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**NEGATIVE INTEREST RATES, EXCESS LIQUIDITY
AND BANK BUSINESS MODELS: BANKS' REACTION
TO UNCONVENTIONAL MONETARY POLICY IN
THE EURO AREA**

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Negative interest rates, excess liquidity and bank business models: Banks' reaction to unconventional monetary policy in the euro area

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Abstract

In June 2014 the ECB became the first major central bank to lower one of its key policy rates to negative territory. The theoretical and empirical literature is silent on whether banks' reaction would be different when the policy rate is lowered to negative levels compared to a standard reaction to a rate cut. In this paper we examine this question empirically by using individual bank data for the euro area to identify possible adjustments by banks triggered by the introduction of negative interest rates through three channels: government bond holdings, bank lending, and wholesale funding. We find evidence of a significant adjustment of banks' balance sheets during the negative interest rate period. Banks tend to extend more loans, hold more non-domestic government bonds and rely less on wholesale funding. The nature and scope of the adjustment depends on banks' business models.

Keywords: negative rates, bank balance sheets, monetary transmission mechanism

JEL Classifications: E43, E52, G11, G21

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1. Introduction

In June 2014 the ECB decided to cut the rate on its deposit facility to negative territory, an unprecedented move as no major central bank had used negative rates before.² Further rate cuts followed (September 2014, December 2015 and March 2016) bringing the rate on the ECB's deposit facility to -0.40 percent.³

The ECB's decision to cut rates below zero was solely motivated by the desire to provide further monetary easing to the economy. This contrasts with the declared aim of some other central banks that introduced negative rates to discourage capital inflows to stabilise the exchange rate (e.g. the Switzerland). A particular implication of this policy change was that banks started to pay a charge for their excess liquidity holdings (reserve holdings in excess of minimum reserve requirements). Many banks are likely unable to pass this charge fully on to their customers.⁴ Individual banks may therefore try to minimise this charge by reducing their excess liquidity holdings through balance sheet adjustments. These adjustments, in turn, are likely to change the way the rate cut impacts other interest rates and, ultimately, the economy.

The focus of this paper is the question as to whether banks operate differently when policy rates are negative compared to how they operate under positive rates. To answer this question, we use individual bank balance sheet information available at a monthly frequency from a confidential dataset collected for the compilation of aggregate monetary statistics. The banks included in the dataset account for approximately 70 percent of main assets of euro area banks. We match this data with banks' excess liquidity positions with the ECB and add

² This follows a similar decision by the Danish central bank (Danmarks Nationalbank) in July 2012. Subsequently, the Swiss National Bank and the Swedish Riskbank introduced negative policy rates in December 2014 and February 2015, respectively, see Jackson (2015). The Bank of Japan, as the second major central bank, followed in January 2016.

³ The negative rate is not only applied to recourses to the deposit facility but to all parts of banks' current accounts with the Eurosystem in excess of their reserve requirements. The same applies to other potential "loopholes", e.g. the remuneration of government deposits as well as deposits in the context of reserve management services offered by the ECB were also lowered in the process to (at least) -0.40%.

⁴ An often cited example is that the rate applicable to retail deposits is, for a variety of reasons, floored at zero in many countries, see Section 2 below for a more detailed discussion.

further control variables. Results based on panel, fixed-effect regressions suggest that banks indeed specifically react to negative policy rates and that the extent of this reaction generally depends on their business model. We find that banks relying heavily on deposit funding adjust their balance sheets during the negative interest period by reducing their excess liquidity to fund more loans. Investment banks mainly use their excess liquidity to scale down their recourse to wholesale funding while some adjustment of these banks is also done through loans. Finally, wholesale funded banks tend to react by increasing their government bond portfolios.

The next section offers a conceptual discussion of why banks may operate differently when policy rates are in negative territory. Section 3 illustrates the channels that banks may use to adjust their balance sheets in the face of negative rates. Section 4 describes our empirical strategy and dataset while section 5 reports our results. Section 6 concludes.

2. Why might monetary policy transmission under negative rates be special?

Banks are important for the transmission of monetary policy impulses to the economy, especially for bank-centred financial systems such as the one in the euro area. Changes in monetary policy rates trigger reactions in bank behaviour but the theoretical and empirical literature studying these reactions exclusively refers to environments where policy rates are adjusted (and remain) in positive territory. It is therefore *ex ante* unclear whether these mechanisms carry over, or indeed are even amplified, in a context where policy interest rates are reduced to levels below zero.

Prima facie, it might be argued that there is nothing special about policy rates crossing the zero line. What matters for financial intermediaries is not the level of policy rates per se, but instead the spread between the interest rate they pay and the interest rate they earn for a unit of money they intermediate. This spread determines the financial intermediaries' interest

income. The level of the policy rate impacts, however, the spread that financial intermediaries can earn. For example, lower policy rates, if they are expected to prevail for a long period of time, may lead to an overall flatter yield curve, which typically lowers the spread that intermediaries earn by using short-term liabilities to fund longer-term assets (Hannoun, 2015, Claessens et al., 2016, Borio et al., 2015). Negative policy rates could thus be associated with lower margins for financial intermediaries, but this effect would merely be an extension of a mechanism already at work with positive rates.

A number of frictions or institutional arrangements, however, may qualify this simple view and can make a negative interest rate policy (NIRP) a very “special” case of a conventional easing policy. Perhaps the most important factor which can impart specialness to NIRP is the existence of currency. This offers a zero-yielding potential alternative to deposits as a store of value, which in turn makes banks extremely reluctant to lower retail deposit rates below zero. The effective zero lower bound on retail deposits implies that a large part of banks’ funding cannot be re-priced further once this threshold is reached.

The “specialness” of NIRP may also derive from a range of institutional features of the financial system. In some jurisdictions there may be legal restrictions to the application of negative rates to bank customers or at least uncertainty regarding the legal standing of such an arrangement. Some financial contracts (e.g. money market funds or floating rate notes) may not foresee the possibility of payments from the lender to the borrower (see Witmer and Yang, 2015) and in any case the logistics of collecting interest payments from holders of securities can be intractable. Similarly, some IT systems may not be designed to cope with negative rates. Other examples of possible institutional restrictions include the tax treatment of negative interest rate income, which is often not symmetric to the treatment of positive interest rate income, e.g. payments triggered by negative interest rates may not be tax deductible, while positive interest rate income is generally taxable. Finally, internal risk management

practices and rules in banks may in some cases prevent transactions that imply a loss on principal, such as holding negatively remunerated central bank reserves. While some of these institutional features may be adapted in light of the introduction of NIRP, such changes typically can only be implemented slowly.

As NIRP drives yields on assets lower while part of the funding can no longer be re-priced, the policy entails the potential to, *ceteris paribus*, reduce bank interest margins in a non-linear fashion.⁵ This situation may be further aggravated in the presence of excess liquidity (EL), in particular if this EL is generated (or “mirrored”) by retail deposits in banks’ balance sheets. Banks with EL will earn a negative return on this asset, which may, however, be funded by (retail) deposits that carry a zero interest rate. While this specific channel may not matter for small levels of EL, it may well become significant in a situation in which the central bank is committed to a policy of asset purchases which inevitably leads to increasing levels of EL which may end up being very large.⁶

3. Channels of balance sheet adjustments in the face of excess liquidity

The positive spread between the rate of return on bank’s assets and the deposit facility rate represents an opportunity cost associated with holding EL which should generally induce banks to limit their holdings. There are several ways in which banks can adjust their balance sheets to limit their EL holdings. When the deposit facility rate moves into the negative territory banks may tap these channels even more aggressively to reduce their EL due to the frictions associated with NIRP that we described earlier.

⁵ For an overview of potential implications of negative rates for bank profitability as well as broader implications for the economy and financial stability, see Arteta and Stocker (2015) and McAndrews (2015).

⁶ The example of the ECB is a case in point. With the asset purchase programme (APP) that started in March 2015, the ECB committed to inject EUR 60bn of reserves every month into euro area banks balance sheets. The programme was expanded and extended twice since then, raising the to be expected peak level of excess liquidity from EUR 300 billion before the programme to EUR 1.7 trillion and stretching the time period until full reabsorption from initially 2019 to well after 2025 after the last extension announced in December 2016. As a consequence, the costs for banks associated with excess liquidity holdings rose not only with every rate cut but also with every round of additional easing through the extension of the APP.

The literature on the effects of liquidity creation on other assets through portfolio adjustments is not new. Friedman and Schwartz (1963) note that creation of EL prompts banks to increase their holdings of securities and loans. Tobin (1969) argues that a higher supply of bank reserves leads to adjustments in bank portfolios until the marginal return from holding alternative assets is equalized. This implies larger holdings of securities and more loan issuance until the rates of return on these assets decline to the return of holding reserves.

To illustrate the available adjustment channels, a look at a typical bank balance sheet is instructive as shown in Figure 1.

Figure 1: Possible adjustment channels for banks to reduce their excess liquidity holdings

A 0 Initial situation L		A 1 Wholesale borrowing channel L	
Loans	Retail deposits	Loans	Retail deposits
Government bonds	Interbank deposits	Government bonds	Interbank deposits ↓
Central bank cash	RR EL	Central bank cash ↓	RR EL Securities issued ↓
Σ	Σ	Σ ↓	Σ ↓
A 2 Government bond channel L		A 3 Loan channel L	
Loans	Retail deposits	Loans ↑	Retail deposits
Government bonds ↑	Interbank deposits	Government bonds	Interbank deposits
Central bank cash ↓	RR EL	Central bank cash ↓	RR EL Securities issued
Σ →	Σ →	Σ →	Σ →

Banks' assets will be comprised of loans and securities (e.g. sovereign debt holdings) financed by private sector deposits (from households, the corporate and institutional sector as well as from other banks), securities issued (e.g. covered bonds and unsecured bank bonds) and borrowing from the central bank (not shown in Figure 1). A large EL position of the bank reflects more reserves than the legal requirement, and is a direct expression of a so-called funding overhang: the bank has more funding available than what it needs for its core business. A funding overhang does not necessarily need to manifest itself in a large build-up

in EL. Equally, the bank may increase its vault cash holdings or increase its securities holdings above the level that would be implied by its stock (and risk profile) of loans alone. The latter point hints at an important adjustment channel for banks when faced with a large (and costly) funding overhang: banks could simply buy (sovereign) bonds (lower left panel in Figure 1) issued by domestic or other issuers. Likewise, a bank can try to reduce its funding overhang by using the available funding to grant more loans (lower right panel), either to the real economy or to other financial intermediaries, including in the interbank market. Adjustments on its liability side are another possibility to shrink the funding overhang. Simply by reducing its demand for refinancing (e.g. not rolling-over maturing bonds, repaying interbank loans and central bank funding) it can reduce a funding overhang (upper right panel).

There are two important caveats to any such strategy: banks cannot change aggregate EL (in the short-run at least) and prudential regulation. While any individual bank can plausibly expect that a strategy to reduce its funding overhang will be successful, it will not work for the system as a whole, i.e. some banks will inevitably end up with EL holdings as there is no escape from aggregate EL to be held by the banking sector.⁷ The system as a whole can only reduce EL by repaying borrowing from the Eurosystem or by acquiring banknotes. Balance sheet adjustments involving the acquisition of assets or the repayment of other liabilities merely redistribute EL from one bank to another but do not reduce it in aggregate terms. The impact of prudential regulation is reflected in a multitude of regulations that govern the possible evolution of a banks' balance sheet (e.g. capital needed for loans, liquidity regulations constraining the funding strategy and leverage ratios limiting the balance sheet

⁷ This statement is true if banks holding excess liquidity are different from the ones having borrowed from the central bank, which is a good approximation of the situation in the euro area. Furthermore, after the introduction of APP this statement is always true. Excess liquidity circulates within the closed system of the banks that are counterparties to Eurosystem operations.

size). For example, a bank may want to increase its holdings of government bonds to decrease its EL holdings but may be barred from doing so by its regulator who considers the exposure of the banks to the sovereign as too high. Regulation can thus be considered as an additional constraint on banks' attempts to manage their funding overhang (see Bonner (2016) for the example of government bonds).

The stylised channels of adjustment illustrated in Figure 1 can be linked back to conventional transmission channels that have been identified in the literature. The adjustment through extension of loans can, for instance, be seen as a special case of the bank lending channel.⁸ According to the bank lending channel, expansionary monetary policy – in particular involving outright asset purchases – increases bank reserves and deposits. The exogenous increase in the availability of this typically low-cost yet stable source of financing boosts banks' willingness to extend more loans for a given level of the interest rate, increasing credit supply. Under NIRP, the incentive of banks to expand their supply of loans is strengthened by the fact that additional reserves injected by the central bank entail a charge on banks. Thus, while NIRP might weaken the interest rate channel by reducing the ability of banks to transfer negative interest rates to retail deposits, the policy amplifies the credit channel by increasing the cost of holding EL, in particular for banks with a high share of retail deposit funding on their balance sheet.

Another means through which the bank lending channel might strengthen during NIRP is due to increased risk appetite. The exchange of very safe assets such as central bank reserves for riskier assets such as loans and bonds can also be seen through the lens of the risk-taking channel, which emphasises the role of risk perceptions and risk tolerance (Borio and Zhu (2008), Adrian and Shin (2009), Jimenez et al. (2014), Dell'Ariccia et al. (2016)).

⁸ The seminal exposition of the bank lending channel is Bernanke and Blinder (1988).

The increase in asset prices and collateral values prompted by lower monetary policy rates can increase banks' capacity and willingness to take on more risk, for instance through the reliance on measures of risk that are based on market equity prices such as expected default frequencies and the use of Value-at-Risk frameworks for asset-liability management. Moreover, "sticky" rate-of-return targets defined in nominal terms can prompt a "search for yield" effect when interest rates are reduced, which results in higher risk tolerance. In fact, one objective of quantitative easing policies is considered to be promoting risk taking by encouraging lenders to invest in riskier assets when the returns on safer assets decline (see Aramonte et al. (2015) and Heider et al. (2017)) and this is likely further reinforced by the prevalence of negative rates.

While NIRP may enhance the bank lending channel due to negative charges on EL and increased risk taking, there might be "tipping points" beyond which banks cannot tolerate further squeezes in their profits and adopt different strategies to avoid these squeezes (Bech and Malkhozov (2016)). This argument is further taken up in Brunnermeier and Koby (2016) who argue that below some level of the policy rate, further reductions can in fact be contractionary owing to the financial instability that they induce and the ensuing contractionary effects on bank lending. At the same time, these authors recognise that this threshold rate is not necessarily zero. Rognlie (2015) shows in a theoretical model that for an economy that is expected to be in a recession over the planning horizon, negative interest rates are beneficial and hence zero is not a lower bound for the central bank that wants to boost economic growth. As the theory incorporates offsetting factors, determining the net impact of NIRP on bank lending is ultimately an empirical question, which we turn to in the next section.

4. Empirical strategy and data

In line with the conceptual discussion in the previous section, our empirical analysis focuses on tracing out the possible bank balance sheet adjustments triggered by the introduction of NIRP through three basic channels: banks' loan creation, banks' securities holdings and banks' adjustment to their wholesale funding.

The introduction and further roll-out of NIRP occurred in tandem with the announcement of other non-standard monetary policy measures by the ECB. In particular, the first reduction of the deposit facility rate (DFR) to negative territory in June 2014 coincided with the announcement of the targeted long-term refinancing operations (TLTROs, starting in September 2014). The next reduction of the DFR to -0.20% was decided in September 2014, together with the announcement of the asset backed securities purchases programme (ABSPP) and the third covered bond purchase programme (CBPP3). The rate cuts of December 2015 and March 2016 coincided with extensions of the ECB's asset purchase programme (APP), which started in March 2015 and which was broadly expected by financial markets already in December 2014.

This confluence of various policy measures can have a bearing on banks' decisions and thus renders the identification of the effects of NIRP based purely on the timing of its introduction problematic. For example, Krishnamurthy and Vissing-Jorgensen (2011) recently ask how declines in government bond yields spill over to yields on other assets in the context of large scale asset purchases conducted by the Federal Reserve. They note that when the Federal Reserve buys safe, longer-term assets it could induce investors to shift their portfolios toward other, potentially riskier assets, pushing down those yields. Hence, it is plausible to expect that similar portfolio rebalancing effects would be triggered by the APP. The availability of long-term funding at an attractive price through the TLTRO can also be expected to incentivise the acquisition of assets. Moreover, the targeting elements of this measure would be expected to spur increased lending in particular.

In view of this, our identification strategy relies on the idea that the intensity of the pressure for banks to pursue any of the balance sheet adjustment strategies described in the previous section depends on the volume of EL that each bank holds. This is because it is the volume of EL held by a bank that defines the overall charge the bank has to pay for its recourse to the deposit facility (and parts of its current account with the Eurosystem). The charge on EL can be seen as capturing the essence of the specialness of negative rates, which arises because parts of banks' liabilities are floored at zero, while the return on banks' assets is not. By the same logic, banks not holding any EL will not be subject to the charge on EL and we would not expect these banks to react to the negative rate environment with pronounced changes to their balance sheet. This means that there is cross-sectional variation in the intensity of the "treatment" (the NIRP) and this variation is linked to a variable that is observable at the bank level: EL. We exploit this cross-sectional variation in the treatment to identify this effect of NIRP from the effects of other non-standard measures, such as the APP, which operate mainly through the impact on yields on bonds and broader financial market prices and do not vary across banks depending on the level of their EL holdings.

An additional element in our identification approach refers to the expectation that for a given level of EL, banks' balance sheet adjustment in the face of negative rates will differ depending on characteristics that relate to the composition of their funding and structural features defining their role in the financial system, such as their business model. As regards the funding composition, Section 2 has set out a number of considerations suggesting that banks more reliant on retail deposit funding would be more heavily affected by negative rates as they are likely to face a larger compression of their net interest margins. A significant reaction to holdings of EL during the NIRP period by banks highly reliant on deposit funding would, therefore, corroborate that this reaction is economically associated with negative rates. By that logic, the introduction of negative rates should lead to a redistribution of EL from

banks with high costs of holding onto it to those with lower costs. Table 1 shows evidence that this redistribution occurred during the NIRP period.

Bank business models determine banks' position in the financial architecture and, therefore, influence whether they are structural attractors of EL in the system. For instance, banks that have a business model oriented towards the intermediation of trading activities of institutional investors tend to structurally attract EL. This, in turn, affects their expectations regarding the persistence and future volume of their EL holdings, which has a bearing on how they react to the cost associated with the negative rate applied to these holdings. Those banks that expect to receive large volumes of EL over a protracted period of time in a dynamic sense will be subject to a higher total cost associated with NIRP. Therefore, these banks are expected to be more active in adjusting their balance sheets in the face of NIRP. The argument that banks with different business models may be affected from NIRP differently is consistent with previous literature which highlights that banks with different funding structures may exhibit a heterogeneous response to monetary policy (see e.g. Kashyap and Stein (2000), Crosignani and Carpinelli (2016), Drechsler et al. (2016)).

To test this hypothesis, we group each bank in our sample into a category reflecting its business model, using standard hierarchical clustering methods (see Ayadi et al. (2011)). Statistical tests suggest that five different business models exist in our data. Table 2 illustrates the business models that are exploited in our empirical identification. By controlling for bank business models we are able to capture two aspects that are key for banks' reaction to negative rates: the difference in their costs of holding EL as well as in their ability to adjust to these costs. Both dimensions should be reflected in their business model. Annex 2 provides a more detailed illustration of each of the identified bank business models.

5. Empirical results

5.1. Bank Loans

Our aim in this sub-section is to investigate whether NIRP prompts banks to use their EL to extend more loans, over and above what standard determinants of loan issuance would suggest. To answer this question, we need to frame it within the broader context of the motivations driving banks' loan issuance decisions. As loan extensions are a portfolio allocation decision, standard considerations relating to the rate of return on loans and that of alternative investment opportunities need to be taken into account. Determinants of bank loans have been heavily investigated in the literature. We specify an equation that is similar to the loan regression in Cornett et al. (2011), to estimate the impact of NIRP on bank loans.

$$\begin{aligned}
 Loan\ ratio_{i,t} = & T_t + B_i + \beta_0 Loan\ ratio_{i,t-1} + \beta_1 EL\ ratio_{i,t-1}(1 - D^{NIR}) \\
 & + \beta_2 EL\ ratio_{i,t-1}(1 - D^{NIR})D^{Business\ Model} \\
 & + \beta_3 EL\ ratio_{i,t-1}(D^{NIR}) \\
 & + \beta_4 EL\ ratio_{i,t-1}(D^{NIR})D^{Business\ Model} \\
 & + \beta_5 Liquidity\ ratio_{i,t-1} + \beta_6 Leverage\ ratio_{i,t-1} \\
 & + \beta_7 BLS\ demand_t + \beta_8 r_{j,t-1}^{Loan} + \beta_9 Core\ ratio_{i,t-1} \\
 & + \beta_{10} Unemployment_{i,t-1} + \beta_{11} Loan\ Ratio_{i,t-1}^{Stock} \\
 & + \beta_{12} Bond\ ratio_{i,t-1}^{Flow} + \beta_{13} Wholesale\ ratio_{i,t-1}^{Flow} + \varepsilon_{it}
 \end{aligned} \tag{1}$$

where $Loan\ ratio_t = \frac{Loans_{i,t}}{Assets_{i,t-1}}$ constructed from flow data on bond holdings, $EL\ ratio_{i,t} =$

$$\frac{\Delta Excess\ Liquidity_{i,t}}{Assets_{i,t}}, \quad Liquidity\ ratio_{i,t} = \frac{Liquid\ assets_{i,t}}{Assets_{i,t}},$$

$$Leverage\ ratio_{i,t} = \frac{(Capital+Reserves)_{i,t}}{Assets_{i,t}}, \quad Core\ ratio_{i,t} = \frac{Core\ Deposits_{i,t}}{Assets_{i,t}}, \quad Loan\ Ratio_t^{Stock} =$$

$$\frac{Loans_{i,t}}{Assets_{i,t}}, \text{ constructed from stock data on loans to the nonfinancial private sector,}$$

$$Bond\ ratio_t^{Flow} = \frac{Bonds_{i,t}}{Assets_{i,t}}, \text{ constructed from flow data on nondomestic bond holdings,}$$

$$Wholesale\ ratio_t^{Flow} = \frac{Wholesale\ funding_{i,t}}{Assets_{i,t}}, \text{ constructed from flow data on debt securities}$$

issued and interbank loans, D^{NIR} is a dummy variable that is equal to 1 for NIRP (after June 2014), and $D^{Business\ Model}$ is a dummy variable that is equal to 1 for the specific business

model described in Table 2. $BLS\ demand_t$ is a proxy for loan demand measured from the BLS survey.⁹ The subscript i denotes individual bank i , and j is the country in which a bank is located in.

Liquid assets are defined as the sum of interbank lending, holdings of government bonds, holdings of debt securities issued by MFIs, holdings of debt securities issued by the private sector, and holdings of equity. Core deposits are defined as deposits (of all maturities) of households and non-financial corporations. r_i^{Loan} is the composite lending rate of bank i , while r_j^{10y} is the yield on the 10-year government bonds issued in the country j , i.e. the country where the respective bank is located in. Summary descriptive statistics for the variables used in our empirical analysis are provided in Table A1 in the Annex 1.

Our strategy for identifying the effects of the NIRP period on bank loan issuance is operationalised in equation (1) by interacting the EL ratio with a dummy variable for the NIRP period. If banks are indeed more motivated to turn their EL into loans during the NIRP period, and if this is due to the frictions that are particular to a specific business model, then we expect $\beta_4 > 0$ and $\beta_3 + \beta_4 > \beta_1 + \beta_2$.

Equation (1) is estimated as a panel fixed effects model. We include bank fixed effects (B_i) to control for unobservable time-invariant bank-specific factors that affect the decision to extend loans.¹⁰ Moreover, our specifications include time fixed effects (T_t) to control for aggregate shocks. The errors are clustered at the bank level. The estimation sample covers the period from August 2007 to October 2016. The monthly frequency of our dataset allows us to work with a long panel with over 108 observations, which does not require the use of an

⁹ Note that country results for the BLS are used, which ensures cross-sectional variation across countries and therefore does not lead to collinearity problems with the time fixed effects.

¹⁰ Pooled OLS estimates without fixed effects (not reported in the paper) as well as a model that replaces bank fixed effects with country fixed effects give qualitatively similar results.

Arellano and Bond (1991) type of estimator to address the dynamic structure.¹¹ In order to address potential endogeneity problems, all bank-level variables enter with a one-month lag. To avoid that our results are unduly influenced by outliers, all bank-level flow data are winsorized at the 1 and 99 percent levels. Moreover, we have excluded banks resident in Greece and Cyprus from our sample as these countries faced banking crises during part of the sample, which profoundly restricted banks' capacity to adjust their portfolios in an optimal manner.

Banks that have more liquid balance sheets or higher capital ratios are expected to issue more loans ($\beta_5, \beta_6 > 0$). An increase in demand should increase the volume of loans ($\beta_7 > 0$). Banks that have more funding through core deposits are also more likely to issue loans ($\beta_9 > 0$). We control for demand with the unemployment rate. An increase in the unemployment rate should lead to a decline in loan issuance ($\beta_{10} < 0$).

Table 3 shows the estimation results. We consider all five bank business models present in our sample (through dummies) in the estimation and only include the ones that are statistically significant at the final stage. Focusing on rows 6 and 7, we note that highest deposit holders and investment banks have a larger tendency to convert their EL holdings into loans during NIRP. $D^{High Dep}$ captures high deposit banks (top decile), based on their average deposits during the period from June 2013 through May 2014 (i.e. in the year before NIRP started). While there are only 26 banks included in this category, this set of banks amount to 40 percent of average NFPS loans in our sample. In section 3, we had noted that the presence of market frictions may squeeze the profit margins of banks during NIRP. This may be binding particularly if this excess liquidity is generated by retail deposits. Based on

¹¹ The Arellano-Bond (1991) estimator is designed for short panels. In long panels, a shock to the cross-sectional fixed effect declines with time and the correlation of the lagged dependent variable with the error term becomes insignificant. Judson and Owen (1999) use Monte-Carlo simulations and show that the so-called "Nickell bias" is no longer significant for panels where the time dimension is larger than 30.

the results presented in Table 3 the NIRP effect corresponds on average to 5% of the monthly lending by high deposit banks during the NIRP period. Also banks with a business model oriented towards investment banking seem to adjust by extending loans, although in this case the main channel of adjustment seems to be a reduction of (relatively costly) wholesale funding (see Section 5.3). This notwithstanding, the estimates reported in Table 3 suggest that on average 9% of the lending extended by investment banks during the NIRP period can be accounted for by the NIRP effect.

Other control variables are generally in line with our expectations. Banks that have more liquid balance sheets or higher leverage ratios tend to issue more loans (rows 8 and 9) although the coefficient estimates are not statistically significant. Banks that obtain more funding through core deposits generate more loans (row 12). This is consistent with the bank dominant financial structure in Europe. A decrease in demand, captured by the increase in the unemployment rate, leads to less loan extension as expected (row 13). Meanwhile there seems to be a trade-off between nondomestic bond holdings and loan issuance as suggested by the negative coefficients on the bond ratio (row 16).

5.2. Government bond holdings

We follow the same logic as in the previous section to identify the effects of NIRP for bank bond holdings in the framework of portfolio reallocation. One reason that banks hold bonds is to obtain a positive rate of return. In addition, there is a considerable body of literature making the case that banks hold sovereign bonds for reasons other than their expected return. Gennaioli et al. (2013) and Holmstrom and Tirole (1993) argue that banks hold government bonds as a buffer against the materialisation of liquidity shocks. Other authors, such as Bonner (2016) and Popov and van Horen (2013) highlight the relevance of the preferential treatment of government bonds in capital and liquidity regulation as a driver

for holding government bonds. With these considerations in mind, we use the following equation, similar to our loan equation in the previous section:

$$\begin{aligned}
\text{Gov. bond ratio}_{i,t} &= T_t + B_i + \beta_0 \text{Gov. bond ratio}_{i,t-1} \\
&+ \beta_1 \text{EL ratio}_{i,t-1} (1 - D^{NIR}) \\
&+ \beta_2 \text{EL ratio}_{i,t-1} (1 - D^{NIR}) D^{\text{Business Model}} \\
&+ \beta_3 \text{EL ratio}_{i,t-1} (D^{NIR}) \\
&+ \beta_4 \text{EL ratio}_{i,t-1} (D^{NIR}) D^{\text{Business Model}} \\
&+ \beta_5 \text{Liquidity ratio}_{i,t-1} + \beta_6 \text{Leverage ratio}_{i,t-1} + \beta_7 r_{i,t-1}^{\text{Loan}} \\
&- r_{j,t-1}^{10y} + \beta_8 \log(\text{Assets})_{i,t-1} + \beta_9 \text{Unemployment}_{i,t-1} \\
&+ \beta_{10} \text{Bond Ratio}_{i,t-1}^{\text{Stock}} + \beta_{11} \text{Loan ratio}_{i,t-1}^{\text{Flow}} \\
&+ \beta_{12} \text{Wholesale ratio}_{i,t-1}^{\text{Flow}} + \varepsilon_{it}
\end{aligned} \tag{2}$$

We estimate equation (2) for domestic and nondomestic bond holdings. Similar to our logic in the previous section, if banks are more motivated to buy bonds with their EL during NIRP, we expect $\beta_4 > 0$ and $\beta_3 + \beta_4 > \beta_1 + \beta_2$.

Table 4 reports the estimation results where the dependent variable is the ratio of changes in non-domestic bond holdings over assets. Row 7 reports the coefficient for our main variable of interest, which turns out to be statistically significant and indicates that wholesale funded banks are more likely to convert their EL into government bond holdings during the NIRP period. In terms of economic significance, these results suggest that the reduction of non-domestic government bond holdings by wholesale funded banks observed during the NIRP period would have been 25% higher in the absence of NIRP. The choice of adjustment channel for this group of banks would be consistent with their role in the capital and money markets and in providing liquidity management services, all of which would tend to favour a preference for holding highly-liquid assets such as government bonds. By contrast, in the previous period there is no significant reaction of banks' non-domestic bond holdings to EL (row 3). The finding for the period before NIRP started is consistent with Ennis and Wolman (2015) who find no evidence of substitution between excess reserves and other forms

of liquid assets for the US. It should be noted that our estimate of the effects of NIRP is likely a conservative one that underestimates the true impact. This is because while NIRP encourages banks to convert their EL into bonds, APP encouraged banks to sell their bond holdings to the ECB (see e.g. Koijen et al. (2016)). Even though we control for the APP period with time fixed effects, we do not have access to control variables at the bank level that would affect the bank's decision such as the expected rate of return on alternative assets.

Better capitalised banks (row 9) tend to be more inclined to acquire nondomestic bonds. There is no significant reaction to the opportunity cost of holding government bonds (row 10). Smaller banks tend to acquire significantly more nondomestic bonds relative to their size (row 11), a result that may reflect a more limited universe of investment opportunities than their larger peers, perhaps owing to more limited portfolio management capacity and sophistication. General macroeconomic conditions as proxied by the unemployment rate do not seem to significantly influence nondomestic bond buying behaviour (row 13). To allow for interaction among the adjustment channels considered we also include the loan and wholesale funding ratios as controls in our specifications but they are not significant.

We do not show the results for domestic bonds because we do not observe any significant relationship between EL holdings and domestic bond holdings.

5.3. Wholesale funding

Wholesale funding refers to uninsured bank liabilities such as inter-bank loans and debt securities issued that provide additional funding opportunities beyond retail deposits. Wholesale funding, owing to its uninsured nature tends to be costlier than retail deposits and can, in some cases, be adjusted flexibly. One potential impact of NIRP could therefore be to motivate banks to use their EL to pay back wholesale funding debt.

We consider an empirical specification that is similar to the earlier ones:

$$\begin{aligned}
\text{Wholesale ratio}_{i,t} &= T_t + B_i + \beta_0 \text{Wholesale ratio}_{i,t-1} \\
&+ \beta_1 \text{EL ratio}_{i,t-1} (1 - D^{NIR}) \\
&+ \beta_2 \text{EL ratio}_{i,t-1} (1 - D^{NIR}) D^{\text{Business Model}} \\
&+ \beta_3 \text{EL ratio}_{i,t-1} (D^{NIR}) \\
&+ \beta_4 \text{EL ratio}_{i,t-1} (D^{NIR}) D^{\text{Business Model}} \\
&+ \beta_5 \text{Liquidity ratio}_{i,t-1} + \beta_6 \text{Leverage ratio}_{i,t-1} \\
&+ \beta_7 \text{BLS demand}_t + \beta_8 (r_{j,t-1}^{2y} - r_{i,t-1}^{\text{Deposit}}) \\
&+ \beta_9 \text{Unemployment}_{i,t-1} + \beta_{10} \text{Wholesale Ratio}_{i,t-1}^{\text{Stock}} \\
&+ \beta_{11} \text{Loan ratio}_{i,t-1}^{\text{Flow}} + \beta_{12} \text{Bond ratio}_{i,t-1}^{\text{Flow}} + \varepsilon_{it}
\end{aligned} \tag{3}$$

where $r_{j,t-1}^{2y}$ is the yield on the respective two-year sovereign bond, $r_{i,t-1}^{\text{Deposit}}$ is the composite deposit rate of each bank.

If banks are more motivated to use their EL to pay back their wholesale borrowing during the NIRP period and if this motivation is further reinforced by the bank's business model, then we expect $\beta_4 < 0$ and $(\beta_3 + \beta_4) < (\beta_1 + \beta_2)$

The spread between the two-year sovereign bond rate and the deposit rate is a proxy to capture the relative cost of wholesale funding. Billett and Garfinkel (2004) note that banks' choice between insured and uninsured funding depends on the differential rates charged in the two markets. An increase in this spread reflects an increase in the cost of wholesale funding and hence implies a negative coefficient: $\beta_8 < 0$. Variables such as the leverage ratio control for banks' unsecured funding costs as well (see Babihuga and Spaltro (2014)). Accordingly, banks that have better capitalisation (i.e. a higher leverage ratio as defined here) should have lower wholesale funding costs and are, therefore, more likely to tap wholesale funding resources: $\beta_6 > 0$. We include the ratio of bank loans because loans are an essential determinant of bank funding needs. An increase in bank loans should increase the need for wholesale funding: $\beta_{11} > 0$.

Table 5 shows the estimation results. Row 5 suggests that investment banks have indeed used their EL during the NIRP period to reduce their wholesale borrowing. According to these estimates, this effect accounts for 12% of the reduction in wholesale funding that investment banks registered over the NIRP period. This finding may be associated with broader deleveraging strategies followed by investment banks in this period, as they made efforts to have leaner balance sheets in the face of the introduction of the leverage ratio.

Looking at the other control variables, banks that have higher levels of liquid assets tend to rely on less wholesale funding as expected. Meanwhile, higher levels of bond ratios are associated with higher wholesale funding as well (row 14).

5.4. Robustness analysis

We check the robustness of our results in several ways. First, we consider alternative cut off points for various reductions in the deposit facility rate to determine if the NIRP period is indeed special. Our goal is to understand whether other reductions in the DFR that took place in positive territory trigger reactions similar to the reductions in negative territory. To that end, we consider three additional rate cut periods and construct dummy variables to capture them: D^{08-09} captures the period from October 2008 to April 2009, which can be regarded as the “fast” rate cut phase. D^{11-12} captures the period from December 2011 to June 2012 which can be considered as the “slow” rate cut phase. D^{2013} captures the period from May 2013 to December 2013 when the ECB lowered the MRO rate but not the DFR. In addition, we want to shed more light onto the third step in the negative territory. The cut in the deposit facility rate to -30 basis points in December 2015 marks the point when financial markets revised their expectations regarding the future path of short rates because what was previously thought to be the lower bound had to be revised downwards. Grisse et al. (2017) note that if rate cuts below zero shift the believed lower bound, this affects the long term rates

and strengthens the transmission mechanism. D^{DFR3} corresponds to the period from December 2015 to February 2016 when the DFR was reduced to -30 basis points. We test to see if this period is any different from the other phases in the negative territory. We interact these dummy variables with the EL ratio and add them to our specification.

Table 6 shows the regression results from this robustness check. For the sake of brevity, we only report the coefficient estimates for the interactive dummies. Tables 6a, 6b and 6c show the results for loans, non-domestic bonds, and wholesale funding regressions respectively. Our results suggest that the switch to negative interest rate territory is indeed special. There is no attempt to convert EL into loans for the periods when the DFR was in the positive territory as shown in Table 6a, likely because the rate of return on loans was pretty close to the deposit facility rate during those times. For the high deposit banks, the coefficient estimate that is associated with NIRP is positive and significant (row 10).¹² For investment banks, it is the third step of NIRP that prompts more loan issuance (row 17).

While none of the sub-samples yield a significant response for nondomestic bonds (Table 6b), wholesale funding regressions once again suggest that the NIRP period is special as shown in Table 6c. While the net impact for Investment banks for the 2013 period is zero (which is the sum of rows 4 and 10), there is a net negative impact for investment banks during NIRP (row 11).

Table 7 considers another robustness check to see whether banks are more responsive in adjusting their EL depending on their location. In particular, we distinguish countries having experienced some form of financial stress during the financial crisis, past or present (“vulnerable countries”) from those that have not (“less-vulnerable countries”).¹³ Tables 7a,

¹² We do not interact high deposit banks with D^{08-09} because there are only two banks who have positive EL during this period.

¹³ “Vulnerable countries” refers to Ireland, Greece, Spain, Italy, Cyprus, Portugal and Slovenia, while the term “less-vulnerable countries” refers to the remaining euro area countries.

7b, and 7c show the results for loans, nondomestic bonds, and wholesale funding regressions respectively. Table 5a suggests that banks in less vulnerable countries are indeed more likely to extend loans during NIRP (row 8). This result is likely driven by the fact that banks in less-vulnerable countries generally have higher levels of EL compared to their counterparts in vulnerable countries.

6. Conclusions

The existing theoretical and empirical literature on banks' role in the monetary policy transmission mechanism is largely silent on whether bank reactions to changes in policy rates might be special when these changes occur in or drive rates to negative territory. Using confidential bank-level data for the euro area we approached this question empirically. We find evidence that banks' indeed operate differently under negative rates. Affected banks' react to negative policy rates by significantly higher acquisitions of non-domestic bonds, by extending more loans to the non-financial private sector and by lowering their levels of wholesale funding. This reaction is driven by banks holding the highest retail deposit share, investment banks and banks that rely heavily on wholesale funding. These results can be seen as suggesting that the negative deposit facility rate has acted as an empowerment to the ECB's large-scale asset purchases that were also inaugurated during this period and that inject large amounts of excess liquidity into the banking system. The charge on this excess liquidity seems to encourage banks to take action to avoid it, thereby catalysing more active portfolio rebalancing.

The channels for balance sheet adjustment in the face of negative rates that have been considered in this paper focus exclusively on internal, i.e. euro area, assets. Another potentially important channel, however, relates to possible increases in the holdings of foreign

assets, as argued by Khayat (2015). Exploring the impact of the ECB's negative deposit facility rate on banks' external capital flows is, therefore, an interesting area for future work.

Table 1: Change in the Share of Retail Deposits

	Share of retail deposits	
	High ⁱ	Low
June 2012	73%	27%
October 2016	58%	42%

Table 2: Business Models

Business Model	Description
Focused retail	Most active in traditional deposit loan intermediation.
Diversified retail	Deposit funded, moderate loan origination but also engaged in other activities.
Debt funded retail	Debt based market funding with moderate loan origination but also engaged in other activities, principally investment.
Investment	Mixed funding, high investment and trading activities.
Wholesale	High bank lending supported by debt funding.

Table 3: Effects of Negative Interest Rate (NIR) policy on Bank Loans

1.	Lagged dependent variable	-0.04
		-1.12
2.	$\Delta EL\ ratio_{t-1} \times (1 - D^{NIR})$	0.00003**
		3.91
3.	$\Delta EL\ ratio_{t-1} \times (1 - D^{NIR}) \times D^{High\ Dep.}$	-0.01*
		-1.69
4.	$\Delta EL\ ratio_{t-1} \times (1 - D^{NIR}) \times D^{Investment}$	0.00
		-1.12
5.	$\Delta EL\ ratio_{t-1} \times D^{NIR}$	0.00
		-0.51
6.	$\Delta EL\ ratio_{t-1} \times D^{NIR} \times D^{High\ Dep.}$	0.04**
		3.14
7.	$\Delta EL\ ratio_{t-1} \times D^{NIR} \times D^{Investment}$	0.01*

		1.75
8.	$Liquidity\ ratio_{t-1}$	0.00
		0.16
9.	$Leverage\ ratio_{t-1}$	0.01
		0.87
10.	BLS^{Demand}	0.00
		1.14
11.	r_{t-1}^{Loan}	0.00
		-1.02
12.	$Core\ ratio_{t-1}$	0.01**
		2.22
13.	$Unemployment_{t-1}$	-0.0004**
		-6.88
14.	$Stock\ loan\ ratio_{t-1}$	-0.01**
		-1.93
15.	$Flow\ wholesale\ ratio_{t-1}$	0.00
		0.55
16.	$Flow\ bond\ ratio_{t-1}$	-0.05**
		-2.50
17.	Number of cross sections	205
18.	Adjusted R^2	0.13

Regressions include a constant. t-ratios under coefficient estimates. **/* reflects significance at 95/90 percent level of confidence. Regressions include cross section and period fixed effects.

Table 4: Effects of Negative Interest Rate (NIR) policy on Non-domestic Bonds

1.	Lagged dependent variable	0.03
		0.44
2.	$\Delta EL\ ratio_{t-1} \times (1 - D^{NIR})$	0.00
		-1.36
3.	$\Delta EL\ ratio_{t-1} \times (1 - D^{NIR}) \times D^{Wholesale}$	0.00
		0.63
5.	$\Delta EL\ ratio_{t-1} \times D^{NIR}$	0.00
		0.46
7.	$\Delta EL\ ratio_{t-1} \times D^{NIR} \times D^{Wholesale}$	0.01**
		2.11
8.	$Liquidity\ ratio_{t-1}$	0.00
		0.48
9.	$Leverage\ ratio_{t-1}$	0.002**
		3.41
10.	$r_{t-1}^{Loan} - r_{t-1}^{10y}$	0.00
		1.43
11.	$\log(Assets)_{t-1}$	-0.0003*

		-1.80
12.	$Unemployment_{t-1}$	0.00
		-0.55
13.	$Stock\ nondomestic\ bond\ ratio_{t-1}$	-0.02**
		-5.58
14.	$Flow\ wholesale\ ratio_{t-1}$	0.00
		-0.44
15.	$Flow\ loan\ ratio_{t-1}$	0.00
		-0.14
16.	Number of cross sections	205
17.	Adjusted R ²	0.02

Regressions include a constant. t-ratios under coefficient estimates. **/* reflects significance at 95/90 percent level of confidence. Regressions include cross section and period fixed effects.

Table 5: Effects of Negative Interest Rate (NIR) policy on Wholesale Funding

1.	Lagged dependent variable	-0.12**
		-4.21
2.	$\Delta EL\ ratio_{t-1} \times (1 - D^{NIR})$	0.00
		-0.04
3.	$\Delta EL\ ratio_{t-1} \times (1 - D^{NIR}) \times D^{Investment}$	-0.01
		-1.03
4.	$\Delta EL\ ratio_{t-1} \times D^{NIR}$	0.02
		1.29
5.	$\Delta EL\ ratio_{t-1} \times D^{NIR} \times D^{Investment}$	-0.03*
		-1.80
7.	$Liquidity\ ratio_{t-1}$	-0.01**
		-2.41
8.	$Leverage\ ratio_{t-1}$	0.00
		-0.03
9.	BLS^{Demand}	0.00
		-0.12
10.	$r_{t-1}^{2y} - r_{t-1}^{Deposit}$	0.00
		0.25
11.	$Unemployment_{t-1}$	0.00
		-1.55
12.	$Stock\ wholesale\ funding\ ratio_{t-1}$	-0.04**
		-6.18

13.	<i>Flow loan ratio</i> _{<i>t</i>-1}	-0.04 -0.56
14.	<i>Flow bond ratio</i> _{<i>t</i>-1}	0.06* 1.78
15.	Number of cross sections	205
16.	Adjusted R ²	0.05

Regressions include a constant. t-ratios under coefficient estimates. **/* reflects significance at 95/90 percent level of confidence. Regressions include cross section and period fixed effects.

Table 6: Robustness Check for Alternative Easing Periods

Table 6a: Bank Loans

1.	$EL\ ratio_{t-1} \times (1 - D^{NIR})$	0.00005**
		9.75
2.	$EL\ ratio_{t-1} \times D^{08-09}$	-0.00007**
		-15.30
3.	$EL\ ratio_{t-1} \times D^{11-12}$	0.00
		-1.58
4.	$EL\ ratio_{t-1} \times D^{2013}$	-0.01
		-1.06
5.	$EL\ ratio_{t-1} \times D^{NIR}$	0.00
		-0.21
6.	$EL\ ratio_{t-1} \times D^{DFR3}$	-0.01
		-0.83
7.	$EL\ ratio_{t-1} \times (1 - D^{NIR}) \times D^{High\ Dep.}$	-0.01*
		-1.68
8.	$EL\ ratio_{t-1} \times D^{11-12} \times D^{High\ Dep.}$	0.04
		1.17
9.	$EL\ ratio_{t-1} \times D^{2013} \times D^{High\ Dep.}$	-0.01
		-0.44
10.	$EL\ ratio_{t-1} \times D^{NIR} \times D^{High\ Dep.}$	0.05**
		2.85
11.	$EL\ ratio_{t-1} \times D^{DFR3} \times D^{High\ Dep.}$	-0.04
		-0.96
12.	$EL\ ratio_{t-1} \times (1 - D^{NIR}) \times D^{Investment}$	0.00
		-1.09
13.	$EL\ ratio_{t-1} \times D^{08-09} \times D^{Investment}$	0.03
		1.21
14.	$EL\ ratio_{t-1} \times D^{11-12} \times D^{Investment}$	0.01
		1.40
15.	$EL\ ratio_{t-1} \times D^{2013} \times D^{Investment}$	0.00
		0.41
16.	$EL\ ratio_{t-1} \times D^{NIR} \times D^{Investment}$	0.01
		1.08
17.	$EL\ ratio_{t-1} \times D^{DFR3} \times D^{Investment}$	0.03**
		2.47

t-ratios under coefficient estimates. **/* reflects significance at 95/90 percent level of confidence.

Table 6b: Nondomestic bonds

1.	$EL\ ratio_{t-1} \times 1 - D^{NIR}$	0.00
		-0.14
2.	$EL\ ratio_{t-1} \times D^{08-09}$	0.00
		-1.55
3.	$EL\ ratio_{t-1} \times D^{11-12}$	0.00
		-1.17
4.	$EL\ ratio_{t-1} \times D^{2013}$	0.00
		-0.20
5.	$EL\ ratio_{t-1} \times D^{NIR}$	0.00
		0.30
6.	$EL\ ratio_{t-1} \times D^{DFR3}$	0.00
		0.49
7.	$EL\ ratio_{t-1} \times (1 - D^{NIR}) \times D^{Wholesale}$	0.02
		0.91
8.	$EL\ ratio_{t-1} \times D^{08-09} \times D^{Wholesale}$	-0.04
		-1.39
9.	$EL\ ratio_{t-1} \times D^{11-12} \times D^{Wholesale}$	-0.02
		-0.79
10.	$EL\ ratio_{t-1} \times D^{2013} \times D^{Wholesale}$	-0.05
		-1.49
11.	$EL\ ratio_{t-1} \times D^{NIR} \times D^{Wholesale}$	0.01
		1.54
12.	$EL\ ratio_{t-1} \times D^{DFR3} \times D^{Wholesale}$	0.00
		0.38

t-ratios under coefficient estimates. **/* reflects significance at 95/90 percent level of confidence.

Table 6c: Wholesale funding

1.	$EL\ ratio_{t-1} \times 1-D^{NIR}$	0.00
		0.22
2.	$EL\ ratio_{t-1} \times D^{08-09}$	0.00
		-0.86
3.	$EL\ ratio_{t-1} \times D^{11-12}$	-0.01
		-0.80
4.	$EL\ ratio_{t-1} \times D^{2013}$	0.03**
		1.96
5.	$EL\ ratio_{t-1} \times D^{NIR}$	0.02
		1.15
6.	$EL\ ratio_{t-1} \times D^{DFR3}$	0.02
		0.60
7.	$EL\ ratio_{t-1} \times (1-D^{NIR}) \times D^{Investment}$	-0.01
		-1.01
8.	$EL\ ratio_{t-1} \times D^{08-09} \times D^{Investment}$	-0.06
		-0.95
9.	$EL\ ratio_{t-1} \times D^{11-12} \times D^{Investment}$	0.00
		0.18
10.	$EL\ ratio_{t-1} \times D^{2013} \times D^{Investment}$	-0.03*
		-1.73
11.	$EL\ ratio_{t-1} \times D^{NIR} \times D^{Investment}$	-0.03*
		-1.77
12.	$EL\ ratio_{t-1} \times D^{DFR3} \times D^{Investment}$	0.07
		1.58

t-ratios under coefficient estimates. **/* reflects significance at 95/90 percent level of confidence.

Table 7: Robustness Check for Less Vulnerable Countries**Table 7a: Loans**

1.	$EL\ ratio_{t-1} \times (1-D^{NIR})$	0.01 1.49
2.	$EL\ ratio_{t-1} \times (1-D^{NIR}) \times D^{High\ Dep.}$	-0.01* -1.82
3.	$EL\ ratio_{t-1} \times (1-D^{NIR}) \times D^{Investment}$	0.00 -1.06
4.	$EL\ ratio_{t-1} \times (1-D^{NIR}) \times D^{Less\ vulnerable}$	-0.01 -1.49
5.	$EL\ ratio_{t-1} \times D^{NIR}$	-0.08** -2.01
6.	$EL\ ratio_{t-1} \times D^{NIR} \times D^{High\ Dep.}$	0.04** 3.41
7.	$EL\ ratio_{t-1} \times D^{NIR} \times D^{Investment}$	0.01 1.38
8.	$EL\ ratio_{t-1} \times D^{NIR} \times D^{Less\ vulnerable}$	0.08** 2.01

t-ratios under coefficient estimates. **/* reflects significance at 95/90 percent level of confidence.

Table 7b: Bonds

1.	$EL\ ratio_{t-1} \times (1-D^{NIR})$	0.00 -0.39
2.	$EL\ ratio_{t-1} \times (1-D^{NIR}) \times D^{Wholesale}$	0.00 0.69
3.	$EL\ ratio_{t-1} \times (1-D^{NIR}) \times D^{Less\ vulnerable}$	0.00 0.39
4.	$EL\ ratio_{t-1} \times D^{NIR}$	0.00 0.38
5.	$EL\ ratio_{t-1} \times D^{NIR} \times D^{Wholesale}$	0.01** 2.15
6.	$EL\ ratio_{t-1} \times D^{NIR} \times D^{Less\ vulnerable}$	0.00 -0.35

t-ratios under coefficient estimates. **/* reflects significance at 95/90 percent level of confidence.

Table 7c: Wholesale Funding

1.	$EL\ ratio_{t-1} \times (1-D^{NIR})$	0.02 0.58
2.	$EL\ ratio_{t-1} \times (1-D^{NIR}) \times D^{Investment}$	-0.01 -1.01
3.	$EL\ ratio_{t-1} \times (1-D^{NIR}) \times D^{Less\ vulnerable}$	-0.02

4.	$EL\ ratio_{t-1} \times D^{NIR}$	-0.59
		0.06**
5.	$EL\ ratio_{t-1} \times D^{NIR} \times D^{Investment}$	2.44
		-0.03
6.	$EL\ ratio_{t-1} \times D^{NIR} \times D^{Less\ vulnerable}$	-1.56
		-0.04
		-1.54

t-ratios under coefficient estimates. **/* reflects significance at 95/90 percent level of confidence.

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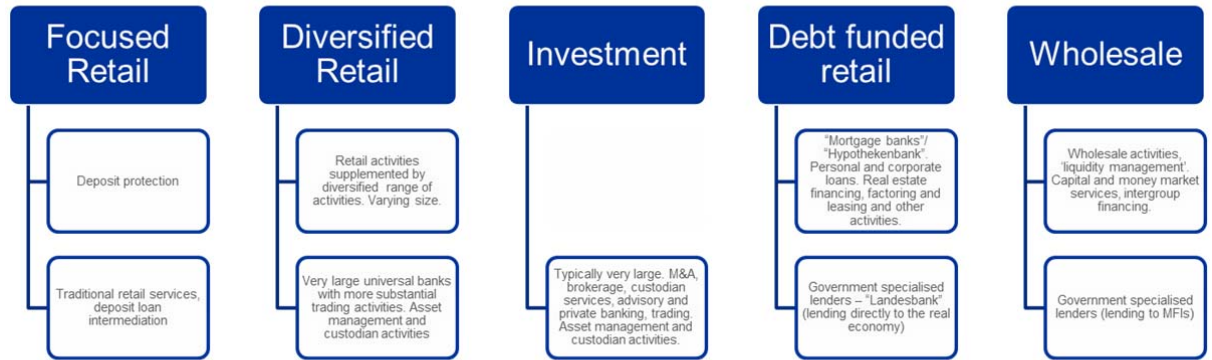
Annex 1

Table A1: Summary descriptive statistics

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness
<i>Non – Domestic Gov. Bond ratio</i>	0.0003	0.00	27.81	-27.53	0.54	3.54
<i>Loans ratio</i>	0.18	0.03	145.98	-101.71	2.72	17.09
<i>Wholesale ratio</i>	0.01	-0.02	549.56	-844.44	7.87	-28.17
$r^{Loan} - r^{10y}$	-1.44	-1.13	4.77	-33.73	2.62	-5.19
$\log(Assets)$	9.71	9.77	13.05	-0.67	1.46	-0.62
<i>EL ratio</i>	0.09	0.00	204.98	-2.88	2.15	64.34
<i>Core ratio</i>	0.35	0.31	20.39	0.00	0.55	17.50
<i>Liquidity ratio</i>	0.36	0.31	3.09	-4.57	0.23	1.66
<i>Leverage ratio</i>	0.09	0.07	2.08	-22.67	0.20	-62.93
<i>BLS demand</i>	-3.08	1.89	87.73	-117.28	31.16	-0.59
r^{Loan}	1.85	1.70	7.23	0.00	0.82	0.68
<i>Unemployment rate</i>	9.55	8.04	27.91	3.31	5.23	1.63

Note: *Gov.Bond ratio*, *Domestic Gov.Bond ratio*, *Non-Domestic Gov.Bond ratio* and *Loans ratio* have been multiplied by 100.

Annex 2: Bank business models



ⁱ Business models with high retail deposit share: Focused Retail and Diversified Retail. Business models with low retail deposit share: Investment banks, Wholesale banks and Debt funded retail.