specific ex-ante sensitivity to the policy – the "treatment intensity". At a fundamental level, we will compare the behaviour of banks with different deposits shares before and after the introduction of negative rates in June 2014. Banks with smaller shares of deposits (the control group) are hence assumed to provide a valid counterfactual for the behaviour of banks with larger shares of deposits (the treated group) had the policy not been implemented.

To justify this assumption we first report balance sheet information for banks with different shares of deposits. Table A3 provides summary statistics on two groups of banks: high and low deposits banks, defined according to whether their deposits share is, respectively, above or below the cross-sectional median as of January 2014. The two groups of banks differ along several dimensions. First, high deposits banks are mainly funded by households and corporate deposits (49% of total assets) and only marginally by interbank deposits (18%) and market-based funding such as debt securities and money market paper (10%). Conversely, low deposits banks rely on interbank deposits (36%) and market-based funding (28%), with retail deposits accounting for a negligible share (3%). Second, high deposits banks are markedly more exposed to the real economy than low deposits banks: the share of loans to households and non-financial corporations for high deposits banks is 42% while it is only 19% for low deposits banks. Conversely, low deposits banks are more exposed to the interbank market with respect to high deposits banks (39% vs. 27%). Third, high deposits banks have on average a positive net interbank position (7%) computed as the difference between interbank loans and interbank deposits over total assets, while the net interbank position of the average low deposits banks is negative (-3%). Further, high deposits banks have a larger liquidity ratio (cash and government securities over total assets) than low deposits banks (7% and 3%, respectively). Finally, high and low deposits banks are quite similar along other dimensions: they have on average a similar size (128 and 120 billions euro in total assets, respectively), hold a similar share of debt and equity securities, and have identical equity capital ratios (9.5%).

The formal econometric validity of the difference-in-differences strategy relies on four assumptions (Blundell et al., 1998). First, the decision to introduce negative rates must have been a surprise, for otherwise banks could have anticipated lending decisions ahead of the treatment date.

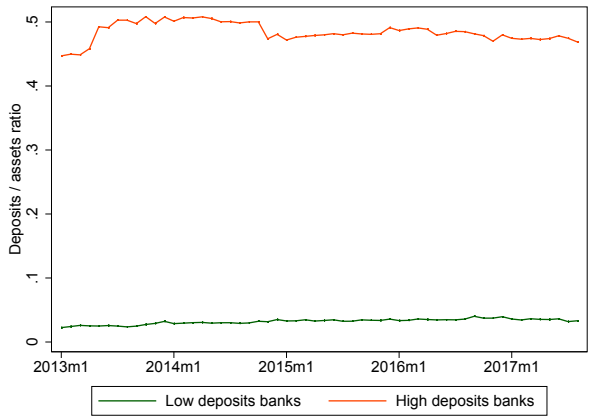
In fact, negative rates were somewhat expected. Substantial preparation was required to ensure that financial institutions were ready to operate in an environment where interest rates can go below zero (Bech and Malkhozov, 2016). This included reviewing IT systems, legal documentation and accounts rules. ECB policy makers also carefully signalled the possibility of negative rates to market participants and the public. On the other hand, precisely because negative rates were unprecedented there was considerable uncertainty around their actual implementation and immediate implications. The actual timing was also difficult to foresee. In this respect, Figures B8 and B9 show that French banks did not particularly adjust their lending ahead of the announcement. On the whole, even if negative rates had been expected by banks, evidence suggests that expectations did not translate into lending decisions ahead of the actual start of the program.

Second, the decision to introduce negative rates should not be related to credit conditions in France. In the Euro Area, monetary policy decisions are taken by the ECB, an independent central bank, as a function of financial and economic conditions prevailing across 19 member states. Decisions are taken on a consensual basis by the Governing Council, a body composed by the six members of the executive board plus the governors of the national central banks of each member country. Until January 2015, the principle of one member one vote gave each country equal weight in the Governing Council. In 2015 a new voting system was introduced which assigned the same voting rights to each of the five largest member states: Germany, France, Italy, Spain and the Netherlands.[13] As a result, although France is the second largest founding member of the European Monetary Union in terms of population and economic activity, it did not formally command commensurate influence on monetary policy decisions at the ECB in the period under study. Additionally, much of the measures taken since 2010 by the ECB were largely in response to the sovereign debt crisis that engulfed Greece, Italy, Ireland, Spain and Portugal between 2010 and 2012 (Hartmann and Smets, 2018). The fact that France was not directly hit by this crisis hence also suggests that the decision to introduce negative rates was plausibly exogenous to French domestic conditions.

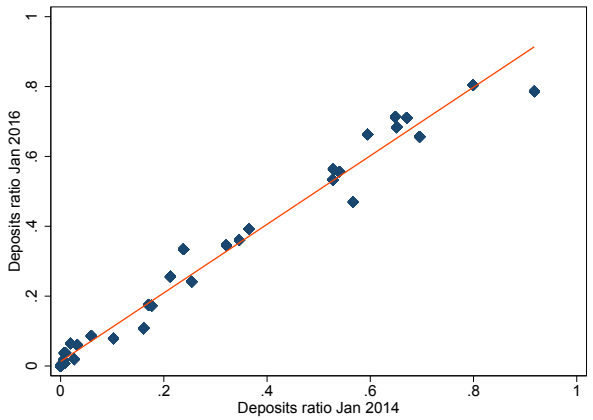
Third, there should be no compositional changes within treatment and control groups over time. That is, banks must not endogenously adjust their share of deposits as a result of negative rates. Below we document that this assumption likely holds in our sample. Figure 4a shows that deposits ratios are very stable across high and low deposits banks. Similar information is conveyed by Figure 4b: banks' deposits ratios plotted in January 2014 and January 2016 lay on

[13] See the ECB's explainer for more information.

Figure 4: Time-invariant composition: deposits ratio



(a) Deposit ratios by high and low deposits banks defined as banks with above or below median deposits ratio as of January 2014. Source: Banque de France, IBSI database (2019).



(b) Correlation between banks' deposits ratio in January 2014 and in January 2016. Source: Banque de France, IBSI database (2019)

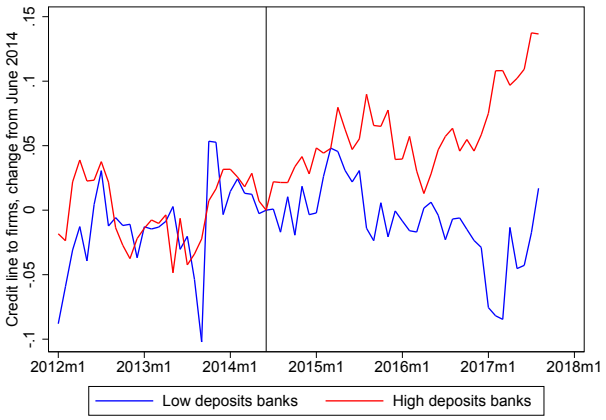
the 45° line, suggesting that the distribution of deposits shares is sticky.[14] This evidence lends support to the validity of the time-invariant composition assumption as it is unlikely that treated banks switch into the control group following the implementation of negative rates.

Fourth, high and low deposits banks must have parallel trends in lending (parallel trends assumption). In other words, had negative policy rates not been implemented, differences in lending between high and low deposits banks would have remained constant over time. In this regard, Figure 5 reveals a picture consistent with this assumption. Specifically, the figure plots the evolution of credit lines (5a) and outstanding loans (5b) supplied by banks to non-financial corporations provided by banks to firms (normalized with respect to the start of the policy in June 2014) by high and low deposits banks. Both figures also provide prima facie evidence of a differential trend between high and low deposits banks: lending by high deposits banks appears to increase by more relatively to low deposits banks since the introduction of negative policy rates.

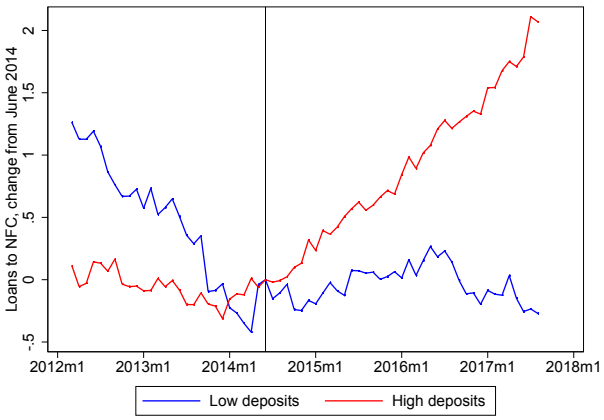
While informative, univariate statistics do not warrant causal interpretation as several identification concerns and confounding factors remain unaccounted for. The main danger to identification are time-varying differences between high and low deposits banks induced by negative rates. This is because while constant differences between treatment and control groups will be removed by the differences-in-differences procedure, time-varying differences would violate the parallel trends assumption and prevent the identification of a causal effect.

[14] The stability of deposits shares is not surprising given that banks' desired fraction of deposits is typically a function of their business model (Demiralp et al., 2019).

Figure 5: Parallel trends: lending



(a) Outstanding credit lines to firms, % change with respect to June 2014, banks with high and low deposits defined as banks with above or below median deposits ratio as of January 2014. Source: Banque de France, Credit Registry (2019).



(b) Loans to non-financial corporations, % change with respect to June 2014, banks with high and low deposits defined as banks with above or below median deposits ratio as of January 2014. Source: Banque de France, IBSI (2019).

For instance, banks may face systematically different credit demand. High and low deposits banks may well have different business models and form lending relationships with entirely different pools of borrowers. When the ECB lowers the DFR below zero this also lowers the user cost of capital, while increasing firms' net worth and relaxing their funding constraints (Bernanke and Blinder, 1988; Bernanke et al., 1999). If high deposits banks lent to firms endowed with better growth opportunities, they may face higher credit demand and extend more loans following the introduction of negative rates. Under this alternative explanation, Figure 5a could equally indicate that firms related to high deposits banks demand more credit with respect to firms related to low deposits banks following the implementation of negative rates. Disentangling credit supply and demand is therefore crucial in our settings given that monetary policy affects lenders and borrowers alike (Bernanke and Gertler, 1995).

Another concern is that negative rates were not implemented in isolation but rather as part of a comprehensive policy package (Figure B5). For instance, in June 2014 the ECB announced a funding-for-lending program termed Targeted Long Term Refinancing Operations (TLTRO). The policy was first implemented in September 2014 through eight quarterly auctions that lasted well into 2016. Moreover, the reward structure of the program was directly related to the negative policy rate. Specifically, the ex-post TLTRO borrowing rate was indexed to the DFR for banks that outperformed a specific lending benchmark (Rostagno et al., 2016). Banks that participated in the TLTRO program had therefore strong incentives to increase lending, particularly so as the

DFR moved deeper into negative territory. As a result, if banks' take up of TLTRO funds were systematically correlated with their deposits share, it would be difficult to attribute the increase in lending to either negative rates or TLTRO.

Addressing these and other identification issues requires formal econometric analysis. In the next sections we will discuss estimating models and exploit granular information contained in our database in order to alleviate these concerns.

3.4 Econometric models

In this section we present various econometric models designed to estimate the transmission of negative rates to French banks. All models are variant of the differences-in-differences specification originally proposed by Heider et al. (2019).

3.4.1 Negative rates, deposits and bank lending

The baseline model tests the two competing hypotheses on the effect of negative rates. According to the *Portfolio Rebalancing Hypothesis (H1)*, negative rates induce banks with large shares of deposits to lend to relatively riskier classes of borrowers and invest in higher-yielding securities. Conversely, the *Reversal Rate Hypothesis (H2)* predicts that high deposits banks should contract lending following the introduction of negative rates. Model 1 is specified as follows:

$$\ln Loans_{it} = \beta[Negative_t \times Deposits\ ratio_i] + \theta X_{it-1} + \alpha_i + \gamma_t + \epsilon_{it} \tag{1}$$

where i denotes banks and t months. The dependent variable ($\ln Loans$) is the natural logarithm of either banks' total outstanding loans, loans to non-financial corporations or loans to households. The key regressor is *Negative*, a time dummy that takes value 1 for all months after June 2014 and zero otherwise. This is interacted with *Deposits ratio*, the sum of deposits by households and non-financial corporations over total assets as of January 2014. Further, X is a vector containing bank level variables such as the natural logarithm of total assets and the ratios of capital and deposits over total assets. These variables are included in order to control for time-varying bank attributes that may matter for the transmission of monetary policy to credit supply (Kashyap and Stein, 1995, 2000; Kishan and Opiela, 2000; Jiménez et al., 2012). To mitigate reverse causality concerns, we introduce bank controls with one lag. Finally, α_i and γ_t are bank and month fixed effects added to absorb all bank-specific and time-varying unobservable heterogeneity. We estimate Model 1 with OLS adopting a symmetric ± 30 months window around the introduction of negative rates

(i.e. Jan 2012 - Jan 2017). We choose a relatively long estimating window in order to capture the medium-term impact of the policy. Standard errors are clustered at the bank level to counter the concern that auto-correlation in lending (in levels) within banks may induce serial correlation of residuals which would underestimate the standard error of β (Bertrand et al., 2004).[15]

Provided that low deposits banks constitute a valid counterfactual of the behaviour of high deposits banks, conditional on covariates and fixed effects the estimate of β measures the causal impact of negative rates on bank lending. The *Portfolio Rebalancing Hypothesis (H1)* would imply $\beta > 0$, indicating that high deposits banks react to negative rates by attempting to restore profitability through higher lending volumes. Conversely, $\beta < 0$ would indicate that high deposits banks are unable to offset the reduction in equity and net interest margins, and therefore cut down on lending. This outcome would be consistent with the *Reversal Rate Hypothesis (H2)*.

As discussed in Section 3.3, loan supply must be disentangled from loan demand. This is because time-varying differences in credit demand faced by banks with different fractions of deposits would prevent the identification of a causal effect. To allay this concern, we turn to bank-firm level data available in the FCR. A large literature in empirical banking controls for time-varying credit demand by comparing multiple banks lending to the same firm (Jiménez et al., 2012, 2014; Iyer et al., 2014; Popov and Van Horen, 2015; Peydro et al., 2017; Bofondi et al., 2018; De Marco, 2019). In our sample, however, only few firms borrow from multiple banks, which precludes the within-firm approach originally proposed by Khwaja and Mian (2008). As a second best approach, we follow Degryse et al. (2019) and use multiple borrower characteristics fixed effects in order to isolate banks linked to firms with similar size and credit rating operating in the same location and industrial sector. The geographical and industry criteria are motivated by the fact that firms within a narrowly defined location and industry are likely to use similar technologies and be equally affected by local developments (Brown et al., 2009; Amiti and Weinstein, 2011). Specifically, our firms reside in 100 French "départements" defined as geographical units between the administrative region and the commune and analogous to counties. For industry, we use 19 macro-industrial categories (NAF codes). The rationale behind the size and rating criteria is that firm size and credit quality are important drivers of demand (Diamond, 1991). For this purpose we use the firm credit rating internally estimated by the Banque de France. French firms are regularly rated according to their solidity and ability to meet financial obligations. The rating system of the Banque de France includes twelve notches and ratings are assigned by staff of

[15] We have enough clusters (40) to obtain a cluster-robust variance estimator since the rule of thumb is to have between 20 and 50 clusters (Bertrand et al., 2004; Cameron and Miller, 2015).

the Bank based on both hard information from financial statements and soft information gained through on-site visits and interviews. The Banque de France also operates a close monitoring of firms running into financial difficulties, which avoids the issue of missing accounting information when firms enter financial distress. Ratings are widely used by banks when deciding whether and how much credit to grant to firms and by the ECB when assessing whether a particular business loan can be pledged as collateral against Central Bank funding (Aghion et al., 2019). In terms of coverage, the system provides ratings to almost all firms with annual turnover over €750.000 and for micro-business firms with credit exposures over €350.000 (Dietsch and Fraisse, 2013). Finally, to measure firm size we use an indicator that distinguishes between micro firms, SMEs and large firms as defined by the French Economic Ministry.[16]

Insofar firms with similar size and creditworthiness operating in the same county and industry face similar demand conditions in any given month, borrower characteristics fixed effects will absorb credit demand. In other words, we will compare changes in lending by high and low deposits banks to the same closely defined group of firms before and after the introduction of negative rates. Degryse et al. (2019) show that this approach yields estimates similar to what one would obtain using the "within firm" approach proposed by Khwaja and Mian (2008). Moreover, this method allows to avoid restricting the analysis to multi-bank firms which is particularly appealing in terms of external validity since the majority of French firms have a unique banking relationship (Cahn et al., 2017). Single-bank firms are also more likely to depend on bank funding and hence most affected by changes in credit conditions induced by monetary policy. Conversely, multi-banks firms tend to be larger and relatively less susceptible to changes in lending conditions (Detragiache et al., 2000). Specifically, we estimate the following bank-firm level model (2):

$$\ln Credit\ line_{ijt} = \beta[Negative_t \times Deposits\ ratio_i] + \theta X_{it-1} + \alpha_i + \gamma_t + Firms\ FE + \epsilon_{ijt} \quad (2)$$

The dependent variable ($\ln Credit\ line$) is the natural logarithm of credit line funds committed by bank i to firm j in month t. As before, *Negative* is a dummy variable taking value 1 for all months after June 2014 and 0 otherwise, while *Deposits ratio* denotes banks' deposits to assets ratio as of January 2014. Vector X includes the same bank controls as per Model 1, and α_i and γ_t are bank and month fixed effects. To control for bank-specific credit demand shocks, we include

[16]The classification is based on the Application Decree (n°2008-1354) of Article 51 of the Law on Modernisation of the Economy. Specifically, micro firms are enterprises which employ less than 10 persons and either have an annual turnover or a total balance sheet not exceeding €2 million. SMEs are firms that employ less than 250 persons and either have an annual turnover not exceeding €50 million or a balance sheet total not exceeding €43 million. Large firms are all remaining companies.

(multiplicatively) borrower characteristics fixed effects: county-industry-rating-size-month fixed effects (*Firms FE*). As before, standard errors are clustered at the bank level.

3.4.2 Negative rates and bank capital

The key difference between the *Portfolio Rebalancing* and the *Reversal Rate* hypotheses is the role of bank equity. The former view emphasises that, by threatening equity losses and flattening the yield curve, negative rates stoke risk-taking incentives by high deposits banks. The latter maintains that negative rates have a contractionary effect on lending because they erode bank equity and hence limit the ability of high deposits banks to perform financial intermediation. As discussed in Section 2, this modelling dichotomy suggests an additional test based on bank capital which is formalised by the following model (3):

$$\ln Loans_{it} = [Negative_t \times Deposits\ ratio_i][\beta_1 + \beta_2 Low\ capital_i] + \theta X_{it} + \alpha_i + \gamma_t + \epsilon_{it} \tag{3}$$

where, as before, i denotes banks and t months. Dependent variable, bank controls and fixed effects are included as per Model 1. The distinctive feature of Model 3 is *Low capital*, a dummy that takes value 1 if a bank has a capital to assets ratio in the bottom tercile of the distribution as of January 2014, and 0 otherwise. The coefficient of interest is β_2 and tests whether, within the group of deposits dependent banks, weakly capitalized banks had a differential lending response to the introduction of negative rates with respect to better capitalized banks. Under the *Reversal Rate Hypothesis*, β_2 is expected to be negative: the contraction in lending associated to negative rates should be stronger in high deposits banks that are also under-capitalised. This follows from the fact that less capitalised banks are closer to the regulatory minimum (Van den Heuvel, 2002) and face higher funding costs (Peek and Rosengren, 2005; Ellis and Flannery, 1992; Flannery and Sorescu, 1996; Gambacorta and Shin, 2018). Vice versa, β_2 should be positive under the *Portfolio Rebalancing Hypothesis*, implying that the increase in lending associated to negative rates is driven by undercapitalised, high deposits banks. This is because the risk-shifting incentives of monetary easing are stronger for banks with limited equity and little "skin in the game" (Holmstrom and Tirole, 1997; Hellmann et al., 2000; Jiménez et al., 2014).

3.4.3 Negative rates and deposits characteristics

The transmission mechanisms discussed in Section 2 yield an additional testable prediction. By increasing the competition between cash and deposits, negative rates disproportionately affect

banks that are unable or unwilling to pass negative rates to their deposits base. However, there are significant differences across deposits. Banks may be especially wary of charging negative rates on households deposits, but not so for corporate deposits. By the same token, the zero bound may be harder for liquid deposits that are redeemable at no cost and carry a lower rate with respect to less liquid savings instruments. Since both the *Portfolio Rebalancing* and *Reversal Rate* hypotheses predicate the transmission of negative rates on the downward rigidity of deposits, one would expect the predictions of both hypotheses to apply even more strongly to liquid and households deposits. We formalise these conjectures in Model 4 below:

$$\begin{aligned}\ln Loans_{it} = Negative_t[&\beta_1 HH\ Deposits_i + \beta_2 NFCs\ Deposits_i \\ &+ \beta_3 Liquid\ Deposits_i + \beta_4 Savings\ Deposits_i] \\ &+ \theta X_{it} + \alpha_i + \gamma_t + \epsilon_{it} \quad (4)\end{aligned}$$

where, as before, i denotes banks, and t months. Dependent variable, bank controls and fixed effects are included as in Model 1. In Model 4 the test relies on comparing the four beta coefficients. Under *H1* (*H2)*, the increase (decrease) in lending following the introduction of negative rates should be larger for banks with larger shares of households and liquid deposits with respect to banks with larger shares of corporate and less liquid savings accounts, that is: $\beta_1 > \beta_2$ and $\beta_3 > \beta_4$ ($\beta_1 < \beta_2$ and $\beta_3 < \beta_4$). Variables are computed as follows. *HH Deposits* and *NFC Deposits* are the share of deposits by households and non-financial corporations, respectively, over total assets as of January 2014. *Liquid Deposits* is the sum of overnight deposits and deposits redeemable at notice within three months over total assets. *Savings Deposits* denotes accounts with agreed maturities over total assets. The former variable includes deposits that are demandable and highly liquid, while the latter variable contains accounts that are locked in for term and hence less liquid (Drechsler et al., 2017).[17] Unfortunately, we have no observations on *Savings Deposits* before July 2015.[18] As a result, both *Liquid Deposits* and *Savings Deposits* are measured as of July 2015. This choice is supported by the fact that banks' deposits shares remain constant over time as suggested

[17]Overnight deposits are defined as "convertible into currency and/or transferable on demand by cheque, banker's order, debit entry or similar means, without significant delay, restriction or penalty". Similarly, deposits redeemable at notice are defined as "non-transferable deposits, usually with no agreed maturity, but which may be withdrawn without penalty only after a period of notice". Conversely, deposits with agreed maturity are "non-transferable deposits which cannot be withdrawn before an agreed fixed term, or that can be withdrawn only subject to a penalty".

[18]Specifically, the lack of observations prior to July 2015 concerns the series of deposits with agreed maturity, while we have historical observations on overnight deposits. However, we measure the different deposits ratio at the same point in time to ensure a meaningful comparison.

by Figures 4 and B6. The share of overnight deposits is also sticky: sorting by pre/post negative rates periods, Figure B7 shows that the distribution of overnight deposits over total assets remains broadly unchanged.

4 Results

This section presents the results obtained by estimating the models presented in Section 3.4. We first discuss the findings on the transmission of negative rates to bank lending (Section 4.1) and asset allocation (Section 4.2). Second, we review the evidence conditioning on bank capital (Section 4.3) and finally test whether the transmission of negative rates varies across types of deposits (Section 4.4).

4.1 Negative rates and bank lending

We start by testing whether the introduction of negative rates is associated to a differential lending response according to banks' reliance on deposits (Model 1). Table 1 reports bank level results for total loans (columns 1-5), loans to non-financial corporations (columns 6-10) and households (columns 11-15). Results indicate a positive and statistically significant treatment effect of negative rates via deposits, especially for corporate loans. After the DFR is lowered below zero, banks with larger shares of deposits extend more loans than banks with lower deposits shares (columns 1,6 and 11). The effect is economically sizeable: a one-standard-deviation increase in *Deposits ratio* (0.17) is associated to a 9% increase in total loans ($0.17 \times 0.553 = 0.094$) and to a 13% increase in both corporate and household loans. The effect on corporate loans is large in economic terms, equivalent to 10% of the standard deviation of the dependent variable.[19] These results are robust to adding bank level variables to control for observable co-determinants of credit supply (columns 2,7 and 12). Note that the inclusion of bank and month fixed effects subsumes the estimates of coefficients on *Deposits ratio* and *Negative*.

An alternative explanation is that banks' predisposition to increase loans after the introduction of negative rates depends on excess liquidity, rather than reliance on deposits. By charging reserves and penalizing the holding of liquid and safe assets, negative rates may induce banks with large excess liquidity to rebalance toward higher-yielding assets such as corporate loans (Bottero et al., 2019; Basten and Mariathasan, 2018; Demiralp et al., 2019). Since high deposits banks in our sample are also liquid (see Table A3), $\hat{\beta}$ may endogenously reflect the fact that banks with large

[19] By comparison, the effect on total loans and household loans correspond to 7.6% and 5.7% of the standard deviation of these variables, respectively

Table 1: Negative rates and bank lending: bank level

Dep. variable	ln Total Loans$_{it}$					ln Loans to Non-Financial Corporations$_{it}$					ln Loans to Households$_{it}$				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Deposits ratio$_i$	0.553**	0.450**	0.414	0.448**	0.411**	0.777***	0.687***	0.733***	0.674***	0.646***	0.792*	0.623*	0.558	0.668*	0.592*
×Negative$_t$	(0.218)	(0.203)	(0.248)	(0.218)	(0.186)	(0.210)	(0.209)	(0.246)	(0.214)	(0.208)	(0.432)	(0.355)	(0.371)	(0.372)	(0.339)
Interbank position$_i$			0.050					-0.129					0.121		
×Negative$_t$			(0.177)					(0.171)					(0.363)		
Liquidity ratio$_i$			0.556					0.266					1.724		
×Negative$_t$			(0.674)					(0.704)					-1.077		
Deposits ratio$_i$				0.311					0.544*					-0.079	
×Placebo cut$_t$				(0.188)					(0.277)					(0.265)	
TLTRO Loans$_i$					0.314					0.334					0.395
×Negative$_t$					(0.305)					(0.318)					(0.541)
Bank controls		Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N° of banks	38	38	38	34	38	38	38	38	34	38	35	35	35	32	35
Observations	2,135	2,087	2,087	1,931	2,087	2,131	2,083	2,083	1,927	2,083	1,852	1,808	1,808	1,712	1,808
Adjusted R^2	0.973	0.974	0.974	0.974	0.974	0.971	0.972	0.972	0.972	0.972	0.977	0.978	0.978	0.977	0.978

Notes: The table reports results of the estimation of Model 1 estimated with OLS. The dependent variable is the log of banks' total outstanding loans (columns 1-5), loans to non-financial corporations (columns 6-10) and loans to households (columns 11-15). The estimation window is January 2012 - January 2017 for all specifications. *Negative* is a dummy variable taking value 1 for all months following June 2014 and 0 otherwise. *Deposits ratio* denotes a bank's deposits/assets ratio as of January 2014 and as of January 2012 for columns 4,9 and 14. *Interbank position* and *Liquidity ratio* denote a bank's net interbank position and liquid assets, respectively, scaled by total assets as of January 2014. *Placebo cut* is a dummy variable taking value 1 for all months after July 2012 and 0 otherwise. *TLTRO Loans* correspond to loans to households and non-financial corporations minus loans to households for house purchase, all divided by total assets and measured as of January 2014. Lagged bank controls variables (not reported) include the log of total banking assets, the common equity to assets ratio and the ratio between deposits by households and non-financial corporations over total assets. Bank and month fixed effects are included as indicated. Standard errors are clustered at the bank level and reported in parentheses.*,**,*** refer to significance levels at 10%,5% and 1%, respectively.

excess liquidity rebalance more intensively toward corporate loans after the introduction of negative rates. To address these concerns, in columns 3,8 and 13 we add two measures of bank liquidity: *Interbank position*, computed as interbank loans minus interbank deposits and scaled by total assets; and *Liquidity ratio*, corresponding to the sum of cash and government debt securities divided by total assets. Both variables are taken as of January 2014 and interacted with the dummy *Negative*.[20] Results confirms that negative rates transmit to corporate lending via deposits. Measures of excess liquidity always enter the model insignificantly, while the estimate of β for corporate loans remains strongly statistically significant (column 8). The opposite is true for total loans and loans to households: once measures of excess liquidity are included, coefficients become smaller, less precisely estimated and lose statistical significance (columns 3 and 13). These findings underscore the robustness of the effect on corporate loans and suggest that dependence on deposits, rather than excess liquidity, drives banks' increase in credit following the introduction of negative rates. Comparing Figures 5a and B3 visually confirms this result. While Figure 5a shows a sustained increase in corporate lending by high deposits banks with respect to low deposits banks after mid-2014, Figure B3 reveals no differential trend between banks with high and low net interbank positions.

In the remaining columns of Table 1 we carry out additional robustness tests. First, negative rates may not be special. Rather than emanating from a downward rigidity on deposits rates, results may reflect a hitherto unknown transmission channel of the DFR working through deposits. To address this possibility, we perform a placebo test whose rationale is as follows: if the differential lending behavior is specific to negative rates, one should fail to observe a similar response around prior rate cuts in *positive* territory (Nucera et al., 2017; Heider et al., 2019). This test is performed by interacting *Deposits ratio* with *Placebo cut* a dummy that takes value 1 for all months after July 2012 and 0 otherwise. As in Heider et al. (2019), this date is selected for this was the last time the ECB cut the DFR from 0.25% to 0. If lowering the DFR below zero is special, we would expect $\hat{\beta}$ to remain similar to the baseline estimate and the coefficient on the placebo term to be statistically insignificant.[21] Columns 4,9 and 14 of Table 1 indicate that our results survive this

[20] Ideally, we would include banks' excess reserves position vis-à-vis the Eurosystem as in Demiralp et al. (2019). Unfortunately, this information is not available in our database. We note however that excess reserves are typically strongly correlated with banks' overall liquidity position (Basten and Mariathasan, 2018). Banks' net interbank position and liquidity ratio should be able to capture the extent to which negative policy rates transmit to banks through banks' excess liquidity.

[21] Note that to meaningfully carry out this placebo test, the *Deposits ratio* variable is taken as of January 2012 in order to be able to properly compare the placebo treatment with the baseline treatment. This accounts for the lower number of banks available for the estimation, since 4 banks do not report values for deposits as of January 2012.

test: the coefficient on the placebo treatment is mostly statistically insignificant, while the main coefficient of interest (β) remains positive and statistically significant for all types of loans.

Second, the apparent relationship between deposits, negative rates and lending may be driven by the simoultaneous implementation of the TLTRO program by the ECB. The potential endogeneity of this program is compounded by the fact that the ex-post interest rate on TLTRO funds was tied to the DFR (Lane, 2019). This program may be driving the results if, for instance, it succeeded in stimulating lending while at the same time banks' take up of TLTRO funds was correlated with their shares of deposits. To address this concern, we follow Bottero et al. (2019) and interact *Negative* with *TLTRO Loans*. According to ECB guidelines, the TLTRO program take-up has a maximum threshold corresponding to 7% of the total amount of bank loans to non-financial corporations and households excluding loans to households for house purchases. We therefore construct *TLTRO Loans*, a bank-specific measure of ex-ante TLTRO take-up capacity, as the the sum of loans to households and non-financial corporations (excluding loans to households for house purchase) over total assets as of January 2014. Columns 5,10 and 15 confirm that $\hat{\beta}$ remains unchanged even after controlling for banks' potential ex-ante TLTRO borrowing capacity.

Finally, banks mainly funded by deposits may face different credit demand following the introduction of negative rates. In order to isolate credit supply, we employ data from the FCR and estimate Model 2. Bank-firm level results reported in Table 2 are in line with bank level estimates and robust to controlling for bank-specific changes in credit demand. Column 1 indicates that banks with larger shares of deposits provide relatively more funds through credit lines following the introduction of negative rates. In terms of economic significance, a one-standard-deviation increase in *Deposits ratio* (0.17) is associated to a 12% increase in credit supplied through credit lines ($0.17 \times 0.701 = 0.119$). Note that the semi-elasticity is almost identical to that obtained for corporate loans using bank level data (13%) as reported in Table 1.

In columns 2-5 of Table 2 we verify the robustness of bank-firm findings to the checks carried out above. Specifically, column 2 includes bank characteristics and column 3 controls for bank liquidity. Next, the placebo test is replicated in column 4 and column 5 accounts for banks' potential TLTRO take-up capacity. Estimates of β remain positive and strongly statistically significant throughout, with the point estimate relatively unchanged across specifications. Next, the regression is saturated with borrower characteristics fixed effects to isolate the impact of negative rates on credit supply. To do so, we progressively include month-rating-industry-county-size fixed effects (columns 6-9). As discussed in Section 3.4, this is done to absorb unobservable credit demand

Table 2: negative rates and bank lending: bank-firm level

Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	ln Credit lines$_{ijt}$								
Deposits ratio$_i$ × Negative$_t$	0.701***	0.700**	0.716***	0.878***	0.906***	0.565**	0.859***	1.620**	1.742**
	(0.217)	(0.254)	(0.218)	(0.261)	(0.303)	(0.243)	(0.212)	(0.641)	(0.616)
Interbank position$_i$ × Negative$_t$			0.580						
			(0.445)						
Liquidity ratio$_i$ × Negative$_t$			1.538						
			(1.808)						
Deposits ratio$_i$ × Placebo cut$_t$				-0.077					
				(0.221)					
TLTRO Loans$_i$ × Negative$_t$					-0.404				
					(0.504)				
Bank controls		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month-Rating FE						Yes			
Month-Rating-Industry FE							Yes		
Month-Rating-Industry-County FE								Yes	
Month-Rating-Industry-County-Firm Size FE									Yes
N° of banks	27	24	25	24	25	24	23	18	18
N° of firms	1,882	1,556	1,613	1,556	1,613	1,556	1,486	781	722
Observations	26,085	23,040	25,683	24,317	25,683	23,024	20,932	7,028	6,493
Adjusted R^2	0.143	0.147	0.147	0.133	0.147	0.267	0.293	0.163	0.209

Notes: The table reports results of the estimation of Model 2 estimated with OLS. The dependent variable is the log of the credit line and outstanding short-term credit provided by bank *i* to firm *j* in month *t*. The estimation window is January 2012 - January 2017. *Negative* is a dummy variable taking value 1 for all months following June 2014 and 0 otherwise. *Deposits ratio* denotes a bank's deposits/assets ratio as of January 2014 and as of January 2012 for colums 4 and 9. *Interbank position* and *Liquidity ratio* denote a bank's net interbank position and liquid assets, respectively, scaled by total assets as of January 2014. *Placebo cut* is a dummy variable taking value 1 for all months after July 2012 and 0 otherwise. *TLTRO Loans* correspond to loans to households and non-financial corporations minus loans to households for house purchase, all divided by total assets and measured as of January 2014. Lagged bank controls variables (not reported) include the log of total banking assets, the common equity to assets ratio and the ratio between deposits by households and non-financial corporations over total assets. Bank and month fixed effects are included as indicated. Fixed effects are included as indicated. Specifically, *Rating* denotes the Banque de France internal rating on firms' creditworthiness (12 categories); *Industry* is one of 19 NAF industrial sectors; *County* corresponds to 100 French dèpartements; *Firm size* is an indicator variable that classifies firms as either micro-firm, SMEs or large firms. Standard errors are clustered at the bank level and reported in parentheses.*,**,*** refer to significance levels at 10%,5% and 1%, respectively.

components shared by firms of comparable size and risk profile that operate in the same county and industry in any given month. Our results survive this test and hence suggest that negative rates are associated with a shift in credit supply.[22]

Findings reported so far suggest that banks most reliant on deposits increase corporate lending and credit lines by more than other banks since the introduction of negative rates. This evidence is consistent with the *Portfolio Rebalancing Hypothesis*: negative rates induce banks with large shares of deposits to offset the compression of intermediation margins by increasing lending, especially to riskier borrowers. Indeed, corporate loans typically carry a higher interest rate and default risk with respect to households loans.[23] These results accord to the findings of Schelling and Towbin (2018), Bittner et al. (2019) and Tan (2019) for Switzerland, Germany and the Euro Area. More broadly, the result that negative rates are expansionary is consistent with Hong and Kandrac (2018), Bottero et al. (2019) and Demiralp et al. (2019).

Our findings contrast instead with the evidence provided by Heider et al. (2019) and Eggertsson et al. (2019) in which the introduction of the policy is associated with a *decline* in lending by banks more reliant on deposits. We note that this discrepancy may be driven by the average riskiness of loans under study. For instance, Eggertsson et al. (2019) focus on mortgage and consumer loan data. Similarly, Heider et al. (2019) employ syndicated loan data which are typically extended to large, transparent and established firms (Dennis and Mullineaux, 2000; Altunbas et al., 2010). Insofar the results presented above capture banks' attempt to restore profitability through higher credit risk, banks may have reduced exposure to households and syndicated loans – two relatively low-yielding loan classes – and moved toward riskier credit to non-financial corporations. This explanation is also consistent with a second result by Heider et al. (2019), namely that banks with more deposits concentrate their syndicated lending toward riskier firms.

4.2 Negative rates and asset allocation

To support this interpretation, we conduct an additional test. Under the *Portfolio Rebalancing Hypothesis*, negative rates should incentivise banks to generally reallocate resources toward riskier

[22] To perform this highly-dimensional fixed effect regression, we use the `reghdfe` command in Stata written by Sergio Correia (Correia, 2016). Note that as the regression is saturated with fixed effects, the number of observations falls drastically and point estimates more than double in size (although the main coefficient of interest retains statistical significance). The loss of observations occurs because the program automatically drops singleton observations in order to avoid incorrect inference stemming from overstated statistical significance (Correia, 2015).

[23] As of 2018, mortgage loans are considered relatively safe in France by the French Prudential Authority. More generally, banks may find it easier to increase corporate as opposed to household lending due to structural and cyclical reasons. Indeed, corporate loans typically exhibit more variability and had more margin to recover after the credit crunch experienced by French firms following the Global Financial Crisis (Kremp and Sevestre, 2013).

and higher yielding assets, not only in terms of loans. We therefore re-estimate Model 1 with a larger set of dependent variables at the bank level: loans to non-financial corporations and households at different maturities, interbank loans, holdings of debt securities issued by the government and by the private sector, and holdings of stocks. To infer substitution effects, all variables are scaled by total assets.

Columns 1-5 of Table 3 indicate that banks reliant on deposits reallocate resources toward riskier assets following the introduction of negative rates. The coefficient on *Deposits ratio*×*Negative* is positive and statistically significant for the share of loans to non-financial corporations, both at short and long horizons (columns 1-3), while negative and insignificant for the share of loans to households (columns 4-5). The reallocation appears to be larger for long-term corporate loans, suggesting that high deposits banks search for yield and increase maturity risk. Banks more reliant on deposits also decrease their share of interbank loans following the implementation of negative rates (column 6) and increase their share of debt securities (column 7). Moreover, the shift into securities is mainly driven by those issued by the private sector, i.e. financial and non-financial corporations (column 11). In terms of magnitude, the reallocation prompted by negative rates is material: a one-standard-deviation increase in *Deposits ratio* (0.17) is associated to a 0.9% increase in the share of corporate loans, a 1.2% increase in the share of privately issued securities and to a 1.9% decrease in the share of interbank loans. We find instead a statistically insignificant effect for the share of bonds issued by the French and Euro Area governments (columns 8-9), by banks (column 10) and for the share of assets invested in stocks (column 12).

We consider the evidence above consistent with the *Portfolio Rebalancing Hypotheses*. The fact that banks more reliant on deposits increase their share of loans to non-financial corporations, especially at long-term horizons, while leaving unchanged their share of loans to households is consistent with search for yield, as the former typically offer a higher return.[24] Conversely, since interbank assets traded at negative rates after the DFR moved below zero (see Figure 2a), a decrease in the share of interbank loan is in line with a shift away from low yielding assets by banks most exposed to negative rates (Demiralp et al., 2019; Bottero et al., 2019). The increase in private, but not public, debt securities is also consistent with the notion that negative rates induce a portfolio rebalancing toward higher-yielding securities (Bubeck et al., 2020). The lack of reallocation toward government debt and private stocks can be explained by the fact that French and Euro

[24]Longer term loans typically carry a higher yield under the normal term structure of interest rates. In turn, riskier borrowers with long-term projects should demand more expensive longer maturity loans anticipating higher refinancing risk (Flannery, 1989; Diamond, 1991; Berger et al., 2005) .

Table 3: Negative policy rates and assets allocation

Dep. variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Asset class	**Loans**$_{it}$						**Debt securities**$_{it}$					**Stocks**$_{it}$
Counterpart	Non-financial corporations			Households		Banks	Total	French gvt	EA gvt	Banks	Private	Total
Maturity	Total	≤ 1 year	> 1 year	Total	> 1 year	Total	Total	Total	Total	Total	Total	Total
Deposits ratio$_i$	0.054**	0.021**	0.033*	-0.012	-0.022	-0.114**	0.094**	0.017	0.008	0.001	0.069**	0.003
$\times$Negative$_t$	(0.025)	(0.008)	(0.017)	(0.019)	(0.016)	(0.048)	(0.040)	(0.018)	(0.008)	(0.012)	(0.026)	(0.004)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N° of banks	40	40	40	40	40	40	40	40	40	40	40	40
Observations	2,233	2,233	2,233	2,233	1,585	2,233	2,233	2,233	2,233	2,233	2,233	1,585
Adjusted R^2	0.955	0.899	0.968	0.981	0.991	0.914	0.766	0.801	0.798	0.514	0.647	0.953

Notes: The table reports results of the estimation of Model 1 estimated with OLS. The dependent variables are: outstanding loans to non-financial corporations (total maturity, maturity under 1 year and maturity over 1 year); loans to households (total maturity and maturity over 1 year-lending for house purchase); loans to banks; debt securities holdings (total, issued by the French government, issued by Euro Area governments, issued by banks, issued by private financial and non-financial corporations); stock holdings. The estimation window is January 2012 - January 2017. *Negative* is a dummy variable taking value 1 for all months following June 2014 and 0 otherwise. *Deposits ratio* denotes a bank's deposits/assets ratio as of January 2014. All dependent variables as measured as shares of total assets. Lagged bank controls variables (not reported) include the log of total banking assets, the common equity to assets ratio and the ratio between deposits by households and non-financial corporations over total assets. Bank and month fixed effects are included as indicated. Bank and month fixed effects are included as indicated. Standard errors are clustered at the bank level and reported in parentheses.*,**,*** refer to significance levels at 10%,5% and 1%, respectively.

Table 4: Negative rates and bank fees

Dependent variable ln Net fees & commission income from	(1) Customer services	(2) Financial services	(3) Off-balance sheet ops.	(4) FX ops.	(5) Liquidity ops.	(6) Securities ops.
Negative	0.208*	0.180*	-0.0327	0.00700	0.182	0.121*
× High deposits	(0.117)	(0.0933)	(0.117)	(0.0388)	(0.358)	(0.0580)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Semester FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	150	112	144	146	131	97
R^2	0.973	0.993	0.907	0.973	0.878	0.917

Notes: The table reports results of the estimation of Model 1 estimated with OLS. The dependent variables is the log of banks' net fees and commission income from customer services (column 1), Financial services (column 2), off-balance sheet operations (column 3), foreign exchange operations (column 4), liquidity and interbank operations (column 5) and operations on securities (column 6). For each variable, net fees and commissions income is the difference between all income and expenses related to a particular type of service or operations. Since data is semiannual and is available either for June or for December, the estimation window is Dec 2012 - Dec 2015. *Negative* is a dummy taking value 1 for all semesters following June 2014 and 0 otherwise. *High deposits* is a dummy taking value of 1 for banks whose deposit to assets ratio lies below the cross-sectional median as of January 2014 in the original IBSI database. Lagged bank controls variables (not reported) include the log of total banking assets, the log of net income, the common equity to assets ratio and the ratio between deposits by households and non-financial corporations over total assets. Bank and month fixed effects are included as indicated. Bank and semester fixed effects are included as indicated. Standard errors are clustered at the bank level and reported in parentheses.*,**,*** refer to significance levels at 10%,5% and 1%, respectively.

Area government bonds offered low (or even sub-zero) yields during this period, while stocks may be judged too risky under Basel III capital regulation. Overall, results presented in this section are in line with the findings presented in Section 1. Our preferred explanation is that banks that rely heavily on deposits embark on activities aimed at restoring their desired level of profitability by increasing lending volumes and investing in riskier assets.

As discussed in Section 2, banks that depend on deposits may also respond to negative rates by increasing non-interest income accruing from fees and commissions. We check for this possibility by combining balance sheet and income statement data (IBSI and CR databases) and re-estimating a new version of Model 1. The dependent variable is now the log of net fees and commission income (i.e. the difference between income and expenses derived from fees). Since data in the CR is semi-annual and available for only 20 banks, we replace the treatment variable with *High deposits*, a dummy that takes value 1 if a bank had above median deposits share as of January 2014 in the original IBSI database, and 0 otherwise. Results presented in Table 4 provide some evidence that high deposits banks adjust their fees and commissions after the introduction of negative rates. These banks report higher commission income on customer and financial services as well as on securities operations with respect to other banks after the DFR moved below zero.

On average, high deposits banks increase net commission income on customer services, financial services and securities operations by, respectively, 21%, 18% and 12% more than low deposits banks after the introduction of negative rates. Conversely, the effect for other fees (off-balance sheet, foreign exchange and liquidity and interbank operations) is not statistically different from zero. These results are consistent with the evidence of Basten and Mariathasan (2018), Lopez et al. (2018) and Arce et al. (2018) and suggest that banks respond to negative rates by also boosting their non-interest income through higher fees.

4.3 Negative rates and bank capital

As discussed, bank capital is a key factor in the transmission of negative rates to bank activities for both the *Reversal Rate* and *Portfolio Rebalancing* hypotheses. Under the former, the contractionary effect of negative rates on high deposits banks should be stronger for under-capitalised banks, because their level of equity is relatively closer to the regulatory floor. For the latter hypothesis, instead, under-capitalised low deposits banks are expected to be more prone to take additional risk in response to negative rates because of risk-shifting incentives.

We test these conjectures by estimating Model 3, where the impact of negative rates is allowed to vary across banks with different levels of capitalization. Results are presented in Table 5. In columns 1-3 the dependent variable is the natural logarithm of outstanding loans to non-financial corporations at different maturities, while the dependent variable in columns 4-8 is the logarithm of credit lines from banks to firms. Consistent with the *Portfolio Rebalancing Hypothesis*, columns 1-3 suggest that, among banks reliant on deposits, the increase in credit associated with negative rates is stronger for under-capitalized banks (i.e. banks in the 1^{st} tercile of the distribution of equity-assets ratio as of January 2014) with respect to better capitalised banks (2^{nd} or 3^{rd} terciles). In column 1 the coefficient estimate for the triple interaction (*Deposits ratio*$\times$*Negative*$\times$ *Low capital*) is positive and statistically significant, indicating that weak capitalization amplifies the credit expansion by high deposits banks (the positive coefficient on *Deposits ratio*$\times$*Negative*). Breaking down across loans maturities reveals that the effect is driven by loans with maturity over 1 year (column 3), while the effect is not statistically significant for loans with maturity under 1 year (column 2). Insofar long-term loans yield higher returns and are inherently riskier (Flannery, 1989; Diamond, 1991; Berger et al., 2005), these results suggest that negative rates encourage less capitalized banks to increase maturity risk by more than better capitalised banks equally reliant on deposits. Figure B4 provides a graphical representation of this result by plotting the change in

Table 5: negative rates, deposits and bank capital

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	ln Loans to NFC$_{it}$			ln Credit line$_{ijt}$				
Maturity	Total	$\leq$1 year	>1 year					
Deposits ratio$_i$ × Negative$_t$	0.315**	1.004*	0.317**	0.084	-0.180	0.019	-0.164	0.049
	(0.128)	(0.563)	(0.133)	(0.308)	(0.251)	(0.290)	(0.605)	(0.651)
Deposits ratio$_i$ × Negative$_t$ × Low capital$_i$	0.790**	0.596	0.763*	1.197**	1.421***	1.585***	3.330**	3.116***
	(0.368)	(0.810)	(0.410)	(0.456)	(0.404)	(0.494)	-1.346	(0.927)
Low capital$_i$ × Negative$_t$	-0.307	-0.409	-0.294	-0.445**	-0.509***	-0.610***	-1.086*	-1.187**
	(0.218)	(0.493)	(0.259)	(0.182)	(0.156)	(0.179)	(0.568)	(0.415)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month-Rating FE					Yes			
Month-Rating-Industry FE						Yes		
Month-Rating-Industry-County FE							Yes	
Month-Rating-Industry-County-Firm Size FE								Yes
N° of banks	38	37	37	24	24	23	18	18
N° of firms				1,556	1,556	1,486	781	781
Observations	2,083	2,023	2,038	23,040	23,024	20,932	7,028	6,493
Adjusted R^2	0.973	0.917	0.984	0.147	0.267	0.295	0.166	0.213

Notes: The table reports results of the estimation of Model 3 with OLS. The dependent variable in columns 1-3 is the log of outstanding loans to non-financial corporations, total maturity, maturities under 1 year and maturities over 1 year, respectively. The dependent variable in columns 4-8 is the log credit line and outstanding short-term credit provided by bank *i* to firm *j* in month *t*. The estimation window is January 2012 - January 2017. *Negative* is a dummy variable taking value 1 for all months following June 2014 and 0 otherwise. *Deposits ratio* is a bank's deposits to assets ratio as of January 2014. *Low capital* is a dummy taking value 1 if a bank has capital-to-assets ratio in the 1st tercile as of January 2014, and 0 otherwise. Lagged bank controls variables (not reported) include the log of total banking assets, the common equity to assets ratio and the ratio between deposits by households and non-financial corporations over total assets. Fixed effects are included as indicated. Specifically, *Rating* denotes the Banque de France internal rating on firms' creditworthiness (12 categories); *Industry* is one of 19 NAF industrial sectors; *County* corresponds to 100 French dèpartements; *Firm size* is an indicator variable that classifies firms as either micro-firm, SMEs or large firms. Standard errors are clustered at the bank level and reported in parentheses.*,**,*** refer to significance levels at 10%,5% and 1%, respectively.

long-term loans to non-financial corporations since the introduction of the policy for four groups of banks. As in Section 3.3, high and low deposits refer to banks with above/below median deposits ratio as of January 2014. High capital banks refer to banks in the 2nd or 3rd tercile of the distribution of capital-to-assets ratio as of January 2014, while low capital banks refer to those in the 1st tercile. The four bank groups are thus permutations of the classification high/low deposits and high/low capital. Consistent with results in Table 5, Figure B4 shows graphically that the increase in long-term loans to non-financial corporations following the introduction of negative policy rates is relatively more pronounced for low capital/high deposits banks.

Bank-firm level estimates offer a similar picture. In column 4, the coefficient on the triple interaction (*Deposits ratio*×*Negative*×*Low capital*) is positive and statistically significant. This finding is also robust to controlling for bank-specific, time-varying credit demand by fully saturating the regression with the set of month-rating-industry-county-firm size fixed effects (columns 5-8). Ceteris paribus, after the introduction of negative rates the increase in credit supply appears to be driven by the subset of low capital/high deposits banks. Moreover, these results confirm that standard channels of monetary policy alone do not account for the effect of negative rates. Under the bank lending and risk-taking channels of monetary policy, under-capitalised banks are expected to be more responsive to monetary policy easing due to their higher funding costs and incentives to take risks (Kishan and Opiela, 2000; Disyatat, 2011; Jiménez et al., 2012; Ioannidou et al., 2015). However, the term *Low capital*×*Negative* is negative across specifications: after the DFR turns negative low deposits/low capital banks increase lending by relatively less with respect to equally capitalised banks that are more reliant on deposits. These results provide an additional piece of evidence in support the *Portfolio Rebalancing Hypothesis* whereby banks most reliant on deposits respond to negative rates by taking additional risk on their lending portfolios. Our evidence is consistent with the result provided by Heider et al. (2019) whereby, among deposits dependent banks, poorly capitalised banks finance more ex-ante risky firms as the policy rate becomes negative. In the same vein, results in table A4 and in columns 4,9 and 14 of Table 1 show that that the transmission of negative rates does not significantly depend on bank size or liquidity – as would be under the traditional bank lending channel (Kashyap and Stein, 1995, 2000; Ehrmann et al., 2002) – but rather on banks' reliance on deposits.

4.4 Negative rates and deposits characteristics

Finally, we ask whether the transmission of negative rates varies across deposits. At their core, both the *Reversal Rate* and *Portfolio Rebalancing* hypotheses expect banks to be exposed to negative rates according to their inability to pass negative rates on depositors. As discussed in Section 2, we expect that households and liquid deposits make banks particularly exposed. To test this conjecture, we estimate Model 4 where the transmission of negative rates is allowed to vary across deposits with different characteristics.

Results presented in Table 6 suggest that differences across deposits matter. Banks with larger shares of households deposits increase corporate lending and funds supplied through credit lines by more than banks with larger shares of corporate deposits following the introduction of negative rates (columns 1 and 4). The maturity structure of deposits also affects the response to negative rates. In columns 2 and 5 we include four variables capturing banks' reliance on deposits of different maturities as presented in Section 3.4. Consistent with the *Portfolio Rebalancing Hypothesis*, the transmission of negative rates is stronger for banks funded by short-term deposits. By contrast, as the average maturity of liabilities increases, the coefficients lose statistical significance and eventually become negative for long-term savings accounts. To tease out the importance of liquid and households deposits, we construct *Liquid HH deposits* and *Liquid NFC deposits* as banks' shares of overnight deposits and deposits redeemable at notice by households and non-financial corporations, respectively, and measured as of January 2014. Columns 3 and 6 confirm that the effect is mainly driven by households deposits, indicating that the differential response of banks to negative rates depends on their reliance on deposits most closely equivalent to cash – liquid deposits held by households.

Overall, these results are in line with the *Portfolio Rebalancing Hypothesis*: negative rates are associated with larger increases in lending by banks reliant on deposits classes most susceptible to downward rigidity emanating from the zero lower bound. While Heider et al. (2019) provide similar evidence on the importance of households deposits on bank risk taking, we reveal that the maturity structure of deposits also matters for the transmission mechanism of negative rates. Building on their results, our findings supports the notion that demandable liquid deposits are special because they are seen by the public as the electronic counterpart of cash. Indeed, by mid-2014 rates on overnight deposits in France were already nearing zero, while savings accounts still carried a positive rate (see Figure 3b). Banks with larger shares of liquid deposits may have then suffered a larger shock to their funding costs with respect to banks more reliant on less liquid

Table 6: Negative rates across deposits

Dependent variable:	(1)	(2)	(3)	(4)	(5)	(6)
	ln Loans to NFC_{it}			ln Credit $line_{ijt}$		
$Negative_t \times$HH $Deposits_i$	0.699***			1.115***		
	(0.212)			(0.336)		
$Negative_t \times$NFC $Deposits_i$	0.628			-0.973		
	(0.619)			(1.211)		
$Negative_t \times$Liquid $Deposits_i$		0.950***			0.999*	
		(0.292)			(0.506)	
$Negative_t \times$Savings $Deposits_i$						
Maturity$<$ 1*year*		1.469*				
		(0.783)				
Maturity between 1 and 2 years		-2.665				
		(2.207)				
Maturity$>$ 2*years*		-0.573			-0.224	
		(0.515)			(1.523)	
$Negative_t \times$Liquid HH $deposits_i$			1.085***			1.300**
			(0.203)			(0.520)
$Negative_t \times$Liquid NFC $deposits_i$			-1.102*			-0.540
			(0.637)			(2.300)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
N° of banks	38	38	38	24	24	24
N° of firms				1,556	1,556	1,556
Observations	2,083	2,083	2,083	23,040	23,040	23,040
Adjusted R^2	0.972	0.972	0.972	0.147	0.147	0.147

Notes: The table reports results of the estimation of Model 4 with OLS. The dependent variable in columns 1-4 is the log of outstanding loans to non-financial corporations, while the dependent variable in columns 5-8 is the log credit line and outstanding short-term credit provided by bank i to firm j in month t. The estimation window is January 2012 - January 2017. *Negative* is a dummy variable taking value 1 for all months following June 2014 and 0 otherwise. *HH deposits* and *NFC deposits* denote, respectively, the share of a bank's households deposits or corporate deposits over total as of January 2014. *Liquid Deposits* is a bank's share of overnight deposits and deposits redeemable at a notice under 1 month, while *Deposits with maturity* $<$ 1 *year*, *Deposits with maturity between 1 and 2 years* and *Deposits with maturity* $>$ 2 *years* denote, respectively, the share of a bank's deposits with agreed maturity under 1 year, between 1 and 2 years and over 2 years. These variable are taken as share of total assets and as of July 2015. *Liquid HH deposits* and *Liquid NFC deposits* denote, respectively, the share of a bank's overnight deposits and deposits redeemable at notice over total assets of January 2014 by households and non-financial corporations, respectively. Lagged bank controls variables (not reported) include the log of total banking assets, the common equity to assets ratio and the ratio between deposits by households and non-financial corporations over total assets. Bank and month fixed effects are included as indicated. Standard errors are clustered at the bank level and reported in parentheses.*,**,*** refer to significance levels at 10%,5% and 1%, respectively.

accounts. The former, unwilling to break the zero lower bound, were unable to pass negative rates on their average liability, while the latter could adjust downward their average deposit rates still in positive territory. This result has important implications given the relevance of checking deposits in banking (Drechsler et al., 2017) and the fact that overnight deposits are the cheapest and most important source of deposits for French banks.[25]

[25]Overnight deposits by non-financial customers account for 46% of total deposits by non-financial customers in France as of January 2020. Authors' calculations based on data from the Banque de France (2020).

4.5 Alternative explanations

In this section we consider additional alternative explanations that may threaten the identifications of the transmission of negative rates through deposits.

A first concern is the ECB's Asset Purchase Program (APP). Started in March 2015, this program expanded the ECB's existing debt purchasing programs to a total of €1000 billion until September 2016.[26] The threat to our identification would be that high deposits banks may have participated more intensively to the APP with respect to low deposits banks. Secondly, the enforcement of Basel III liquidity coverage ratio (LCR) required banks to hold a cushion of liquid assets against net short-term outflows in case of financial distress. Since wholesale funding requires higher liquidity buffers with respect to deposits funding, LCR regulation may be particularly binding for low deposits banks which, as shown in Table A3, are significantly funded by market-based liabilities. Therefore, rather than the effect of negative rates on high deposits banks, one may worry that the lending increase we show is caused by the dampening effect of liquidity regulation on *low* deposits banks.[27]

Ultimately, both APP and LCR may be driving our results if high deposits banks were differently exposed in a way that matters for their lending decisions. In this sense, the advantage of Model 4 estimated in the previous section is that it tests for the effect of negative rates across types of deposits rather than across banks' overall reliance on deposits (Heider et al., 2019). Indeed, it is unlikely that the implementation of APP or LCR affected banks differently depending on the particular counterpart or maturity of their deposits. Suppose, for instance, that the credit expansion by high deposits banks post June 2014 reflects their participation to the APP program as opposed to the friction induced by the zero bound on deposits and negative rates. In this case, one would expect to observe lending to increase across the board rather than it being concentrated in banks with particular types of deposits.

This is the opposite of what we find. Table 6 shows that banks with larger shares of households and liquid deposits increase corporate lending and funds supplied through credit lines by more than banks with larger shares of corporate deposits and less liquid deposits following the introduction of negative rates (columns 1 and 5). Such heterogeneous transmission across deposits should alleviate concerns that other policies – i.e. the APP program or Basel III LCR regulation -

[26] The program was then expanded in June 2016 to include corporate bonds purchases but this may affect only the end of our sample period and hence is less of a concern for our results.

[27] We note however that the timing of LCR makes this less of a concern since it was introduced on January 1, 2015 with a 4-year rollout period (Heider et al., 2019).

are driving our results. Indeed, insofar other concomitant monetary and prudential measures did not affect banks according to the counterpart or liquidity profile of deposits they hold, results presented above are only consistent with negative rates affecting banks' lending decisions through the mechanism that we discussed in this paper.

Another potential concern with our exercise is the presence of regulated deposits. A number of savings products in France offer a remuneration that is fixed by regulation. The most important regulated savings accounts are the A passbook and the PEL (Plan d'Epargne Logement), which represent two-thirds of these products as of June 2014 (see Figure B11). Other regulated deposits include the Blue and Youth Passbooks, LDD (Livret de Developpement Durable), LEP (Livret d'Epargne Populaire) and CEL (Compte d'Epargne Logement). The interest rate on these accounts is set on the basis of a formula that depends on Euro Area money market rates and the French inflation rate. Further, both the Governor of the Banque de France and the French government may choose to deviate from the rate implied by the formula, which also adds to the stickiness of rates on these accounts. As a result, while rates on other deposits are freely determined by banks according to market conditions, the remuneration of regulated deposits is strictly controlled and does not necessarily co-move with ECB monetary policy rates (Duquerroy et al., 2020). Ideally, to assess the transmission of negative rates one would exclude regulated savings accounts altogether. Unfortunately, in our data we are unable to do so. Variables containing information on banks' saving accounts (i.e. deposits redeemable at notice and deposits with agreed maturity) include both regulated and unregulated deposits. One may then worry that our results could be partly driven by changes in banks' funding costs around June 2014 that are related to the downward rigidity on regulated deposits as opposed to the introduction of negative rates and the zero bound on (all) deposits.

Three considerations alleviate this concern. First, as of June 2014 regulated deposits accounted for only 26% of total deposits, a share that has further shrunk over time. By contrast, unregulated overnight and savings deposits make up the lion share of deposits, accounting for more than 70% of total deposits in France (see Figure B10). Furthermore, regulated savings accounts are only available to households and non-profit organizations. Therefore, in terms of their relative importance it seems unlikely that regulated deposits are mainly driving our results.

Second, in principle there should be a lower bound for rates on regulated deposits as well. As shown in Figure B12, the remuneration of regulated deposits has gradually fallen following the DFR and money market rates, albeit in a staggered fashion. Because the remuneration on

regulated deposits is guaranteed by the government as a way to preserve households' purchasing power, a lower bound for these deposits (possibly slightly above zero) may be even stronger as the government may effectively forbid banks to charge a negative rate on regulated savings accounts since this would run counter their original raison d'être. As a result, the more interbank rates plunge into negative territory, the more regulated deposits – in the same way as any other deposits – may pose a problem for bank profitability going forward. In this regard, the same mechanism discussed in this paper should then apply to such saving accounts as well.

Finally, one can see results in Table 6 as an implicit robustness test for this particular issue. Specifically, in columns 3 and 6 we allow banks' lending response pre/post June 2014 to vary across deposits with different maturities. To do so, we included the share of *Liquid Deposits* (overnight deposits and deposits redeemable at notice) and *Savings Deposits* (deposits with agreed maturity at different horizons). Both variables include regulated deposits: the former includes A, Blue and Youth Passbooks, LDD and LEP, while the latter includes PEL and CEL. Importantly, the interest rate on all regulated deposits is linked to that of Passbook A (Figure B12). Note that the arguments for the transmission of negative rates across deposits types would apply to these deposits too. For instance, A and other passbooks are fully liquid, guaranteed, tax-exempt saving accounts. Conversely, PEL is a locked interest-earning account which gives access to a subsidised mortgage loan conditional on keeping the account for 4 years. The differential in remuneration between these accounts is substantial: as of June 2014, the average annualised yield on PEL was 1.68 percentage points higher than the rate on A Passbook. If the differential lending response by banks were related to the inherent stickiness of rates on regulated deposits, one would expect insignificant estimates for *Liquid Deposits* and *Savings Deposits*, for the presence of regulated deposits in both terms would cancel out. Instead, we find a positive and statistically significant coefficient on *Liquid Deposits* and negative estimates for accounts with longer maturities. This result highlights a role for the term structure of bank liabilities around the introduction of negative monetary policy rates while seems inconsistent with the hypothesis of a confounding effect due to the stickiness of rates on regulated deposits.

Conclusion

We study the transmission of negative monetary policy rates in France and document that banks most reliant on deposits react to the policy by increasing lending volumes, taking additional risk and increasing fees and commission income. After the introduction of negative rates, banks

mainly funded by deposits also increase their share of corporate loans and of private securities by more than other banks, while decreasing their share of interbank loans, an asset class that bears low or even negative yield. Furthermore, among deposits dependent banks, the increase in corporate lending induced by negative rates is more pronounced for banks with ex-ante weaker capitalization. Finally, the transmission of negative rates is stronger for deposits facing a stronger competition from cash. Specifically, the increase in lending associated to negative rates is concentrated in banks funded with households and liquid deposits – i.e. deposits that could be easily withdrawn were they charged a negative rate – and smaller for banks funded with less liquid liabilities. Our preferred explanation is that banks react to negative rates by looking for avenues to compensate for lost profitability and search for yield. In line with previous literature, our results support the view that negative rates encourage high deposits banks to embark on activities aimed at restoring their desired level of profitability: increasing lending volumes, tilting the composition of their lending portfolios toward high-yielding assets and increasing non-interest income. We find instead no evidence for the hypothesis that negative rates are contractionary because of their effect on the equity position of banks most reliant on deposits.

From a policy perspective, these findings indicate that negative rates are effective in stimulating the economy when nominal interest rates hit the zero lower bound, although this comes at the price of greater risk taking by banks. The evidence provided in this article hence cautions policymakers that the additional accommodation provided by venturing into negative territory should be weighed against the potential build up of risk in the banking system and attending concerns for financial stability. Finally, it is plausible that this transmission channel is a short-lived anomaly. The emphasis on deposits may eventually loose relevance as banks pass negative rates on an increasingly larger fraction of their depositors (Altavilla et al., 2019; ECB, 2020). In countries where negative rates become the norm, one can then expect negative rates to transmit similarly to conventional rate cuts in positive territory (Eggertsson et al., 2019). In the meantime, however, the zero bound on retail deposits is likely to persist in the near term. As a result, the efficacy of negative rates will depend on the particular funding structure of different banking systems (Bittner et al., 2019). In this respect, diversity in the prevalence of particular types of deposits and in their remuneration, in bank capital structure as well as in institutional and regulatory frameworks may increase the heterogeneity in the transmission of monetary policy that has been already highlighted for more standard monetary policy measures (Ehrmann et al., 2002; De Santis and Surico, 2013; Grandi, 2019).

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A Tables

Table A1: Sample representativeness

Balance sheet item	% of aggregate for French banks
Total assets	62
Total loans	63
Total loans to NFCs, over 1 year	70
Total loans to NFCs, under 1 year	46
Total loans to Households	73
Number of banks	40

Notes: Balance sheet totals are reported as a share of French aggregate as reported by the Banque de France as of January 2016. Source: Banque de France, IBSI database (2019).

Table A2: Descriptive statistics

Variables	N	mean	sd	min	max
Total assets (€ million)	2,744	124,029	187,079	0.000	909,709
As share of total assets:					
Equity	2,545	0.095	0.135	0.004	1.047
Deposits by NFCs	2,564	0.074	0.105	0.000	0.933
Deposits by households	2,564	0.172	0.235	0.000	0.893
Interbank deposits	2,564	0.273	0.262	0.000	0.987
Securities and wholesale funding	2,564	0.191	0.251	0.000	0.991
Extra Euro Area Deposits	2,564	0.132	0.206	0.000	0.939
Cash	1,880	0.001	0.002	0.000	0.007
Loans to NFCs	2,564	0.140	0.147	0.000	0.732
Loans to households	2,564	0.162	0.182	0.000	0.739
Interbank loans	2,564	0.332	0.236	0.001	0.999
Extra Euro Area loans	1,880	0.108	0.177	0.000	0.957
Debt securities holdings	1,880	0.110	0.092	0.000	0.624
Stocks holdings	1,877	0.043	0.073	0.000	0.479

Notes: Descriptive statistics for key balance sheet variables, October 2011 - August 2017. All values except total assets are expressed as share of total assets. Source: Banque de France, IBSI database (2019).

Table A3: Descriptive statistics by deposits ratio

	Low deposits banks (Below median deposits/assets ratio in Jan 2014)					High deposits banks (Above median deposits/assets ratio in Jan 2014)				
Variables	N	mean	sd	min	max	N	mean	sd	min	max
Total assets (€ million)	1,419	119,855	169,657	0.000	846,980	1,325	128,498	204,065	0.000	909,709
Credit line (natural log)	8,196	3.625	2.207	0.000	12.989	22,168	2.901	1.982	0.000	15.098
As share of total assets:										
Equity	1,310	0.095	0.177	0.004	1.047	1,235	0.095	0.068	0.025	0.516
Deposits	1,329	0.031	0.049	0.000	0.200	1,235	0.478	0.223	0.001	0.933
Deposits by NFCs	1,329	0.019	0.028	0.000	0.122	1,235	0.133	0.124	0.001	0.933
Deposits by households	1,329	0.012	0.028	0.000	0.115	1,235	0.345	0.237	0.000	0.893
Interbank deposits	1,329	0.359	0.322	0.000	0.987	1,235	0.180	0.117	0.000	0.838
Securities and wholesale funding	1,329	0.280	0.310	0.000	0.991	1,235	0.096	0.099	0.000	0.389
Extra Euro Area Deposits	1,329	0.166	0.230	0.000	0.939	1,235	0.096	0.169	0.000	0.864
Cash	987	0.000	0.000	0.000	0.001	893	0.002	0.002	0.000	0.007
Loans to NFCs	1,329	0.095	0.150	0.000	0.693	1,235	0.188	0.128	0.002	0.732
Interbank loans	1,329	0.390	0.279	0.001	0.999	1,235	0.269	0.157	0.005	0.909
Loans to households	1,329	0.097	0.164	0.000	0.739	1,235	0.232	0.175	0.000	0.557
Stocks holdings	984	0.038	0.048	0.000	0.479	893	0.049	0.092	0.000	0.456
Extra Euro Area loans	987	0.144	0.212	0.000	0.957	893	0.069	0.116	0.000	0.538
Debt securities holdings	987	0.098	0.082	0.000	0.394	893	0.123	0.100	0.000	0.624
Net interbank position	704	-0.033	0.371	-0.862	0.694	993	0.073	0.128	-0.186	0.715
Liquidity ratio	505	0.027	0.049	-0.024	0.203	722	0.065	0.058	0.000	0.223
Overnight deposits and deposits redeemable at notice	505	0.023	0.029	0.000	0.143	722	0.186	0.083	0.042	0.366
Deposits with agreed maturity, <1year	480	0.007	0.018	0.000	0.114	690	0.013	0.041	0.000	0.292
Deposits with agreed maturity,between 1 and 2 years	480	0.001	0.002	0.000	0.014	690	0.002	0.007	0.000	0.048
Deposits with agreed maturity, > 2 years	480	0.005	0.012	0.000	0.047	690	0.043	0.062	0.000	0.191

Notes: High deposits banks are defined as banks whose deposits/total assets ratio lies above the cross-sectional median as of January 2014, while low deposits banks are defined as banks whose deposits/total assets ratio lies below the cross-sectional median as of January 2014. All values (except total assets and credit line) are expressed as share of total assets. Descriptive statistics refer to the period October 2011 - August 2017 . Source: Banque de France, IBSI database and FCR (2019).

Table A4: Negative rates, deposits and bank size

	(1)	(2)	(3)
Dep. variables	ln loans to NFC_{it}		
Maturity	Total	≤ 1 year	> 1 year
$Deposits_i \times Negative_t$	0.501***	1.507***	0.458***
	(0.158)	(0.552)	(0.168)
$Deposits_i \times Large_i$	-0.261	0.414	-0.282
	(0.218)	(0.402)	(0.223)
$Deposits_i \times Large_i \times Negative_t$	0.596	-0.484	0.584
	(0.494)	(0.778)	(0.477)
Bank controls	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	2,083	2,023	2,038
Adjusted R-squared	0.973	0.918	0.984
N° of banks	38	37	37

The table reports results of the estimation of Model 3 with OLS. The dependent variable in columns 1-3 is the log of outstanding loans to non-financial corporations, total maturity, maturities under 1 year and maturities over 1 year, respectively. The estimation window is January 2012 - January 2017. *Negative* is a dummy variable taking value 1 for all months following June 2014 and 0 otherwise. *Deposits ratio* is a bank's deposits to assets ratio as of January 2014. *Large* is a dummy taking value 1 if a banks' log of total assets is in the 1st tercile as of January 2014, and 0 otherwise. Lagged bank controls variables (not reported) include the log of total banking assets, the common equity to assets ratio and the ratio between deposits by households and non-financial corporations over total assets. Fixed effects are included as indicated. Standard errors are clustered at the bank level and reported in parentheses.*,**,*** refer to significance levels at 10%,5% and 1%, respectively.

B Figures

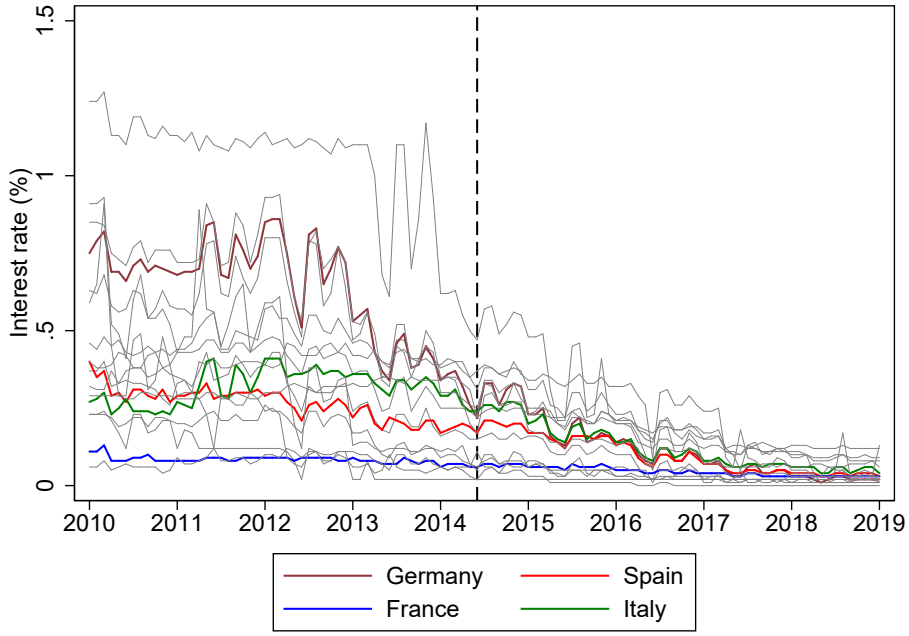

Figure B1: Nominal interest rate (%) on overnight deposits to households for Euro Area countries (rates are color-coded for the four largest countries). Source: ECB (2019).

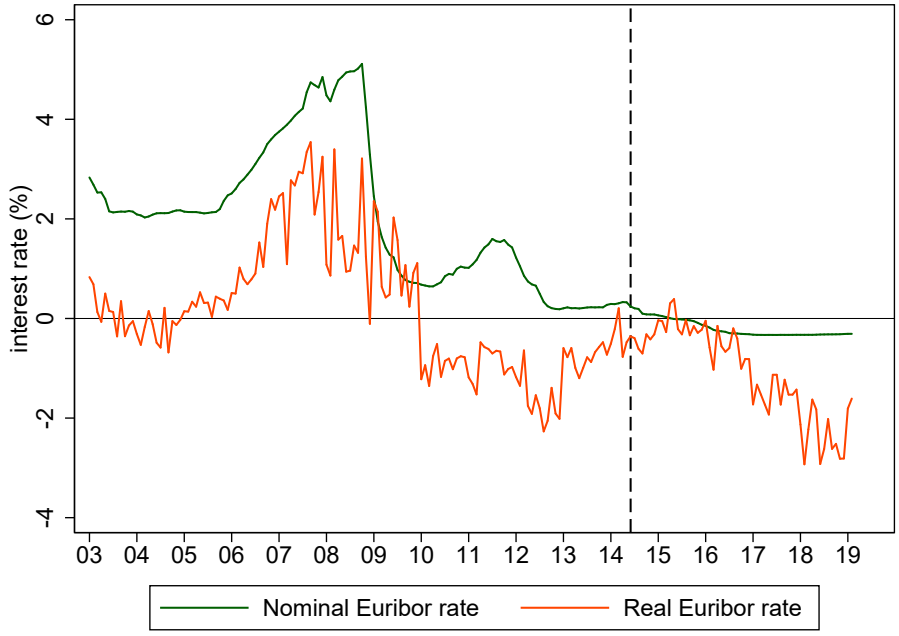

Figure B2: Euribor rate (3 months) in nominal and real (inflation-adjusted) terms,(%). Source: ECB (2019).

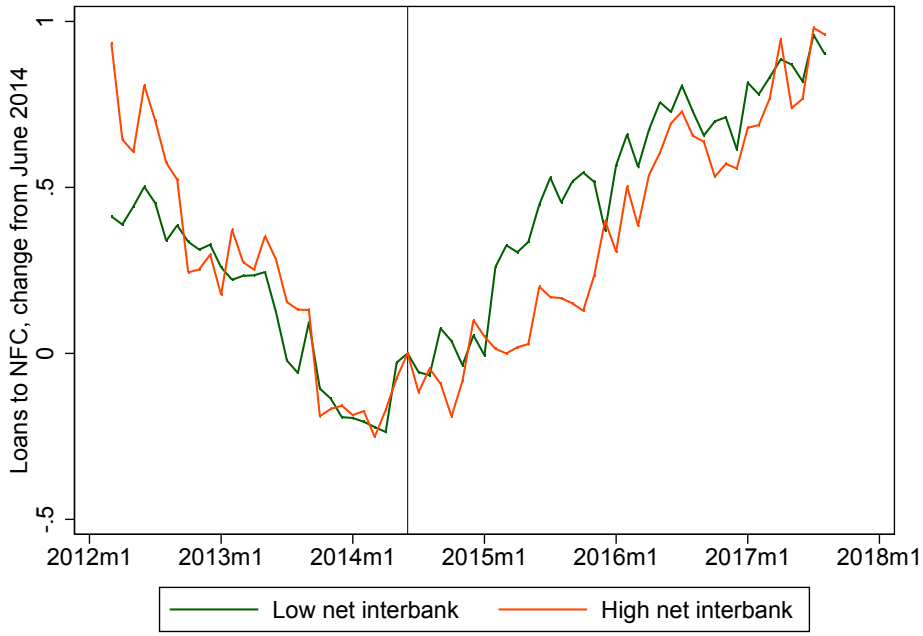

Figure B3: Parallel trends: bank lending to non-financial corporations, percentage change with respect to June 2014, split by banks with high and low interbank position defined as banks with above or below median net interbank position as of January 2014. Source: Banque de France, IBSI Database (2019).

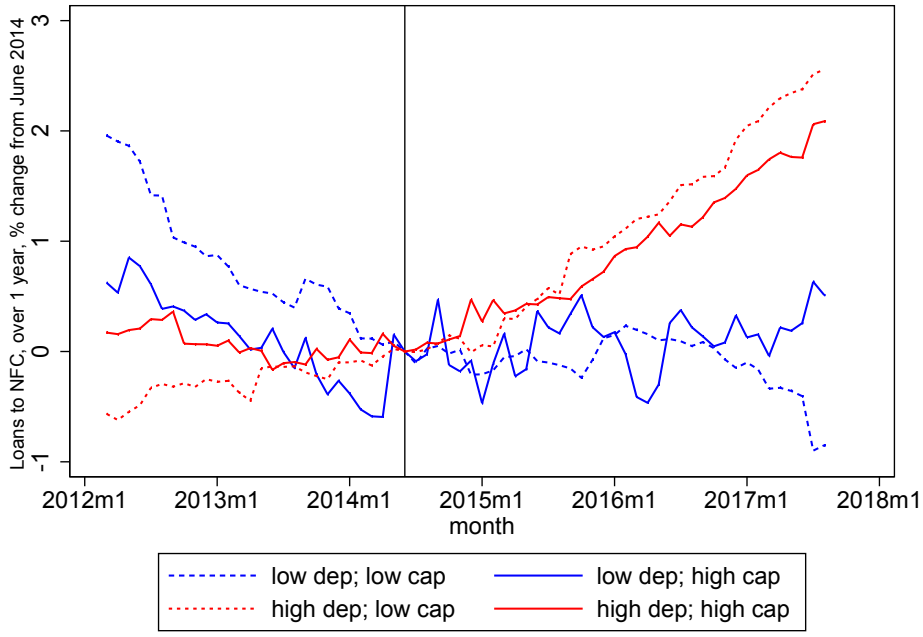

Figure B4: Oustanding loans to non-financial corporations (maturity over 1 year), % change with respect to June 2014. High and low deposits banks are defined as banks with above or below median deposits ratio as of January 2014. High and low capital banks are defined as banks in the 2nd or 3rd tercile of the distribution of capital-to-assets ratio as of January 2014, while low capital banks refer to those in the 1st tercile of the distribution of capital-to-assets ratio as of January 2014. Source: Banque de France, IBSI database (2019).

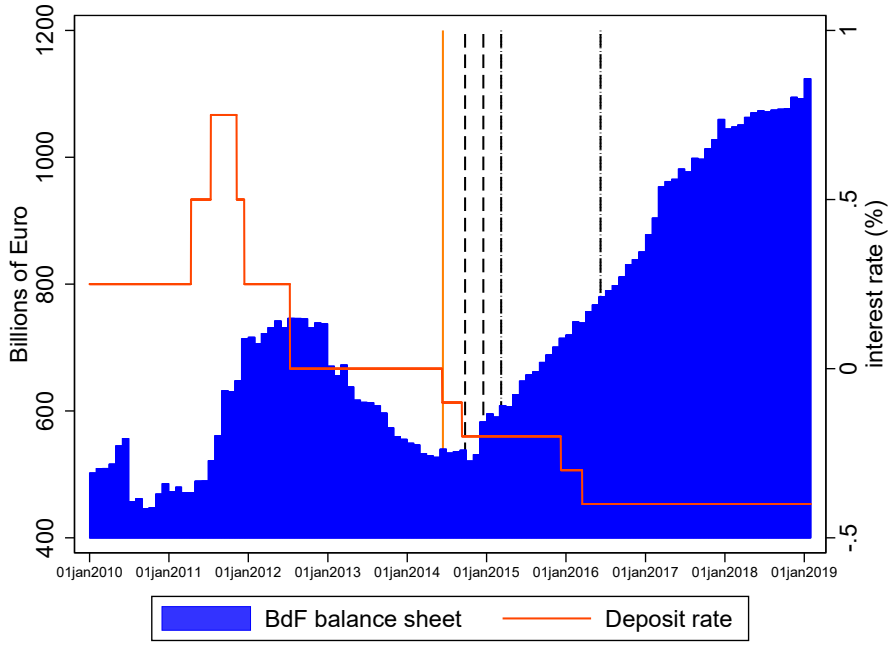

Figure B5: LHS: Banque de France contribution to the balance sheet of the Eurosystem, € billion. RHS: ECB's Deposit Facility Rate, interest rate (%). The black vertical lines represent key policy measures implemented in the vicinity of the start of the negative rates policy (the orange line). The first two dotted lines correspond to the TLTRO programs, while the second dash-dotted lines mark the beginning of the Public Sector Purchase Program (PSPP) and the Corporate Sector Purchase Program (CSPP), respectively, part of the Assets Purchase Program (APP) started in March 2015. Source: ECB (2019).

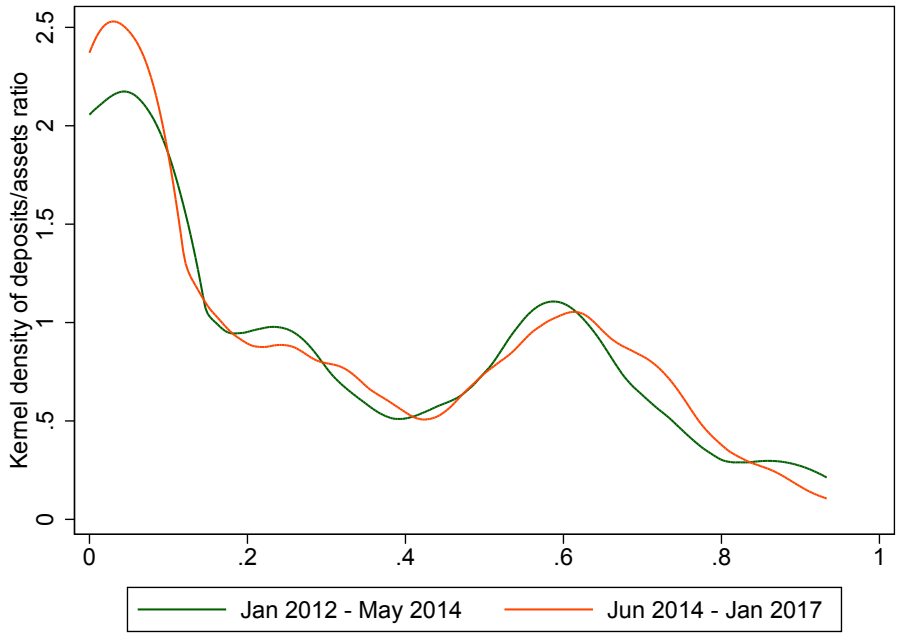

Figure B6: Kernel density distribution of banks' deposits ratio before (Jan 2012 - May 2014) and after (Jun 2014 - Jan 2017) the introduction of negative rates. Source: Banque de France, IBSI database (2019).

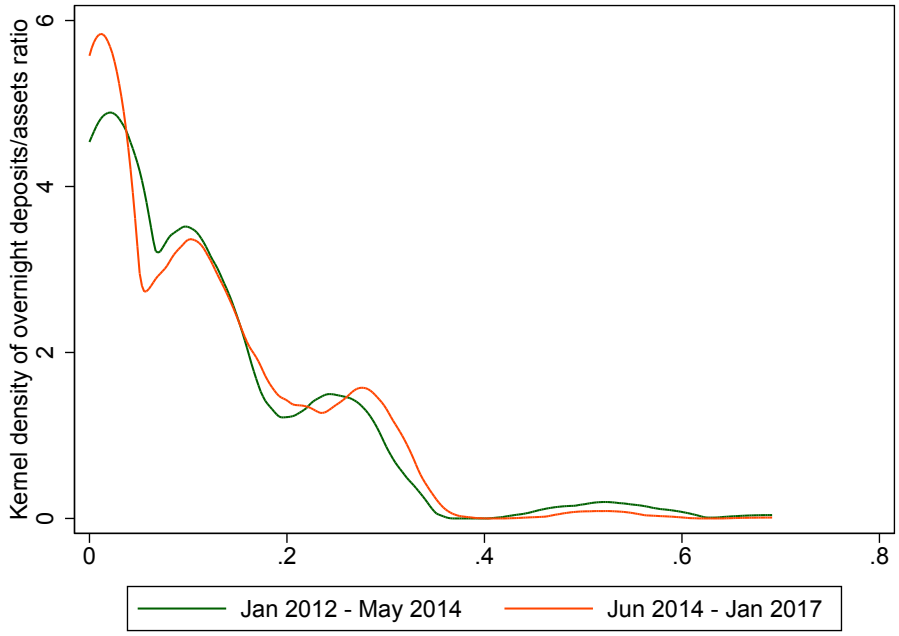

Figure B7: Kernel density distribution of banks' overnight deposits ratio before (Jan 2012 - May 2014) and after (Jun 2014 - Jan 2017) the introduction of negative rates. Source: Banque de France, IBSI database (2019).

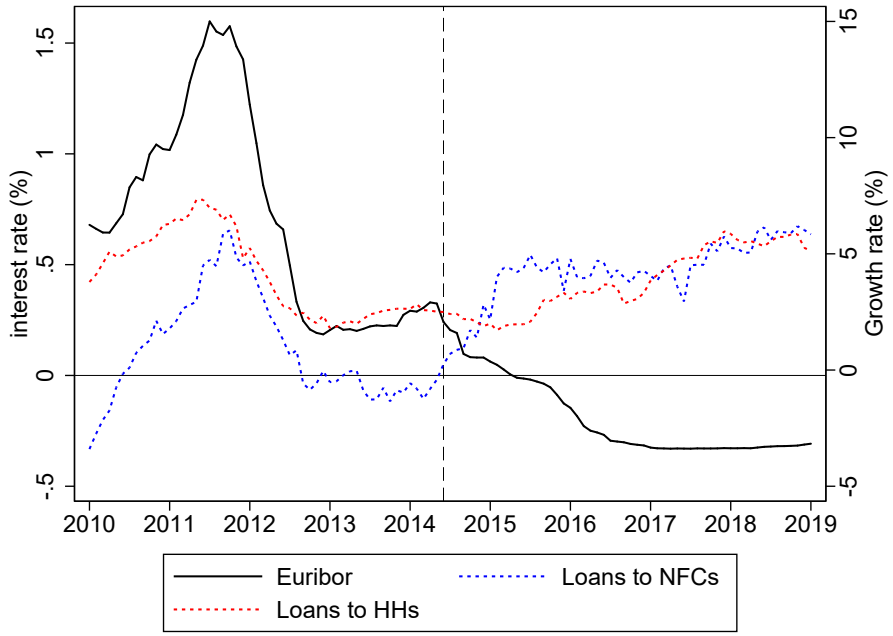

Figure B8: Euribor rate (LHS) and year-on-year growth of loans to households and non-financial corporations by French banks (RHS). Source: ECB (2019).

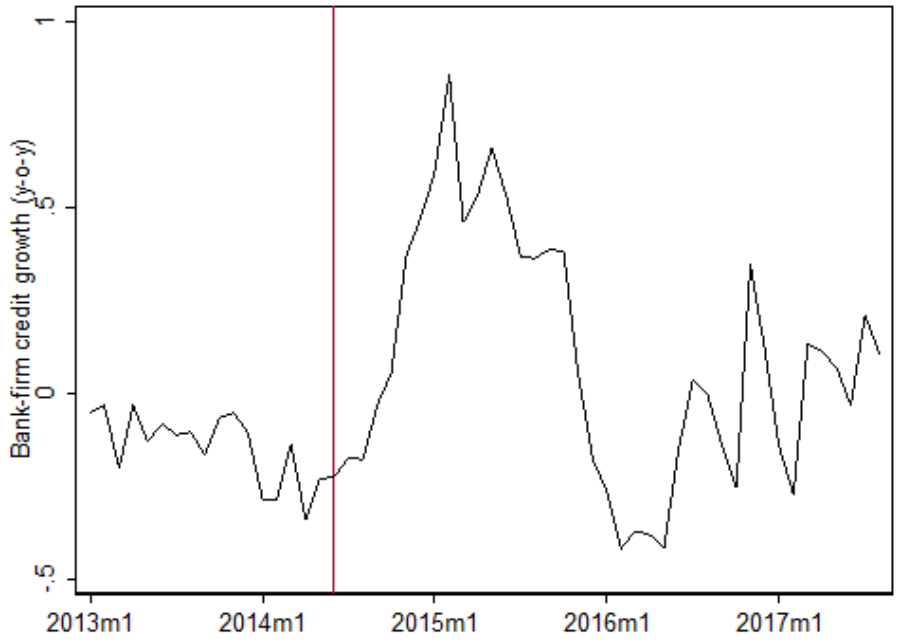

Figure B9: Year-on-year growth of credit provided to firms through credit lines by French banks. Source: Banque de France, FCR (2019).

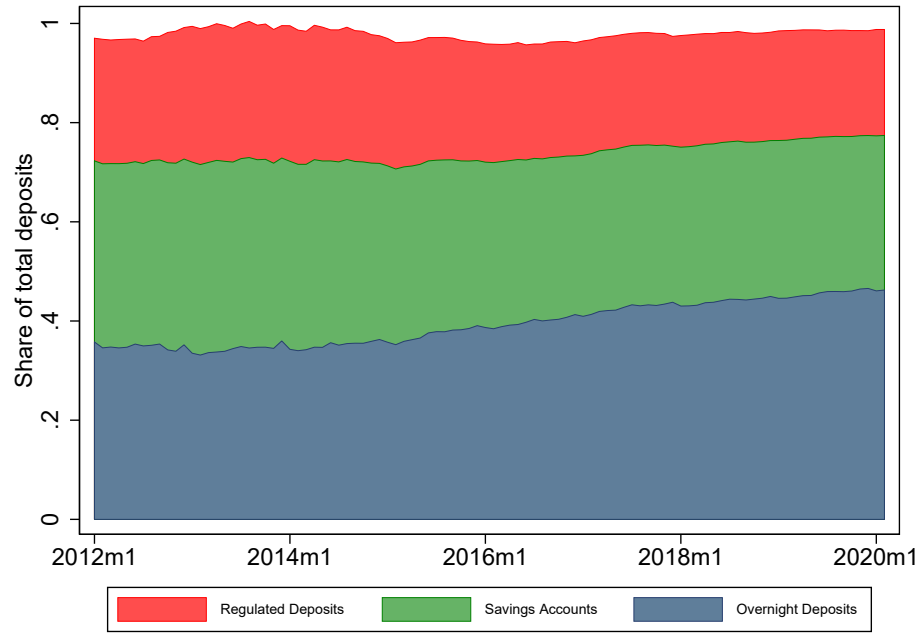

Figure B10: Share of French banks' overnight deposits, savings accounts and regulated deposits over total deposits. Source: Banque de France (2020)

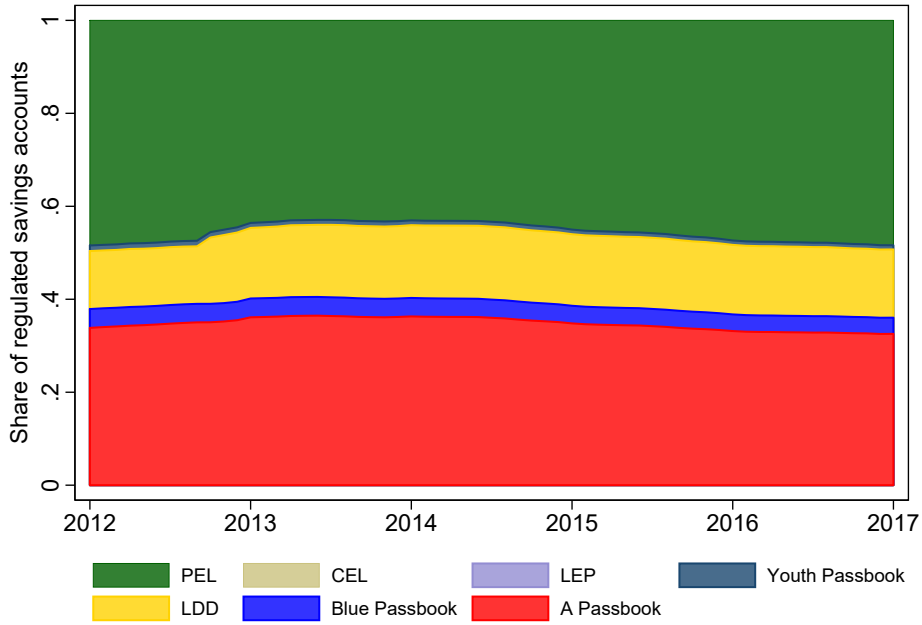

Figure B11: Types of regulated savings accounts as share of the total. Source: Banque de France (2020)

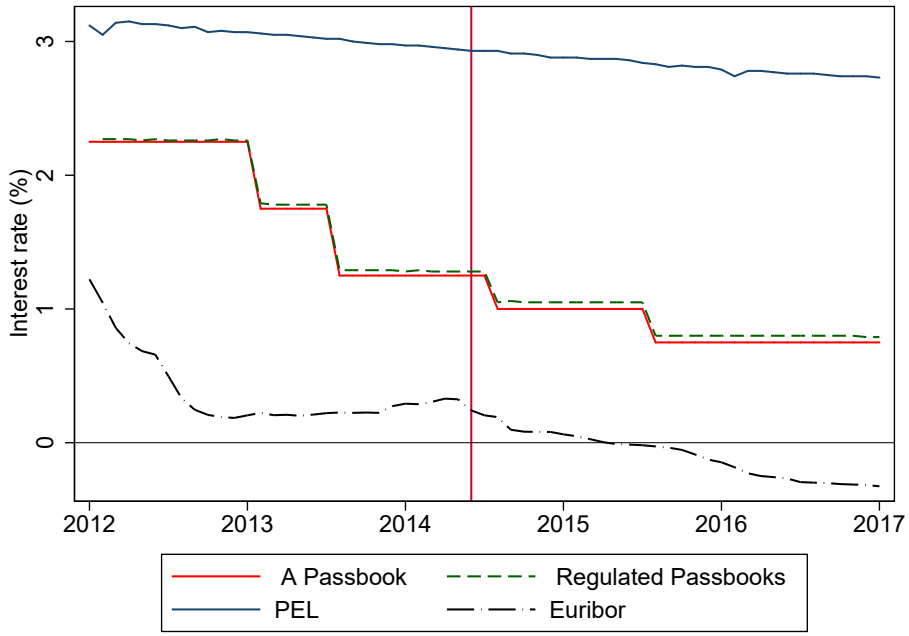

Figure B12: Euribor rate (3 months) and interest rates on French regulated savings accounts. Source: ECB and Banque de France (2020).