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**Working Paper**

## Do conventional monetary policy instruments matter in unconventional times?

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## Do Conventional Monetary Policy Instruments Matter in Unconventional Times?

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# Do Conventional Monetary Policy Instruments Matter in Unconventional Times?\*

## Abstract

This paper investigates how declines in the deposit facility rate set by the European Central Bank (ECB) affect bank behavior. The ECB aims to reduce banks' incentives to hold reserves at the central bank and thus to encourage loan supply. However, given depressed margins in a low interest environment, banks might reallocate their liquidity toward more profitable liquid assets other than traditional loans. Our analysis is based on a sample of euro area banks for the period from 2009 to 2014. Three key findings arise. First, banks reduce their reserve holdings following declines in the deposit facility rate. Second, this effect is heterogeneous across banks depending on their business model. Banks with a more interest-sensitive business model are more responsive to changes in the deposit facility rate. Third, there is evidence of a reallocation of liquidity toward loans but not toward other liquid assets. This result is most pronounced for non-GIIPS countries of the euro area.

*Keywords: bank portfolio, central bank reserves, monetary policy*

*JEL Classification: E52, G11, G21*

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## 1. Introduction

Since the recent financial and sovereign debt crisis, the euro area has faced continued distress in financial markets as well as a hampered ability to supply credit to the real sector. To counter these developments, the European Central Bank (ECB) has implemented both conventional and unconventional policy measures. These measures include, among others, low interest rates, long-term refinancing operations, and the implementation of asset purchase programs. With these measures, the ECB aims at improving credit conditions and providing incentives for banks to increase their loan supply. By the same token, the ECB wants to discourage banks from holding reserves and other liquid assets. However, whether the ECB is successful at maintaining the functioning of monetary policy transmission critically depends on banks' responses to these measures.

Hence, it is not surprising that a recent and expanding strand of literature evaluates the effects of *unconventional* monetary policy measures on bank behavior (e.g., Acharya et al. (2016), Chodorow-Reich (2014), Lambert and Ueda (2014), Mamatzakis and Bermpei (2016)). In contrast, in this paper, we draw special attention to *conventional* monetary policy measures, that is, the effects of changes in interest rates set by the ECB during the recent distress period. Using a sample of euro area banks during the period 2009-2014, we analyze how banks have been addressing the continuing low policy rates of the ECB. We particularly focus on the effect of the deposit facility rate on bank reserves. We ask whether the reduction in the deposit facility rate has successfully prevented banks from storing liquidity as reserves at the ECB during unconventional times.

Studying bank reserves is well-motivated by their development during the recent crisis period. Before the financial crisis, bank reserves were almost entirely attributable to mandatory reserves. These are determined by the reserve ratio multiplied with the reserve base, both of which are set by the ECB. Hence, prior to 2008, the main determinant of reserves was the ECB's policy regarding reserve requirements. In contrast, Figure 1 shows that since 2008, bank reserves have increased above mandatory requirements and have become considerably more volatile. Thus, banks seem to make active use of reserves to manage their liquidity during periods of financial distress. A similar increase in aggregate excess reserves has been documented for the US banking system by Keister and McAndrews (2009) and Martin et al. (2017). A potential reason for the observed excess liquidity is the unlimited provision of liquidity by the ECB in combination with pronounced distress in interbank markets (see, e.g., Abbassi et al. (2014), Acharya and Merrouche (2013), Afonso et al. (2011), Ashcraft et al. (2011), Nyborg and Östberg (2014)).

[Insert Figure 1 here]

Lowering the deposit facility rate should reduce banks' incentives to hold liquidity at the central bank (see also, Arseneau 2017). It is important to understand, from various perspectives, whether and how the policy works. First, large excess reserves indicate that banks withhold or even hoard liquidity instead of channeling it to the real sector and consequently fostering economic activity. If banks park liquidity at the central bank, this can impair the transmission of monetary policy. Therefore, the ECB has repeatedly lowered the deposit facility rate since the start of the financial crisis. The ultimate objective of such a policy is for banks to find it more attractive to supply more loans instead of accumulating liquidity at the central bank. Although the aggregate amount of liquidity within the euro system is determined mostly by the monetary policy of the ECB and cannot be influenced by an individual bank, a decrease in the deposit facility rate can induce cost pressure for the individual bank and create a "*hot potato effect*" of liquidity. Cost pressure is created via forgone profits, as reserves are liquidity holdings that earn very low or negative interest rates. Therefore, the individual bank has an incentive to move its liquidity towards more profitable assets rather than holding reserves. If the deposit facility rate is effective at altering banks' incentives to hold reserves, this can be a useful and transparent tool to reallocate liquidity and foster monetary policy transmission. One potential caveat of this policy, however, is that low interest rates can reduce banks' net interest margins, with possibly negative consequences for financial stability (Claessens et al. (2016, 2017)).<sup>1</sup>

Second, uniform policy rates across euro area countries can have different effects across banks.<sup>2</sup> This can lead to heterogeneous and unforeseen responses of banks to monetary policy depending on their business models (Gambacorta and Marqués-Ibáñez (2011)). In particular, banks with a strong focus on the traditional banking business, that is, banks with a high dependence on interest income and expenses due to a high loan and deposit share, should be more concerned with the interest rate policy of the ECB. The obvious reason is that these banks are more involved in interest-bearing activities, such that they are more affected by changes in interest rates. Furthermore, in a low interest rate environment and in the presence of competitive pressure, banks have to reduce loan rates but cannot reduce deposit rates to the same extent (Claessens et al. (2016, 2017)). For the German banking system, Dombret et al. (2017) show that low interest rates can potentially result in narrowed interest margins. Given that German banks have a focus on interest income, this can impose substantial cost pressure. Banks with an interest-sensitive business model are thus likely to experience a larger decrease in interest revenues than in interest expenses, resulting in depressed margins. In our analysis, we thus account for the heterogeneous responses of banks by specifying a model with

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<sup>1</sup> While depressed margins due to reduced interest rates might increase banks' risk-taking, also known as the risk-taking channel of monetary policy, this is outside the scope of our analysis (see e.g., Buch et al. (2014), Dell'Araccia et al. (2016), Heider et al. (2017), Ioannidou et al. (2015), Jiménez et al. (2014), Lambert and Ueda (2014), Lamers et al. (2016)).

<sup>2</sup> As shown by Garcia-de-Andoain et al. (2016), this argument of uneven effects across euro area countries also applies to central bank liquidity provision during recent years.

interaction terms that include the deposit facility rate and the banks' net interest margins. This approach, in the spirit of Cornett et al. (2011), helps to identify the effects of the deposit facility rate across different types of banks.

We find evidence that banks adjust their reserve holdings in response to changes in the deposit facility rate. Decreasing the deposit facility rate has a negative effect on bank reserves. This reveals that conventional monetary policy can even work during unconventional times. Importantly, the effect is heterogeneous across banks: Banks with high net interest margins seem to be more sensitive to changes in the policy rate. This is consistent with recent discussions about the sustainability of a traditional (or interest-sensitive) business model of banks in a low interest rate environment. We find that banks with a higher net interest margin tend to increase their loan supplies as a response to a decrease in the deposit facility rate. This suggests that freed liquidity due to declining reserves benefits loan supply, thus supporting the functioning of monetary policy. These results remain robust when accounting for simultaneous adjustments of balance sheet positions.

While our paper looks at the effects of conventional monetary policy during times of crisis, there is a growing body of literature focusing on unconventional monetary policy and its effects on bank behavior. Acharya et al. (2016) find a recapitalizing effect for banks through the Outright Monetary Transactions (OMT) programs. This effect is particularly strong for banks from GIPS countries, which have benefitted from declines in the sovereign yields of these countries. In response, banks with a larger exposure to sovereign bond holdings – and thus a relatively larger recapitalization effect – extended their loan supply. This reaction was particularly pronounced for weakly capitalized banks and low-quality borrowers. In contrast, Mamatzakis and Bermpei (2016) find, for the United States, a negative relationship between unconventional monetary policy and bank performance, which weakens as banks increase their asset diversification and have low deposit costs on the funding side.

Another strand of literature studies the effectiveness of monetary transmission during times of crisis, depending on banks' characteristics (Gambacorta and Marqués-Ibáñez (2011)).<sup>3</sup> Acharya et al. (2015) provide evidence for an impaired transmission of monetary policy conditional on banks' riskiness. The results of Cycon and Koetter (2015) suggest that reductions in banks' refinancing costs are attributable to unconventional monetary policy measures. However, they find no evidence that these reductions are passed through to the interest margin or to customer interest rates. Hristov et al. (2014) also obtain a distorted policy rate pass-through for the euro area countries after the financial crisis and attribute it to increased distress in the banking sector. The effect of negative interest rates in the euro area on banks' risk-taking behavior has been recently analyzed by Heider et al. (2017). These

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<sup>3</sup> Key studies of the transmission of monetary policy via the bank lending/ credit channel in normal times include, amongst others, Bernanke and Gertler (1995) and Kashyap and Stein (2000).

authors find that banks with a higher deposit share are more inclined to provide loans to riskier borrowers after the introduction of negative deposit policy rates. One reason behind this finding may be that banks are reluctant to shift negative deposit rates to their depositors. This is in line with the reasoning by Arseneau (2017) who shows for the US that banks expect a decline in profits in a low interest rate environment. We focus specifically on the effect of a declining deposit facility rate on banks' balance sheet management depending on the distribution of the net interest margin.

Given liquidity strains in the interbank market or a lack of solvent counterparties, banks might park liquidity as reserves at the central bank. For example, Nyborg and Östberg (2014) draw a connection between the interbank market situation and the volume of liquid stocks. They show that tighter conditions in interbank markets lead banks to "pull-back" liquidity by selling (less liquid) financial assets, thus increasing the volume of (highly) liquid assets. For the German banking system, Podlich et al. (2016) find that following the Lehman collapse, banks shifted to highly liquid assets, which can easily be converted into central bank liquidity. Thus, reserve holdings at the central bank can be part of banks' liquidity management during crisis times. Cornett et al. (2011) analyze US banks' liquidity management during the recent financial crisis. They find that banks with more illiquid asset portfolios increased their liquid assets while they decreased their lending. Stable funding sources supported lending by banks. We draw on this literature and take into account that the effectiveness of monetary policy is likely to depend on how heterogeneous banks manage their (overall) liquidity.

The paper proceeds as follows. Section 2 describes institutional details and the development of banks' holdings of central bank reserves. In Section 3, we provide an overview of our sample and data, and we also present descriptive statistics. Section 4 presents the empirical model used to analyze the effect of the ECB's deposit facility rate on bank reserves and resultant portfolio reallocations. We discuss the findings and their implications, and we conduct robustness tests. The final section concludes.

## **2. Central Bank Reserves**

In this section, we describe the regulatory setting and changes in monetary policy that drive the evolution of bank reserves held at the central bank. In the pre-crisis period, banks' reserve holdings have approximately matched mandatory reserves. Also for the US, Kroeger et al. (2017) find evidence for a "reserve-scarcity regime" before the crisis. This has changed since the start of the financial crisis and for our research question, it is important that banks not only hold mandatory reserves but also make active use of excess reserves as part of their overall liquidity management. Thus, the increase in reserves, as shown in Figure 1, should not be due to an increase in mandatory reserves but rather due to the evolution of excess reserves. The following arguments support this hypothesis.

From an institutional point of view, it is important to know that bank reserves can be placed in the *current account* and the *deposit facility* at the national central bank. The current account covers *mandatory reserves* but can also hold voluntary reserves.<sup>4</sup> The deposit facility covers only *voluntary reserves*, in contrast to the current account. Figure 1 shows the aggregated holdings of euro area banks in the current account and the deposit facility relative to the total assets of the monetary financial institutions (MFIs) of the euro area. Conventional policy tools that matter for reserve holdings are the reserve requirements and the deposit facility rate set by the ECB. Figure 2 provides a timeline that marks key changes in these monetary policy instruments.

[Insert Figure 2 here]

For the time period before 2012, we can reasonably assume that excess reserves had been held (preferably) at the deposit facility because its yield, the deposit facility rate, was higher than the yield on excess reserves at the current account, which does not bear any interest. Therefore, we can approximately differentiate between mandatory and excess reserves. Mandatory reserves should equal current account holdings, whereas excess reserves should be reflected by deposit facility holdings. Thus, from Figure 1, we can infer that the current account holdings, which have been rather constant – as depicted by the black part of the bars – reflect the mandatory reserves to be held under the constant reserve requirements ratio of two percent. In contrast, reserve holdings in the deposit facility, as depicted by the grey part of the bars, represent the bulk of excess reserves and fluctuate considerably over time.

In 2012, two events changed the set up. First, the *reserve ratio* was halved from two percent to one percent in January 2012. This becomes visible in the drop in reserves held in the current account, as depicted by the black bars in Figure 1. The reduction in the reserve ratio and therefore the (relative) reduction in mandatory reserves shows that the ECB seems to attribute considerable importance to the amount of bank reserves, even though such reserves only make up a small fraction compared to the total assets of the euro area's financial sector. Despite this reduction, the time period has been characterized by a strong increase in the total amount of reserves relative to total assets.

Second, the *deposit facility rate* was reduced to zero percent in July 2012. Due to this second event, it is no longer possible to differentiate easily between mandatory and excess reserves by simply considering the two accounts. The reason is that the deposit facility lost its favorable yield over the current account. Nevertheless, this is no longer crucial for our research because we know with certainty that regardless of the account in which banks place their voluntary reserves, they earn the same interest. Before the ECB reduced the deposit

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<sup>4</sup> Mandatory reserves apply to the following items: overnight deposits, deposits with agreed maturity up to 2 years, deposits redeemable at notice up to 2 years, debt securities issued with agreed maturity up to 2 years, and money market paper; see: [https://www.ecb.europa.eu/press/pr/date/1998/html/pr981013\\_3.en.html](https://www.ecb.europa.eu/press/pr/date/1998/html/pr981013_3.en.html)

facility rate even further in 2014, the equal yield of the two accounts became contractual. The yield of excess reserves on the current account was formally equal to the deposit facility rate, which formalized the uniform yield of bank reserves on the two accounts.<sup>5</sup>

The economic significance of reserves becomes clear when considering the costs that reserves created in recent years for the euro area banking system. Since 2013, banks have not earned any additional interest on their excess reserves. Since 2014, reserves within the euro area have created interest expenses, which amounted to approximately 68 million euro in 2014, 784 million euro in 2015 and 2.68 billion euro in 2016.<sup>6</sup> While these numbers might be small with respect to the overall banking system, it is reasonable that each individual bank wants to minimize its share of these costs.

The underlying reasons for the increase in bank reserves are fundamental changes in the liquidity-providing factors of the euro system. Specifically, the switch to the full allotment mechanism for the main refinancing operations, the introduction of longer-term refinancing operations as well as the asset purchase programs and the easing of collateral requirements have led to a massive supply of liquidity by the central bank. Garcia de Andoain et al. (2016) show that central bank liquidity has replaced the demand for liquidity in the interbank market, whose dysfunctionality is visible in the development of the Euro Overnight Index Average (EONIA).

Figure 3 shows the evolution of the ECB's policy rates since 2005. In addition to the deposit facility rate, the lending facility rate (which is the lending counterpart of the deposit facility rate) and the main refinancing rate are also shown. In addition to the three policy rates of the ECB, the EONIA, which is the rate at which banks can borrow money overnight in the interbank market, is depicted. Prior to the financial crisis, the EONIA fluctuated around the main refinancing rate. However, for the past eight years, the EONIA has moved closer to the deposit facility rate. Hence, Figure 3 shows that the ECB has implicitly switched from a standard "interest rate corridor system" to a "floor operating system".

[Insert Figure 3 here]

This development does not necessarily mean that banks are now able to refinance themselves at a much lower rate in interbank markets. Rather, it is the result of a structural change in the allocation of liquidity within the euro area. Prior to the financial crisis, system-wide liquidity was reallocated via the interbank market, with the ECB injecting only limited amounts of liquidity. Interbank lending rates varied within the interest rate corridor of the deposit facility rate and the lending facility rate and have been close to the main refinancing rate. Since the

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<sup>5</sup> [https://www.ecb.europa.eu/ecb/legal/pdf/oj\\_jol\\_2014\\_168\\_r\\_0015\\_en\\_txt.pdf](https://www.ecb.europa.eu/ecb/legal/pdf/oj_jol_2014_168_r_0015_en_txt.pdf); DECISION OF THE EUROPEAN CENTRAL BANK of 5 June 2014 on the remuneration of deposits, balances and holdings of excess reserves (ECB/2014/23) (2014/337/EU).

<sup>6</sup> Calculations are based on period averages of daily positions.

introduction of the full allotment policy in October 2008, banks have been able to receive large quantities of liquidity directly from the ECB's open market operations and at the main refinancing rate. Hence, banks that have enough collateral to obtain liquidity from interbank markets have no incentive to pay interest rates higher than the main refinancing rate. This exerts downward pressure on interbank rates. In contrast, banks with insufficient collateral can only obtain liquidity from interbank markets at very high rates. Hence, those banks are likely to make use of less costly central bank liquidity with no effective consequences for interbank rates. The closeness of the EONIA and the deposit facility rate shows that the interbank market is frequented only by very selected, highly secure banks. In contrast, banks that are considered less secure due to, for example, their locations in peripheral euro area countries, apply directly to the ECB.

From a macroeconomic perspective, the amount of liquidity within the euro system is fixed and is mostly determined by the monetary policy operations of the ECB.<sup>7</sup> Despite our interest in microeconomic developments, there is also macroeconomic evidence that liquidity is reallocated among euro area countries and therefore also among banks. The Bruegel database of Eurosystem lending operations developed by Pisani-Ferry and Wolff (2012) provides evidence that for banks in some countries, the demand for liquidity provided by the ECB via main and longer-term refinancing operations has changed considerably over time (Figure 4). Banks in countries such as Germany and Luxembourg, which easily attract liquidity through the interbank market, have reduced their demand for central bank liquidity, while banks in the GIIPS<sup>8</sup> countries have increased their demand considerably.

[Insert Figure 4 here]

In sum, three main observations can be made. First, the pattern depicted in Figure 1 indicates that banks' (excess) reserves have increased significantly in recent years. Importantly, this holds in spite of the simultaneously declining deposit facility rate and the decrease in mandatory reserve requirements. Second, changes in the policy tools used to steer bank reserves reflect that the ECB considers them as relevant monetary policy instruments. The deposit facility rate can be considered the yield paid on excess reserves and therefore constitutes the main instrument by which the ECB can affect the excess reserves' volume. Third, the liquidity needs of banks prevail in peripheral euro area countries, as reflected by the divergent use of central bank liquidity. In combination with the malfunctioning of the interbank market, this implies that the increase in bank reserves stems mainly from banks in liquidity-rich countries. This might have implications for the effectiveness of monetary policy transmission in peripheral versus core euro area countries.

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<sup>7</sup> Keister and McAndrews (2009) give a very good explanation on this for the US case.

<sup>8</sup> Greece, Ireland, Italy, Portugal, Spain

### 3. Data

Our analysis is based on bank-level data from Bankscope and covers 17 euro area countries.<sup>9</sup> We only include countries with a common monetary policy because this reduces the distorting effects resulting from different central bank policies. We consider the period from 2009 to 2014 at a yearly frequency. This time span is chosen for various reasons. First, a fundamental change in the set up of the main refinancing operation occurred in 2008, when the ECB changed to the fixed-rate, full allotment policy. Second, our main variable of interest, bank reserves, show reasonable coverage from 2009 onward.<sup>10</sup>

#### 3.1. Bank-Level Data

The bank-level data are taken from Bankscope. Our baseline sample is determined by those banks in the euro area for which we obtain information on central bank reserves. This produces a sample of larger banks that have, on average, lower net interest margins. Regarding our research question, this should work against us in the empirical analysis. The reason is that larger banks have, on average, a less interest-sensitive business model because they are less dependent on interest-bearing activities. As a consequence, these banks should be affected by the ECB's interest rate setting to a minor extent.

We control for outliers by adjusting the sample along the following dimensions. We only keep banks whose specialization type is indicated as bank holding company, commercial bank, cooperative bank or savings bank. We control for unreasonable observations by dropping bank observations with missing assets, zero assets or zero equity. We also drop implausible values for key ratios, for example, if the loan to asset ratio is larger than one. Finally, all bank-level variables are winsorized at the one-percent level. Summary statistics can be found in Table 1.

[Insert Table 1 here]

#### Dependent variable

To analyze the direct effect of the ECB's interest rate policy on banks' portfolio positions, we define our first dependent variable as the change in bank reserves at the central bank relative to assets as of the preceding period.

- (i) **Bank reserves:** Bank reserves are a position on the asset side of the balance sheet. They can be subdivided into mandatory and excess reserves, which are either held at the deposit facility of the ECB or in the current account of the national central

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<sup>9</sup> Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia and Spain. Latvia and Lithuania are excluded because they joined the euro area only recently.

<sup>10</sup> See the data appendix for a description of all variables used and their sources.

banks. From Bankscope, we only obtain the composite position. However, given that mandatory reserves are determined by regulation, banks can only actively manage excess reserves if we plausibly assume that the funding side is relatively stable over time. Hence, excess reserves should be the main component affected by the deposit facility rate.

This assumption is supported by the aggregate data of the ECB, which indicate that mandatory reserves do not fluctuate much over time but are rather determined by the regulatory reserve ratio, which defines how many reserves banks have to hold (Figure 1). Knowing that mandatory reserves equal the reserve ratio times banks' deposits, we implicitly control for the level of mandatory reserves by including banks' deposits to assets ratio in our empirical analysis.

A further advantage is that the regulatory reserve ratio remains constant over a long period of time. One exception is the reduction in the reserve ratio in 2012 from two to one percent. We control for this change in the following regression analysis. Figure 5 shows that despite this decline in the reserve ratio, the average share of reserves for the banks in our sample has remained stable.

[Insert Figure 5 here]

If banks respond to the ECB's policy rate and change their reserve holdings, the immediate question is to which other asset position this freed liquidity is allocated. Hence, if we find significant and direct effects of the deposit facility rate on bank reserves, we extend our analysis to consider the (indirect) impact on further portfolio positions, which are crucial for the transmission of monetary policy. The studied portfolio positions include (ii) liquid assets (excluding reserves) and (iii) total loans.<sup>11</sup> These positions are of interest for the following reasons:

- (ii) **Liquid assets:** Bank reserves are a subcomponent of the position "liquid assets" and can even be considered to be the most liquid assets a bank can hold. Therefore, a natural response to lowering yields on reserves might be to switch to other liquid asset positions. Hence, we analyze the effect of the ECB's policy on liquid assets, excluding reserves, to test whether banks switch from reserves to other liquid assets. This would impede the transmission of the ECB's monetary policy because freed liquidity is not reallocated to loans.
- (iii) **Total loans:** In addition to testing whether banks switch to unwanted portfolio alternatives – liquid assets, we also consider the portfolio position the ECB wants to indirectly affect with its policy interventions, that is, bank loans. By considering

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<sup>11</sup> To obtain a complete picture, we also examine the growth of banks' total assets. In doing so, we want to check whether changes in the different portfolio positions are due to a portfolio rebalancing or to a change in the balance sheet total. The results can be found in the [Web Appendix](#).

the indirect effect of the deposit facility rate on the change in loans relative to the balance sheet total of the preceding period, we test whether the traditional lending channel of monetary policy works.

### Explanatory variables

We expect that banks are differently affected by changes in the deposit facility rate depending on the reliance of their business model on traditional lending and deposit-taking activities (Arseneau (2017), Borio et al. (2015), Busch and Memmel (2015), Claessens et al. (2016), Gambacorta and Marqués-Ibáñez (2011), Genay and Podjasek (2014)). Banks with a more traditional business model, or, in other words, banks that are more reliant on the traditional lending business and funded by traditional retail depositors, should be more sensitive to changes in interest rates. The reason is that the net interest income, that is the difference between interest income and interest expenses, is, to a larger extent, affected by changes in policy rates given a higher reliance on interest-bearing activities. As a consequence, declining interest rates can depress banks' profits via the net interest margin. Hence, the interest-sensitivity of banks' business models is approximated by the *net interest margin*, defined as net interest income relative to average earning assets (in percent).<sup>12</sup>

From Figure 6a, it can be observed that the average net interest margin has been relatively constant over the sample period, with slight evidence of a downward trend. This reflects that changes in banks' business models occur at rather low frequency. To visualize key patterns in the net interest margin and to compare it with other relevant bank characteristics, we define two groups of banks. To do so, we take the sample average of the net interest margin and define a dummy variable that takes a value of one for banks with a net interest margin higher than the sample average, and zero otherwise. This dummy variable thus differentiates between banks with a strong reliance on an interest-sensitive business model and those banks that depend less on interest income and expenses. The rather stable pattern of the net interest margin can also be observed within these two groups of banks (Figure 6b).

[Insert Figure 6 here]

In Section 4.1, we provide a detailed explanation of the net interest margin as a proxy for the stance of the business model. However, a first visual inspection already shows that the dummy variable indicating whether a bank has a more interest-sensitive business model correlates well with other variables that relate to banks' business models. Figure 7 depicts the average amount of a) total assets, b) the net interest income share, c) the deposit share, and d) the loan share over time, differentiating between banks with a high (on average) net interest margin and banks for which the dummy variable as defined above equals zero.

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<sup>12</sup> In robustness tests, we use the loan share as an alternative proxy for banks' business models.

[Insert Figure 7 here]

It can be observed that banks that are, on average, more dependent on interest-generating activities captured by a higher net interest margin are – on average – smaller, have a higher share of net interest income in total income, are – to a larger extent – financed by deposits and are more involved in the traditional lending business. In line with these observations, banks with a more interest-sensitive business model also differ regarding the composition of their portfolios, as seen in Figure 8. In particular, these banks show a larger share of loans to total assets. In contrast, banks with an average lower net interest margin tend to have a higher share of liquid assets on their balance sheets.

[Insert Figure 8 here]

We add further explanatory variables that control for a bank's reliance on deposit funding, calculated as the deposits to total assets ratio, and for a bank's size, measured as the log of total assets. Additionally, we control for bank capitalization by including the equity to assets ratio, and we control for profitability captured by the return on assets ratio. Similar to Figure 7, the correlations in Table 2 show that larger banks seem to have a lower net interest margin. Furthermore, the change in one of the subcomponents of banks' portfolios correlate positively with the change in the total balance sheet scaled by total assets in the previous period.

[Insert Table 2 here]

### **3.2. Country-Level Data**

To evaluate the effects of the ECB's conventional monetary policy, we collect data on key policy rates as provided by the ECB. Our main variable of interest is the deposit facility rate. The pattern of the deposit facility rate becomes visible in Figure 3, and it can be observed that the policy rate is actively managed by the ECB. This suggests that the ECB considers the deposit facility rate to be a relevant monetary policy instrument even when unconventional monetary policy instruments are used.

The relevance of the deposit facility rate is also mentioned by the Financial Times (2016), which states that “The deposit rate charged on bank reserves parked in the coffers of the ECB has, along with quantitative easing, become one of the most important pillars of Eurozone monetary policy.” In addition, lowering the deposit facility rate closely follows the policy applied by the Danish central bank, with the important difference that the ECB offers fewer possibilities to evade the negative deposit facility rate when holding reserves. For example, the Danish central bank did not exert penalty rates on the current account.<sup>13</sup> We complement

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<sup>13</sup> See e.g., <http://bruegel.org/2014/06/negative-deposit-rates-the-danish-experience/>

the data set by adding the main refinancing rate because it tends to be changed simultaneously with the deposit facility rate and might also affect banks' balance sheet decisions.<sup>14</sup>

Since the financial crisis, the ECB has not only applied conventional monetary policy, it has also extended its set of policy measures. Thus, to control for unconventional monetary policy, we include the share of ECB-funded bank liabilities to total assets. The share of ECB funded bank liabilities captures all loans granted by the European System of Central Banks (ESCB) relative to the total liabilities of a country's monetary financial institutions (MFIs). The total liabilities do not cover capital, reserves or remaining liabilities, and the MFIs do not include the ESCB itself or money market funds.<sup>15</sup> Given that we only have euro area banks in our sample, which obtain central bank credit from the ECB via their national central banks, this variable proxies ECB-funded bank liabilities. By including the share of ECB funded bank liabilities, we control for the country-specific effects of unconventional monetary policy measures of the ECB, such as the switch to the fixed rate full allotment policy or changes in collateral requirements. Both measures led to an increase in liquidity access for euro area banks and, therefore, might have had an influence on how banks allocate their funds.

Furthermore, we add the 10-year government bond yield to our data set. The change in the government bond yield is considered to control for the effects of the extensive securities markets programs or public sector purchase programs of the ECB. When the ECB, including the national central banks, buys extensive amounts of government bonds, banks are affected in two ways. First, the value of the government bonds increases due to the additional demand. This leads to an increase in the price of government bonds already held by banks. Acharya et al. (2016) describe this development after the announcement of the Outright Monetary Transactions (OMT) program as backdoor recapitalization, which applies especially to GIIPS countries. However, the second way in which the public sector purchase programs affect banks is by decreasing the yield of government bonds. This makes them less interesting for future investment and might induce banks to reallocate their portfolios. Figure 9 shows that these proxy variables for unconventional monetary policy not only vary substantially over time but also across country groups when comparing the average pattern of GIIPS countries to the remaining sample countries.

[Insert Figure 9 here]

We include further macro controls, such as GDP growth and inflation, taken from the International Financial Statistics of the IMF and stock market data obtained from Datastream.

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<sup>14</sup> The policy rates are included in the regression analysis as first difference. To aggregate policy rates to the yearly frequency, we calculate weighted averages, whereas the weights are based on the fraction of days for which a rate has been set.

<sup>15</sup> Source: <http://sdw.ecb.europa.eu/reports.do?node=1000003383>.

Summary statistics are provided in Table 1. A correlation table of the country-level variables can be found in Table 3.

[Insert Table 3 here]

#### 4. Empirical Analysis

This section contains the empirical analysis of the effect of the deposit facility rate on banks' balance sheet decisions depending on their net interest margin. We first present the empirical model. This is followed by the description of results and various robustness tests.

##### 4.1. Regression Model

To analyze the influence of the deposit facility rate on banks' balance sheet decisions, we use a panel regression model similar to Cornett et al. (2011):

$$\begin{aligned} \frac{\Delta \text{Balance Sheet Position}_{ijt}}{\text{Total Assets}_{ijt-1}} &= v_i + v_t + \alpha_1 \Delta \text{DFR}_t \times \text{NIM}_{ijt-1} + \alpha_2 \text{Bank Controls}_{ijt-1} \\ &+ \alpha_3 \text{Country Controls}_{jt} + \varepsilon_{ijt} \end{aligned} \quad (1)$$

The empirical model measures the change in the balance sheet position ( $\Delta \text{Balance Sheet Position}_{ijt}$ ) of bank  $i$  in country  $j$  from period  $t-1$  to period  $t$  relative to the overall size of the balance sheet in period  $t-1$  ( $\text{Total Assets}_{ijt-1}$ ). The way in which the dependent variable is constructed proxies how the respective position on banks' balance sheets changes relative to the overall size of the balance sheet. By that, we want to measure how banks adapt their portfolio choices, scaled by total assets, in response to changes in the deposit facility rate.<sup>16</sup> Our immediate interest is in the change in bank reserves.<sup>17</sup>

Once we find that banks adapt their reserves at the central bank significantly due to changes in the deposit facility rate, we analyze whether they rebalance their portfolios toward alternative balance sheet positions, such as loans or liquid assets. Lowering the deposit facility rate would have the intended effect if banks reduced reserves and increased loan supply. However, this policy can also be ineffective for various reasons. Given depressed margins in a low interest rate environment, banks might increase lending rates, with negative effects on loan demand. In contrast, if competition in the banking sector forces banks to pass lower rates on to borrowers, banks might seek alternative investment opportunities or income

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<sup>16</sup> Schandlbauer (2016) uses the same approach to define the dependent variable to evaluate effects of tax changes on banks' capital structure.

<sup>17</sup> Regardless of the choice of the dependent variable, we base all regressions on the sample of banks for which we have data on bank reserves.

sources. This can result in a reallocation of reserves into more profitable liquid assets instead of loans.<sup>18</sup>

To identify the influence of the ECB's deposit facility rate, we exploit that the effect of the deposit facility rate is likely to be heterogeneous across banks. Therefore, the empirical model includes an interaction term of the change in the deposit facility rate ( $\Delta DFR_t$ ) with the bank-specific net interest margin ( $NIM_{ijt-1}$ ). The net interest margin captures whether a bank has a stronger focus on interest-bearing activities and is thus more sensitive to changes in interest rates, as explained in the following paragraph. The coefficient  $\alpha_1$  reflects banks' sensitivity to changes in the deposit facility rate depending on the net interest margin. Hence, similar to Cornett et al. (2011), our interest is not in the aggregate effects of changes in the deposit facility rate but in the responsiveness across banks. To reduce simultaneity concerns, we introduce the net interest margin lagged by one period. Furthermore, the ECB's policy can be assumed to be exogenous from the perspective of the individual bank, that is, the probability that the reserve holdings of a single bank drive the ECB interest rate policy should be negligible.

The interpretation of the net interest margin as a proxy for banks' business models is supported by Lepetit et al. (2008), who find that banks with a higher income share in commissions and fees have smaller net interest rate margins. Furthermore, Nguyen (2012) accounts for potential endogeneity between non-interest income and net interest margin and also finds a significant negative relationship between both variables. In addition, central banks, regulators, and academics have recently emphasized the role of the net interest margin in the context of the current low interest rate policy (Claessens et al. 2016).<sup>19</sup>

The hypothesis that banks with a more traditional and thus interest-sensitive business model are more concerned about the low interest rate policy can be traced back to Samuelson (1945), who argues that bank performance is affected by continuously declining interest rates because lending rates are more elastic than deposit rates. This is even more true if banks are faced with interest rates being at the zero lower bound or even reaching into negative territory. As such, Dombret et al. (2017) emphasize that low policy rates can place substantial pressure on German banks due to their focus on interest income. Thus, the net interest margin should not only proxy the extent to which banks generate profits out of interest-bearing activities, it should also cause differential responses to the ECB's interest rate policy.

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<sup>18</sup> To account for simultaneity among balance sheet positions, we check the robustness of our results by estimating 3SLS regressions in Section 4.4.

<sup>19</sup> <http://www.faz.net/aktuell/finanzen/meine-finanzen/sparen-und-geld-anlegen/abhaengigkeit-von-zinserstraegen-aufseher-erhoehen-den-druck-auf-die-banken-14291634.htm>  
<https://www.federalreserve.gov/econresdata/notes/ifdp-notes/2016/low-for-long-interest-rates-and-net-interest-margins-of-banks-in-advanced-foreign-economies-20160411.html>

Heterogeneity in the net interest margin is a common finding. For example, Demirgüç-Kunt et al. (2010) find that fee income-generating activities are more common for larger banks. This is also supported by our sample. For example, Figure 7a shows the banks in our sample sorted into two groups conditional on the net interest margin being above or below the sample average. Banks with a net interest margin higher than the sample average are considerably smaller than banks with net interest margins below the sample average. Similarly, Kasman et al. (2010) find a negative relationship between the net interest margin and bank size, which holds for subsamples of old and new EU member states.

Banks' balance sheet decisions can also be affected by other bank-specific characteristics. Thus, we control for key bank-specific features,  $Bank\ Controls_{ijt-1}$ , by including the deposits to asset ratio, the size of assets (in logs), the equity to assets ratio, as well as the return on assets ratio and the net interest margin. To reduce simultaneity concerns, the bank-specific controls are lagged by one period.

Furthermore, the macroeconomic environment at the country level can influence bank behavior. To account for this, we add country-specific control variables ( $Country\ Controls_{jt}$ ) that include the growth rate of GDP and the inflation rate. To control for simultaneous changes in policy rates other than the deposit facility rate, the change in the main refinancing rate is included. The main refinancing rate is preferred over the lending counterparty of the deposit facility (the marginal lending facility) because the main refinancing operations are the most frequent (conventional) source of liquidity provision in the euro area. We include this lending rate to monitor the effects of changes in lending rates and to control for potential effects of changes in the spread between the two policy rates. Including both rates separately has the advantage that we can identify the effects for each of the two rates while accounting for the correlation between the deposit facility and main refinancing rate. This is essential because we do not know whether the effects of the two rates cancel out or whether banks react differently to equally large changes in the rates. Most importantly, this approach allows analyzing the effect of our main variable of interest, namely the deposit facility rate.

We extend our baseline model with different variables capturing the ECB's unconventional monetary policy. In the spirit of Bremus and Fratzscher (2015), we use the share of loans granted by the ESCB to MFIs<sup>20</sup> relative to total liabilities<sup>21</sup> to capture country-specific effects of unconventional monetary policy interventions by the ECB. Taking into account the asset purchase programs of the ECB, we employ the change in the yield of government bonds as an alternative measure of unconventional monetary policy. By controlling for effects of unconventional monetary policy, we also check for supply effects in line with the theory of Cukierman (2016) concerning the source of bank reserves. The study traces changes in

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<sup>20</sup> Excluding ESCB and Money Market Funds.

<sup>21</sup> Total liabilities exclude capital and reserves as well as remaining liabilities.

aggregate bank reserves of the euro area back to individual operations under the ECB's unconventional monetary policy. In robustness tests, we add further variables to control for stock market developments and demand-side effects in credit markets.

Finally, by adding the fixed effects ( $v_i$  and  $v_t$ ), we extract any confounding factors embedded in time invariant bank characteristics or stemming from common macroeconomic shocks and time trends in the euro area.

## 4.2. Regression Results

The results of our baseline model with *bank reserves* as the dependent variable are shown in Table 4. Banks' decisions to hold liquidity in the form of reserves at the central bank respond positively (negatively) to positive (negative) changes in the deposit facility rate. The effect is heterogeneous along the distribution of the net interest margin, that is, banks with a higher net interest margin are more sensitive to changes in the deposit facility rate. This is in line with the hypothesis that banks with an interest-sensitive business model should be hit more severely by – and thus be more responsive to – the low interest rate policy of the ECB. Consequently, this result complements existing literature on unconventional monetary policy showing that effects are heterogeneous depending on banks' liquidity and balance sheet management (see, e.g., Acharya et al. (2016)). A noteworthy feature is that the heterogeneous effects seem unsurprising in the context of unconventional monetary policies, as those policies can be differentially applied across banks. In contrast, monetary policy rates, such as the deposit facility rate, apply uniformly to all banks, and our result shows that this policy instrument effectively targets some banks more than others. This is in line with the finding of Heider et al. (2017), who focus on the introduction of negative deposit rates and find that banks with a higher deposit ratio are reluctant to pass negative rates to depositors and instead increase their risk-taking to compensate for the funding cost shock.

[Insert Table 4 here]

The result holds while controlling for bank-specific features and macro developments (Column (1)), adding alternative measures for monetary policy such as the government bond yields (Column (2)) or the share of ECB-funded liabilities (Column (3)). In Column (4), we control for the change in the reserve ratio in 2012 by including an interaction between the deposit ratio and a dummy variable that takes a value of one for the period 2012-2014 and zero otherwise. Finally, we limit the sample to the period 2012-2014 to check whether the financial crisis period is driving our results. Furthermore, this serves as an additional robustness check to test whether our results solely emerge due to the change in the reserve ratio in January 2012. Based on the size of the coefficient in Column (1), we can assess the economic significance of the effect. For the bank with a one-standard-deviation higher net interest margin (1.4), the effect of the change in the deposit facility rate on the dependent

variable is higher by approximately 1.2 percentage points. This differential effect can be considered economically meaningful, as it amounts to approximately 41% of the standard deviation of the dependent variable (2.8).

Because we control for time fixed effects, the deposit facility rate cannot be included individually. To evaluate whether the effect of changes in the deposit facility rate goes in a reasonable direction, we rerun the regression model as described for Table 4 excluding time fixed effects but including the change in the deposit facility rate as such. In Figure 10, we depict the marginal effect of a change in the deposit facility rate conditional on banks' net interest margin. The result seems plausible because an increase in the deposit facility rate has a positive effect on banks' reserve holdings; this effect increases and turns statistically significant for banks with a higher net interest margin. This implies that, following a positive increase in the deposit facility rate, banks with a more interest-sensitive business model are more likely to increase their reserves, which then obtain a higher remuneration. Vice versa, if the ECB lowers the deposit facility rate, this is likely to reduce banks' incentives to hold reserves.<sup>22</sup> The effect is economically significant for banks relying on an interest-sensitive business model: For instance, for a bank with a net interest margin of 8 percent, a one percentage point lower deposit facility rate is associated with a reduction in the dependent variable – ranging from about -18 to 18 percent – by 6.52 percentage points.

[Insert Figure 10 here]

Given that banks change their reserve holdings as a response to changes in the deposit facility rate and conditional on the business model, we are interested into which asset positions this freed liquidity is reallocated. Banks might provide more loans, which would reflect successful monetary transmission. In light of depressed margins that lead banks to increase lending rates, reduced loan demand might counteract these increased incentives to provide loans. However, according to Claessens et al. (2016), there is less evidence of shifting negative rates to depositors, as well as less evidence of banks aligning lending rates with declining policy rates due to competitive pressure. If banks cannot shift declines in interest margins to traditional customers, they might invest in more profitable and liquid assets other than loans. This, in turn, can increase risk in the financial system, for example by fueling asset price bubbles.

Therefore, we repeat the calculations wherein the dependent variable now represents other balance sheet positions such as liquid assets (Table 5) and loans (Table 6).<sup>23</sup> In contrast to reserves, we find that changes in the deposit facility rate do not significantly influence banks' sensitivity regarding their decisions to hold *liquid assets*. The sign of the coefficient of the interaction term between the change in the deposit facility rate and the net interest margin is

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<sup>22</sup> For brevity, the underlying regression table is not included but can be obtained upon request.

<sup>23</sup> The results for *total assets* can be found in the [Web Appendix](#).

positive, and thus it is the same like in the regression with reserves as the dependent variable. This implies that banks with a more interest-sensitive business model do not significantly reallocate more liquidity to liquid assets in response to a change in the deposit facility rate and compared to banks with a business model that relies less on interest-bearing activities. Hence, from this point of view, we do not find significant evidence that monetary policy transmission is impeded.

[Insert Table 5 here]

In the regression with *loans* as the dependent variable, it stands out that the interaction of the deposit share with the dummy reflecting the time span with the reduced reserve ratio is positive and significant (Table 6, Column (4)). This suggests that a reduction in the reserve ratio had favorable effects on the loan supply for banks with a higher deposit share, meaning those banks with relatively higher mandatory reserves before the change in the reserve ratio. The interaction term of the change in the deposit facility rate and the net interest margin shows a negative and significant coefficient for *loans* as the dependent variable. This suggests that banks with a more interest-sensitive business model tend to decrease (increase) their loan supply by more given an increase (decrease) in the deposit facility rate and compared to banks with a lower net interest margin. This finding suggests that a reduction in the deposit facility rate can eventually translate into changes in loan supply by banks. This supports the notion that, in principle, a conventional instrument such as the deposit facility rate can effectively foster monetary policy transmission – even during times when unconventional measures are used. However, our results show that the effect is heterogeneous across banks. The way in which a reduction in the deposit facility rate translates into higher loan supply in the aggregate therefore critically depends on the structure of the banking system and, in particular, on the extent to which banks rely on an interest-sensitive business model.

[Insert Table 6 here]

### 4.3. Robustness Tests

We conduct several robustness tests for our baseline model (corresponding to Column (1) of Tables 4-6) with reserves (Table 7), liquid assets (Table 8), and loans (Table 9) as the dependent variables. Column (1) of Tables 7-9 again shows the baseline model. In Column (2), the interest rates are interacted with a bank's average net interest margin over the sample period 2009-2014 instead of the continuous version of the variable.<sup>24</sup> This helps reduce concerns that our results are solely driven by declining net interest margins over the sample

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<sup>24</sup> We also replace the net interest margin with the loan share as an alternative proxy for the reliance on interest-generating business activities. These results can be found in the [Web Appendix](#). We prefer to use the net interest margin as a proxy for the business model because it is a more general measure that is not directly derived from one of the dependent variables.

period. For example, Claessens et al. (2017) show that low policy rates reduce net interest margins as interest expenses decline less than interest income.

Market fragmentation in the euro area, mirrored, for example, by diverging risk premium across countries, has recently been a key concern of policymakers. This might result in differential access to liquidity. For example, Abbassi et al. (2014) find that with the sovereign debt crisis, banks located in peripheral countries face more difficulties accessing liquidity in interbank markets. To test for heterogeneities across euro area countries, Column (3) shows the results for the baseline model excluding the GIIPS countries. Columns (4) and (5) include stock market returns and volatilities as additional country-level controls. The former variable can be taken as a proxy for alternative opportunities to realize returns outside the loan market. The latter variable is a proxy for the degree of uncertainty in the economy, whereas higher uncertainty can reduce banks' propensity to provide credit (Buch et al. (2015)). In Column (6), we alternate the definition of our dependent variable such that the change in the balance sheet position is scaled by total assets of the *current* period.

The results of these robustness tests for the regressions with the change in *bank reserves* relative to total assets of the preceding period are reported in Table 7. The results are robust across all specifications. Interestingly, banks with a more interest-sensitive business model show a higher sensitivity to changes in the deposit facility rate for the sample excluding the GIIPS countries (Column (3)). In contrast, unreported regressions show that the effect vanishes for a sample of GIIPS countries only. Various reasons may be driving this result. From a statistical point of view, the sample of GIIPS countries contains a lower number of observations, resulting in too little variation. This might explain the lack of significance for the sample of GIIPS countries. From an economic point of view, market fragmentation, in particular the divergence of borrowing costs across countries and differences in liquidity needs, might be an explanation for the increasing magnitude of the coefficient for the (more homogeneous) sample of non-GIIPS countries.

[Insert Table 7 here]

In particular, banks in GIIPS countries might suffer from weak fundamentals that reduce their scope of access to interbank markets and reduce their flexibility to adjust to the ECB's monetary policy. Thus, banks in non-GIIPS countries will behave differently than banks in GIIPS countries with regard to their liquidity demand and reserve holdings. While the former deposit excess reserves at the central bank, the latter fulfill their liquidity needs by borrowing from the central bank. The central bank is preferred over the interbank market because funding is provided at lower costs than in the interbank market, which discriminates across countries and demands a risk premium. Hence, it is not surprising that the significant effect on

reserves is driven by non-GIIPS countries given that banks in those countries are much more likely to hold reserves and are thus affected by the interest paid on this asset position.<sup>25</sup>

Regarding *liquid assets* as the dependent variable, we obtain robust results regarding sign and significance of the coefficient of the interaction term (Table 8). Additionally, the significant result for the change in *loans* scaled by total assets of the previous period is retained for the alternative specifications (Table 9). Again, the coefficient size is highest for the sample excluding the GIIPS countries. This suggests that effects are mainly driven by banks in countries that are affected by the recent financial and sovereign debt crisis only to a minor extent and adds another dimension of heterogeneity with respect to the transmission channel of monetary policy. Similar results are found by Al-Eyd and Berkmen (2013), showing that monetary policy transmission does not work in stressed countries of the euro area.

[Insert Tables 8-9 here]

Finally, we conduct further robustness checks for the regressions with *loans* as the dependent variable. Assuming that banks are not identical in their net interest margins, the set-up of our regression model separates demand from supply side effects by making use of heterogeneous responses of banks to changes in the deposit facility rate along the distribution of the net interest margin. To further rule out that demand-side effects drive our result in the loan regression, in Table 10, we include several variables to extract effects stemming from the demand side. These variables include firms' credit demand (Column (2)) and overall credit standards (Column (3)) from the bank lending survey of the ECB. In Column (4), we control for the borrowing costs of non-financial corporations assuming that higher borrowing costs relate to declines in demand for credit. However, across all specifications, our results remain robust.

[Insert Table 10 here]

The results are also robust to excluding countries showing outlier values regarding banks' net interest margins and the amount of reserves. For example, the variable net interest margins has an overall sample mean of two percent. In contrast, Estonia and Cyprus show yearly averages of over four percent of net interest margin. Regarding reserve holdings, Estonia, Greece and Slovakia show the strongest fluctuations. Thus, we run robustness tests excluding those countries.<sup>26</sup>

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<sup>25</sup> Figure 4 has revealed different uses of central bank liquidity across euro area countries. Figure A1 in the [Web Appendix](#) provides some additional evidence of these differences by showing reserve holdings/ borrowing of domestic MFIs at/ from the national central bank for the cases of Germany and Spain (see also Vari 2016).

<sup>26</sup> For brevity, these regression results are not reported but can be obtained upon request.

#### 4.4. Simultaneous Equations

To account for the simultaneity between the individual balance sheet positions, we repeat the previous calculation by running 3SLS estimations.<sup>27</sup> This estimation strategy controls for the endogeneity of balance sheet positions and the simultaneous correlations of error terms across equations. Given that correlations across equations are taken into account, this yields more efficient estimates than a 2SLS approach. From an economic point of view, we can account for the fact that changes in the deposit facility rate should have a direct effect on banks' reserve holdings, particularly for banks with a more interest-sensitive business model. Indirect effects emerge as soon as banks reallocate freed reserves into other asset side positions. This is mirrored in the set-up of the system of equations:

The first stage regression is equal to equation (1) with *reserves* as the dependent variable, which is instrumented with the interaction term between the change in the deposit facility rate and the net interest margin. In the second stage, the dependent variable is either *loans* or *liquid assets*. In contrast to the baseline model, the interaction term of the deposit facility rate and the net interest margin is no longer included. Instead, the second stage regression controls for the effect of changes in banks' reserve holdings relative to the balance sheet total by including the predicted value of reserves that has been obtained by the first stage regression. The results of these estimations can be found in Table 11.

[Insert Table 11 here]

We conduct the 3SLS estimations for the full sample (Columns (1)-(3)) and for the sample excluding GIIPS countries (Columns (4)-(6)). Column (1) shows the first stage regression with *reserves* as dependent variable for the full sample. As is to be expected, for the first stage regression, the results of the 3SLS estimation are close to the previous results obtained by OLS estimations (Table 4, Column (1)). The interaction term of the change in the deposit facility rate and the net interest margin remains positive and significant. Restricting the sample of banks to non-GIIPS countries, the interaction term gains in significance (Column (4)).<sup>28</sup>

In the second stage estimation, we obtain a negative coefficient of the predicted value of reserves on *loans*. Hence, banks' lending decisions are negatively affected by an increasing share of reserve holdings on banks' balance sheets. Vice versa, this provides evidence for a reallocation of freed reserves into loans and supports our results obtained from OLS estimations. However, the coefficient of the predicted value of reserves is only significant in the subsample (Column (5)). Because the estimation involves three stages, it does not come as

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<sup>27</sup> This estimation method has been applied by, e.g., Elyasiani and Zhang (2015), Horváth (2013) and Shim (2013).

<sup>28</sup> We can not apply overidentification tests to evaluate the validity of the instrument because we have only one instrument for the endogenous variable.

a surprise that the estimates are less precise than in the single equation model of our baseline regressions. Yet, also for the full sample, the coefficient of the predicted value of reserves in Column (2) has a p-value of 0.133.

The fact that results of the simultaneous equation model gain in significance for the sample of non-GIIPS countries seems plausible considering that, in Section 4.3, we have shown that banks in these countries seem to drive the results. From a statistical perspective, this result is supported when looking at the regression fit. The Chi-squared test is highly significant across all dependent variables for the non-GIIPS sample. Additionally, from an economic perspective, the improvement of results are reasonable, as excess reserves are mostly located in non-GIIPS countries, and the reallocation of reserves towards loans is more likely for banks with a positive amount of excess reserves.

## **5. Concluding Remarks**

Since the recent financial crisis, financial markets have been in distress, and the monetary transmission mechanism in the euro area has been impaired. In response, the ECB has implemented various (un-)conventional monetary policy measures. We complement the expanding literature on the effects of unconventional monetary policy by analyzing the effect of a conventional policy instrument, the deposit facility rate, on banks' portfolio management. Our sample spans euro area banks over the period 2009-2014. Lowering the deposit facility rate, as the ECB has done in recent years, should reduce banks' incentives to hold reserves at the central bank due to lower interest earnings. As a consequence, banks can reallocate liquidity into other asset positions, such as loans or liquid assets.

Our results show that, first, banks decrease their reserve holdings when the deposit facility rate is reduced. Importantly, banks with a more interest-sensitive business model, captured by a higher net interest margin, are more responsive to changes in the policy rate. This shows that a common monetary policy can result in different outcomes across countries depending on the characteristics of the banking sector. Second, we find evidence that the deposit facility rate has reallocation effects that can play an important role for the transmission of monetary policy: Banks with a more interest-sensitive business model show a negative (positive) sensitivity to decreasing policy rates regarding changes in the liquid asset (loan) position. Third, effects are most pronounced for the non-GIIPS countries of the euro area. This suggests that conventional monetary policy instruments are more effective in countries that are more stable economically in the aftermath of the sovereign debt crisis compared to the GIIPS countries.

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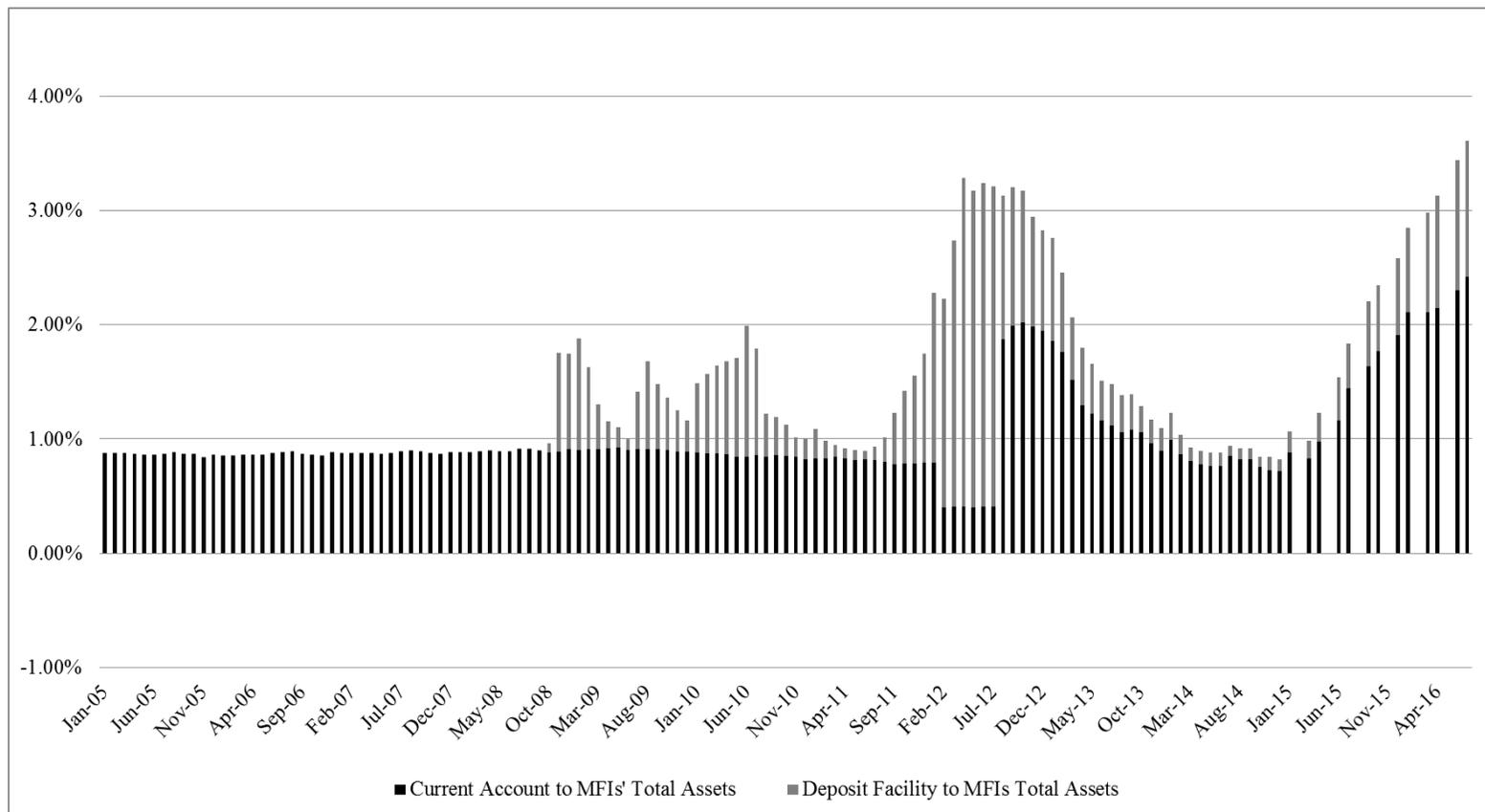
## Data Appendix

Variable	Description	Data Source
<i>Bank-specific variables</i>		
$\Delta$ in Reserves to Total Assets of t-1 (in %)	Change in bank's reserve holdings between period t and t-1 relative to total assets of period t-1	Bankscope
$\Delta$ in Liquid Assets (excl. Reserves) to Total Assets of t-1 (in %)	Change in bank's liquid assets (excl. bank reserves) between period t and t-1 relative to total assets of period t-1	Bankscope
$\Delta$ in Loans to Total Assets of t-1 (in %)	Change in bank's loans between period t and t-1 relative to total assets of period t-1	Bankscope
Growth in Total Assets (in %)	Annual growth of total bank assets	Bankscope
Net Interest Margin (in %)	Net interest income / average earning assets	Bankscope
In Assets	Log of total assets (in million USD)	Bankscope
Deposits to Total Assets (in %)	Bank's total deposits relative to total assets	Bankscope
Equity to Total Assets (in %)	Bank's total equity relative to total assets	Bankscope
Return on Assets (in %)	Operating profit relative to average equity	Bankscope
<i>Country-specific variables</i>		
Inflation (in %)	Annual inflation rate	International Financial Statistics, IMF
GDP Growth (in %)	Annual growth of GDP	International Financial Statistics, IMF
$\Delta$ in 10 Year Government Bond Yield (in percentage points)	First difference of the yield for 10 year government bonds	Main Economic Indicator, OECD
$\Delta$ in Share of ECB Funded Bank Liabilities (in percentage points)	First difference of the ECB funded share of monetary financial institutions' liabilities (excluding reserves, capital and remaining liabilities)	ECB
Stock Returns (in %)	Change in the country's major national stock index	Datastream
Std. Dev. Stock Index	Standard deviation of the country's major national stock index	Datastream
$\Delta$ in Firms Credit Demand (Diffusion index)	First difference of firms overall credit demand for past quarter, annual average, diffusion index whereas positive values correspond to increase in demand	Bank Lending Survey, ECB
$\Delta$ in Overall Credit Standards (Diffusion index)	First difference of overall credit standards to firms for past quarter, annual average, diffusion index whereas positive values correspond to tightening of standards	Bank Lending Survey, ECB
$\Delta$ MFI's Cost of Borrowing for Non Financial Corporations (in percentage points)	First difference of cost of borrowing of new business for non financial corporations	ECB
<i>Euro area rates</i>		
$\Delta$ in Deposit Facility Rate (in percentage points)	First difference of the deposit facility rate, a policy rate of the ECB	ECB
$\Delta$ in Main Refinancing Rate (in percentage points)	First difference of the main refinancing rate, a policy rate of the ECB	ECB
$\Delta$ in ECB Policy Spread = $\Delta$ [MRR - DFR] (in percentage points)	First difference of the spread between main refinancing rate and deposit facility rate	ECB

## Figures and Tables

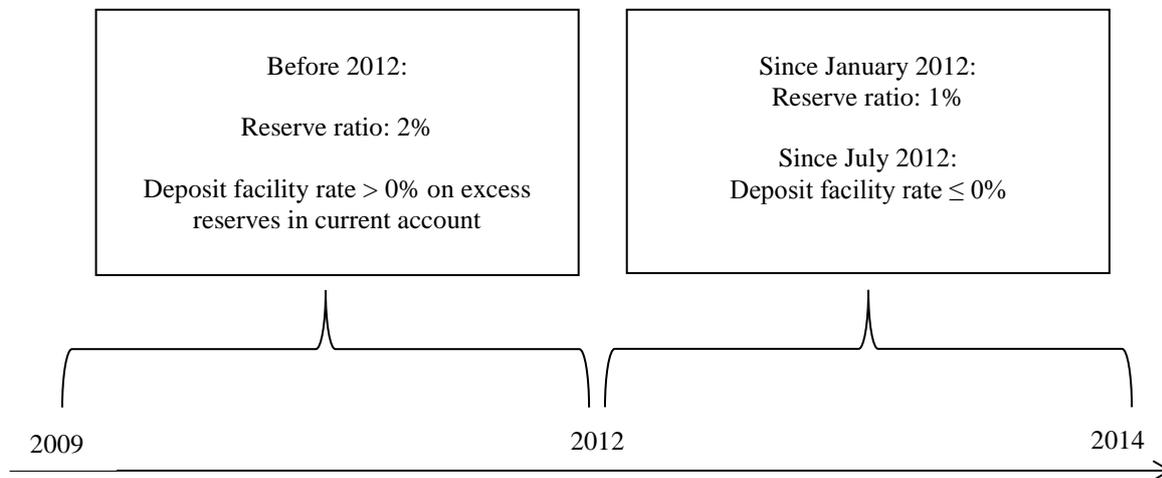
**Figure 1: Bank reserve holdings in the euro area**

This graph shows the evolution of bank reserves of monetary financial institutions (MFIs) in the euro area over the period January 2005 to April 2016. The bank reserves can be decomposed into the current account holdings (depicted in black) and the deposit facility holdings (depicted in grey). The former are located at the national central banks while the latter are administered by the ECB. The graph shows the holdings of the accounts scaled by total assets (in %) of the MFIs in the euro area. *Source: Datastream*



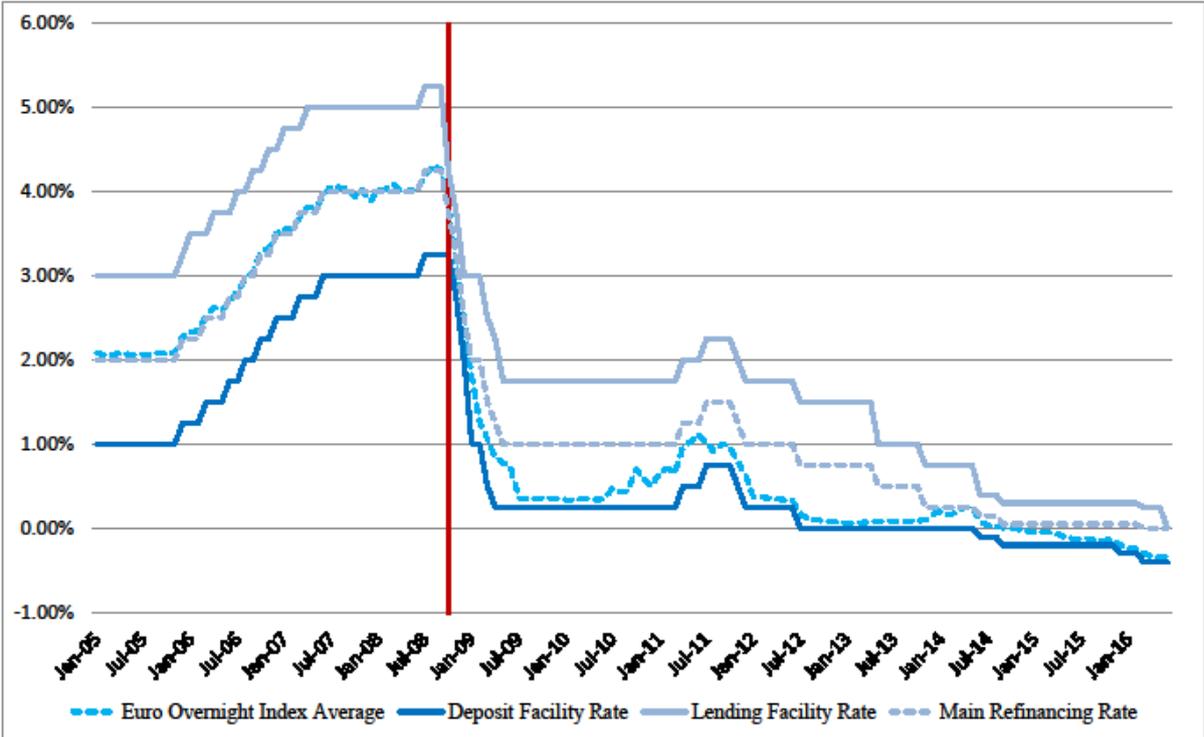
## Figure 2: Time line of the ECB's reserve policy

This graph shows key events regarding changes in the deposit facility rate and reserve requirements set by the ECB during our sample period from 2009 to 2014.



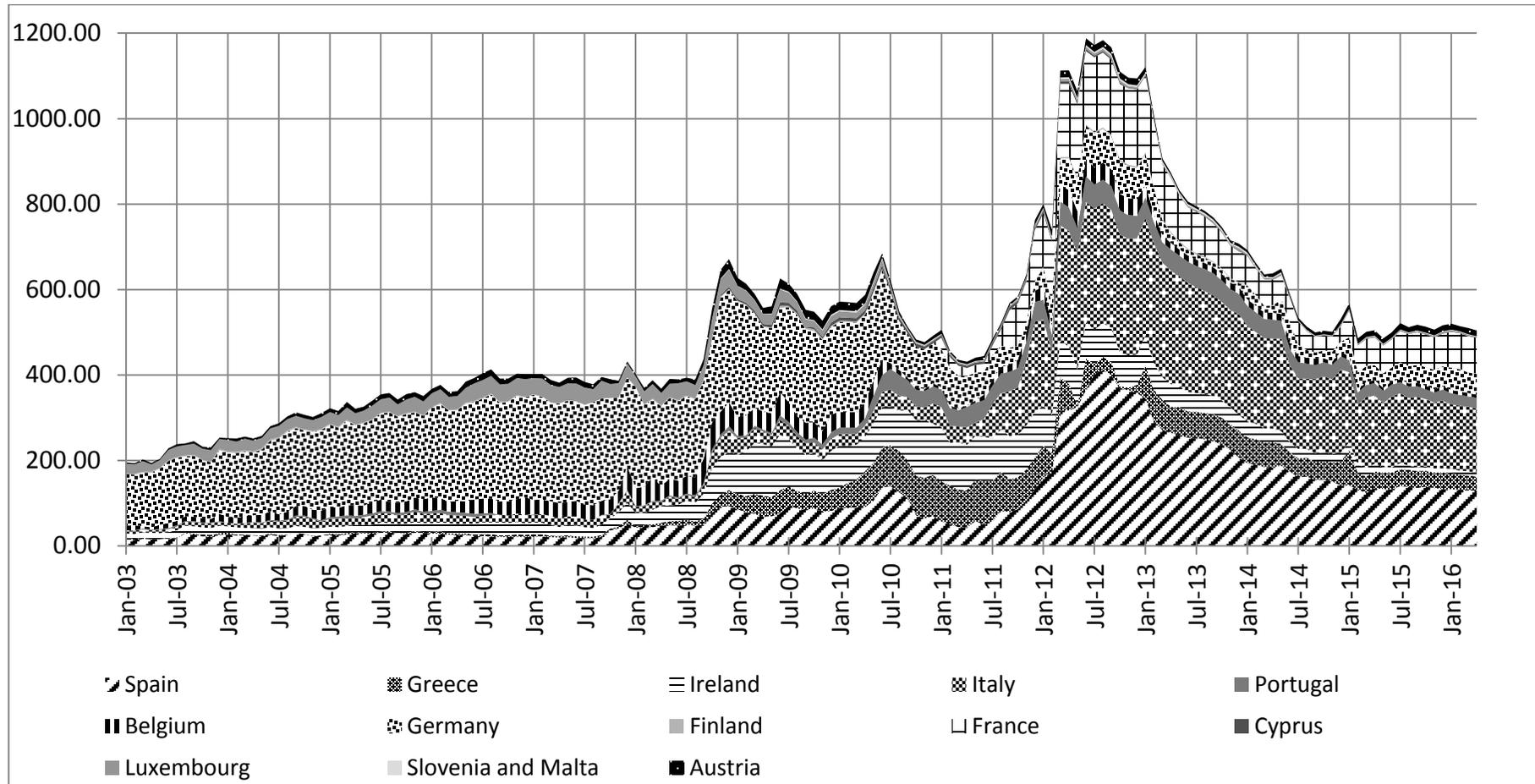
**Figure 3: Key interest rates in the euro area**

This graph shows the evolution of the policy rates (in %) of the ECB over the period from January 2005 to January 2016. The three policy rates include the deposit facility rate (deep blue, solid line), the lending facility rate (light blue, solid line), and the main refinancing rate (light blue, dashed line). The fourth rate displayed in the graph is the Euro Overnight Index Average (EONIA) (turquoise, dashed line). The EONIA is a reference rate for uncollateralized overnight interbank lending. The vertical line marks October 2008, the month when the ECB introduced its fixed full allotment. It also highlights the beginning of a period of continuous decreasing policy rates, which was only interrupted in 2011. *Source: ECB.*



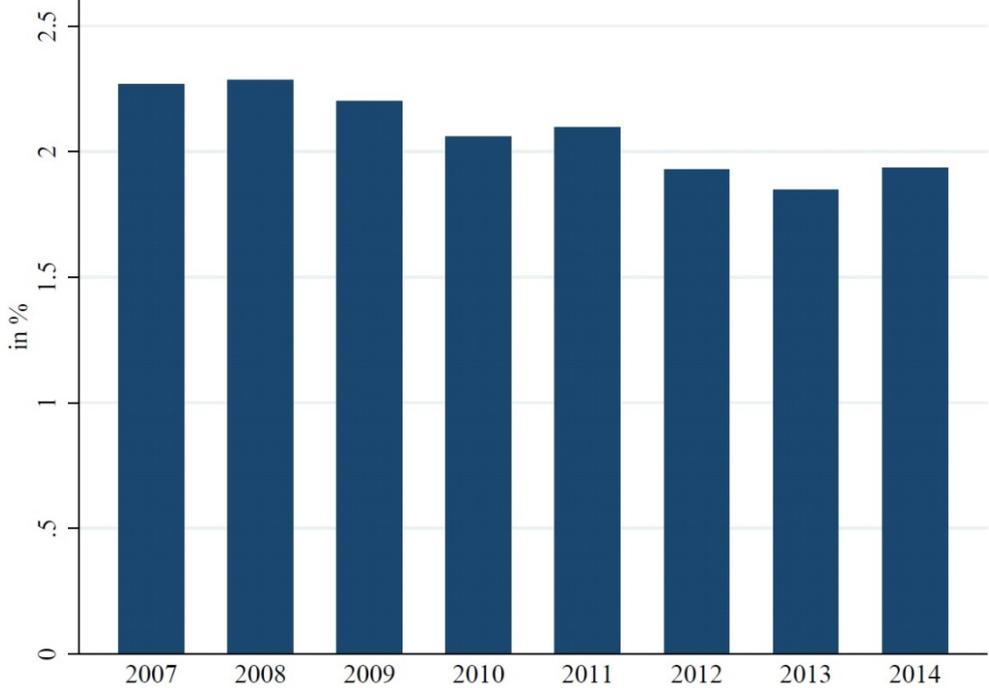
**Figure 4: Usage of euro system main and longer-term refinancing operations**

This graph shows countries' usage of the main refinancing operations and the longer-term refinancing operations in billion Euro for the period from January 2003 to January 2016. Graph and data are taken from the Bruegel database of Eurosystem lending operations as developed in Pisani-Ferry and Wolff (2012).



**Figure 5: Evolution of the average reserve ratio**

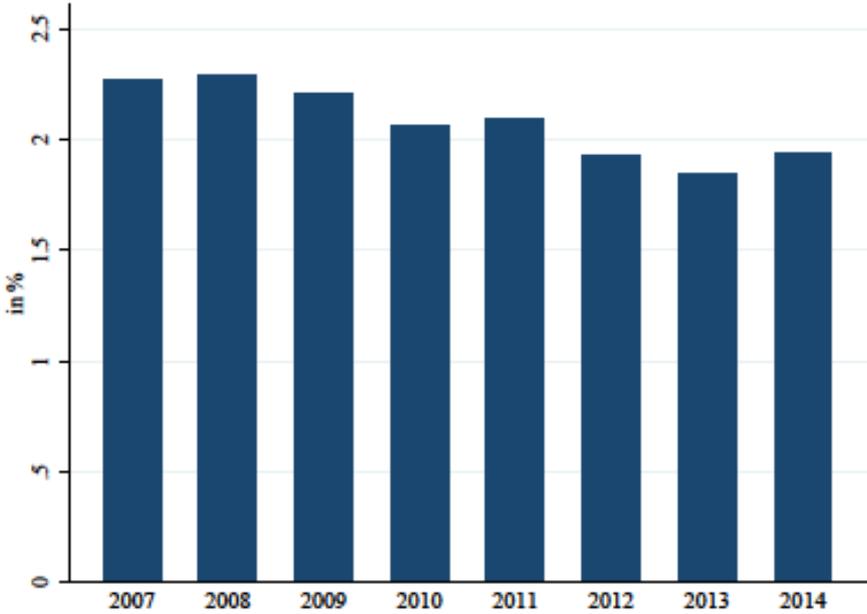
This graph shows the average share of reserves to total assets (in %) of our sample of banks for the period from 2007 to 2014. *Source: Bankscope.*



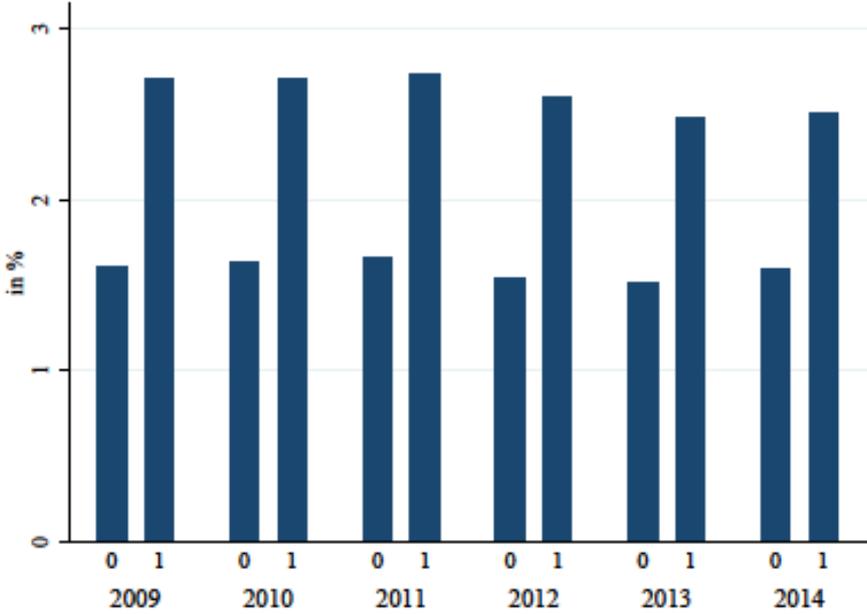
**Figure 6: Net interest margin over time**

This graph shows in panel a) the average net interest margin (NIM) (in %) of our sample of banks for the period from 2007 to 2014. Panel b) shows the average NIM (in %) for our sample period from 2009 to 2014. The sample is decomposed in banks with an average NIM below (0) or equal to/ above (1) the sample mean of the NIM. *Source:* Bankscope.

**a) Average net interest margin**

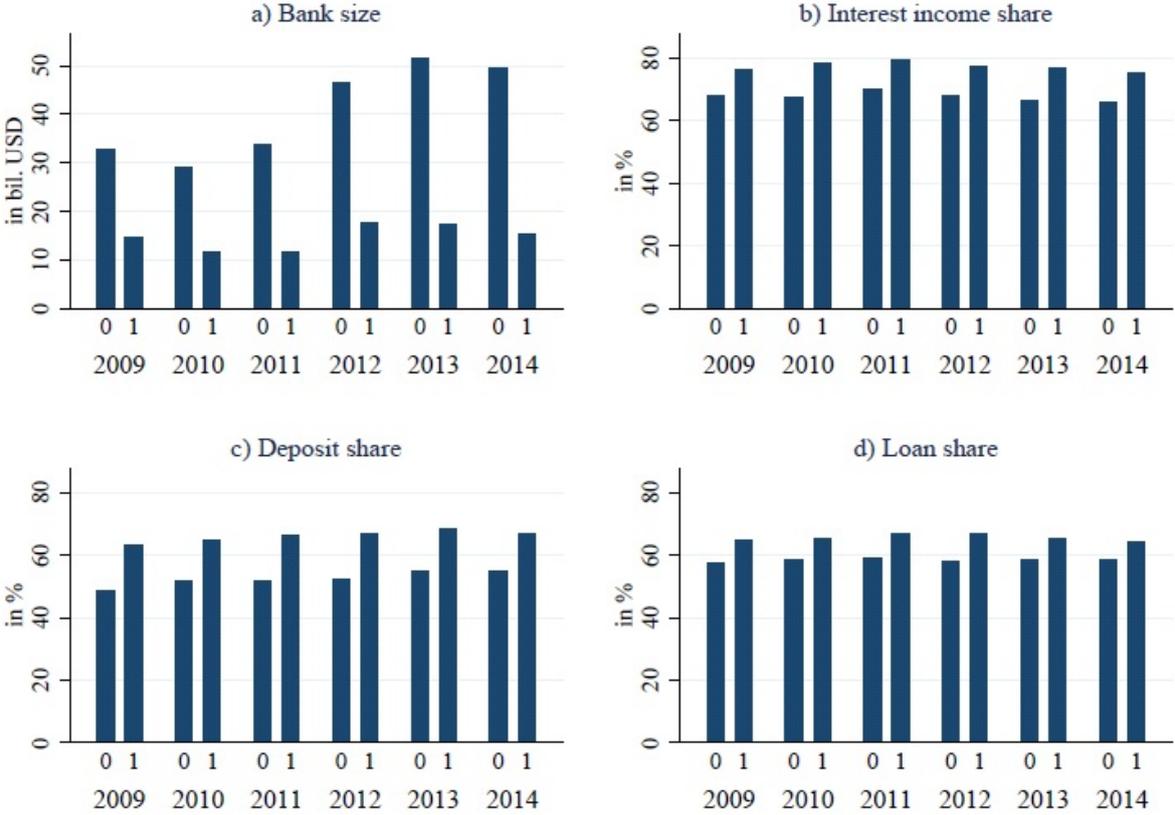


**b) Net interest margin by bank group**



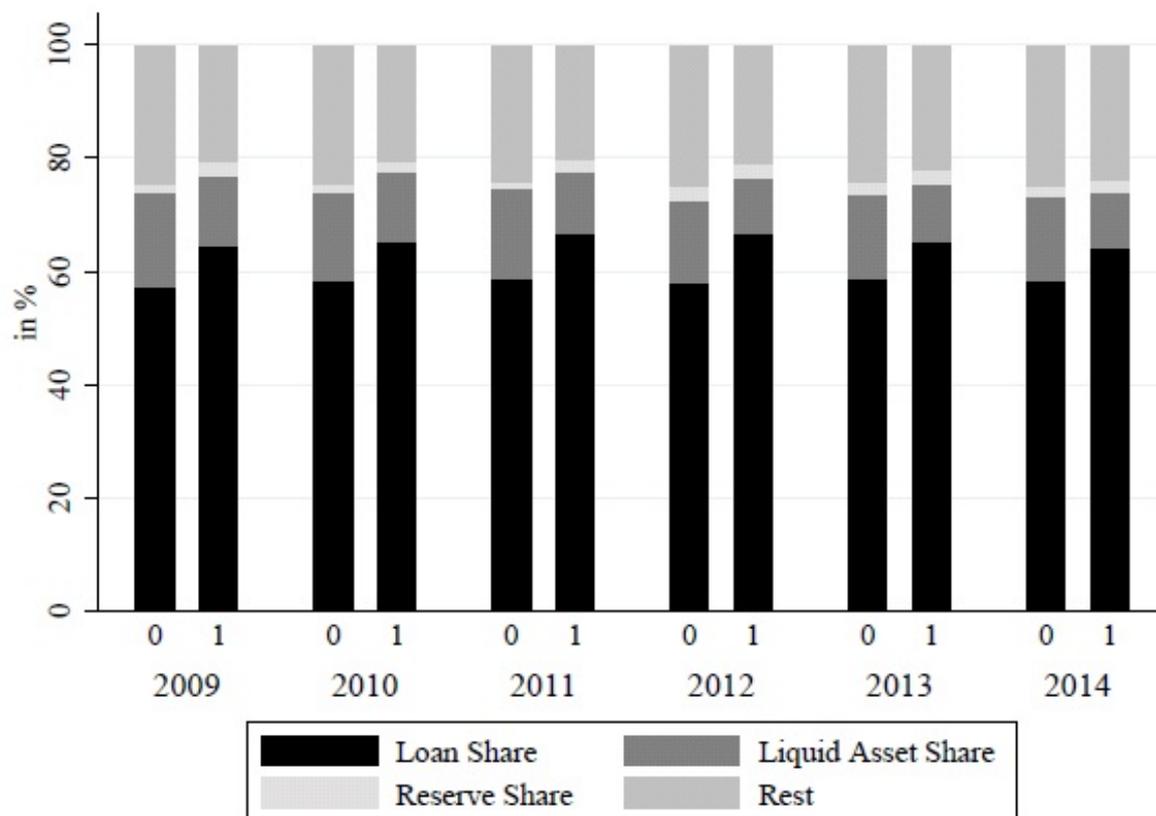
**Figure 7: Heterogeneity of banks by net interest margin**

This graph shows the average amount of a) total assets (in billions of USD), b) net interest income to total net income (i.e. the sum of net interest income, net gains on trading and derivatives, net gains (losses) on other securities, net gains (losses) on assets at FV through income statement, net insurance income, net fees and commissions) (in %), c) share of deposits to total assets (in %), and d) share of loans to total assets (in %) of our sample of banks and the estimation period 2009-2014. The sample is decomposed in banks with an average net interest margin (NIM) below (0) or equal to/ above (1) the sample mean of the interest margin. *Source:* Bankscope.



**Figure 8: Bank portfolio composition by net interest margin**

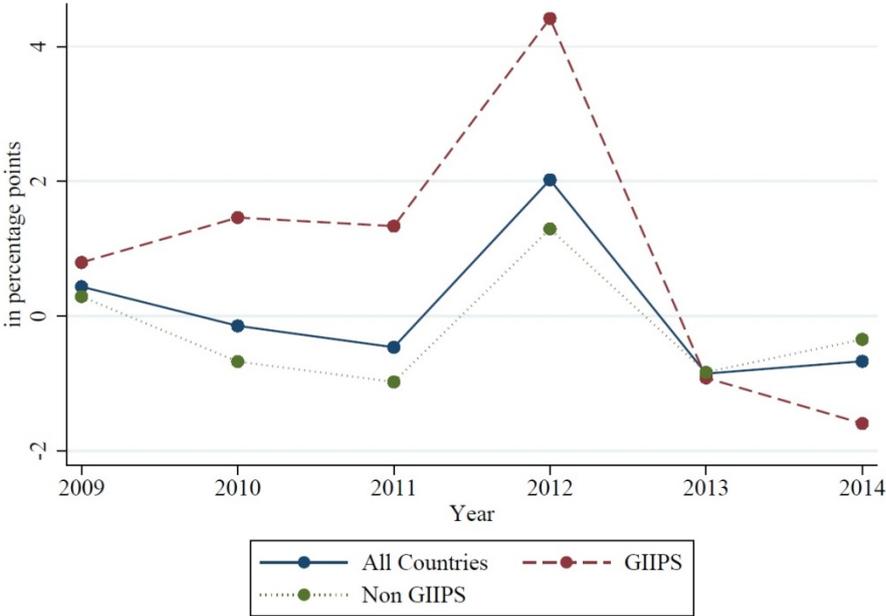
This graph shows the average composition of the balance sheet (in %) of our sample of banks for the period 2007 -2014. The sample is decomposed in banks with an average net interest margin (NIM) below (0) or equal to/ above (1) the sample mean of the interest margin. *Source*: Bankscope.



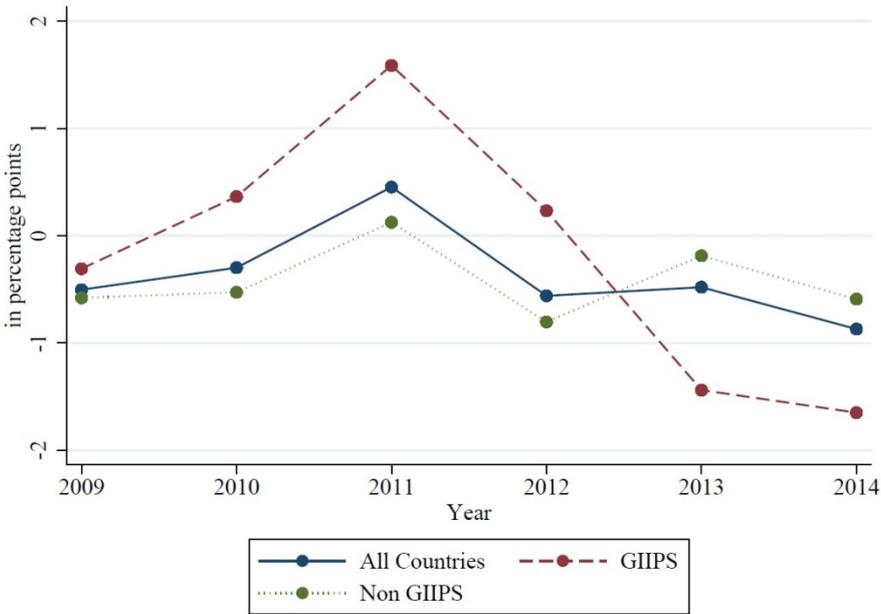
**Figure 9: Controls for unconventional monetary policy**

This graph shows in panel a) the average change in the ECB funded share of monetary financial institutions' liabilities (in percentage points) of our sample of countries for the period from 2009 to 2014. Panel b) shows the average change in government bond yields (in percentage points) for our sample period from 2009 to 2014. We show the average pattern across all sample countries (blue, solid line), GIIPS countries (red, dashed line), and non-GIIPS countries (green, dotted line). *Source:* ECB, Main Economic Indicators, OECD.

**a) Change in the ECB funded share of monetary financial institutions' liabilities**

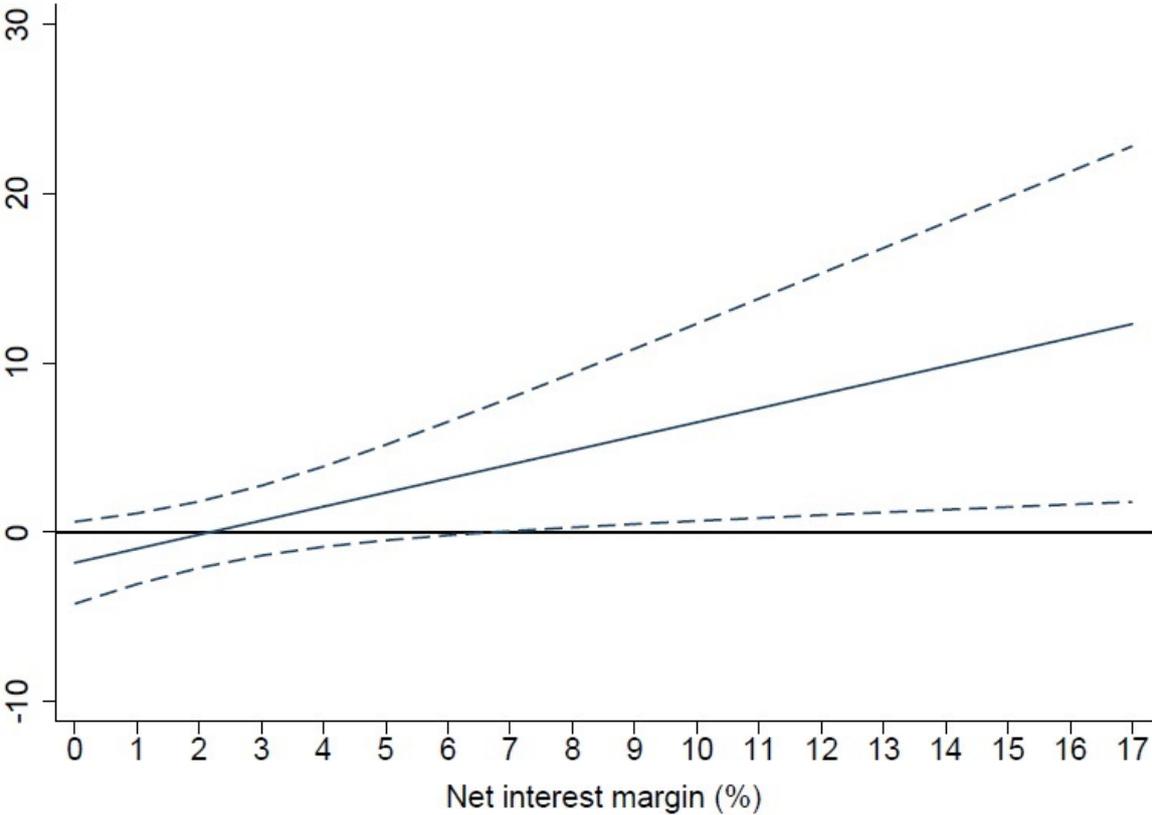


**b) Change in government bond yields**



**Figure 10: Marginal effect of a change in the deposit facility rate**

This graph shows the marginal effect on reserves holdings of the change in the deposit facility rate conditional on a bank's net interest margin (in %). The estimation is based on a sample of euro area banks and the period 2009-2014. The model is specified as in equation (1) with the exception that time fixed effects are excluded and the change in the deposit facility rate as such is included in the regressions. The marginal effect (solid line) is surrounded by 90% confidence bands (dotted lines). *Source:* own calculations.



**Table 1: Summary statistics**

This table shows summary statistics of the bank- and country-level variables used in our analysis. The sample period spans 2009-2014. *Source:* Bankscope, Datastream, IMF, OECD.

<b>Variable</b>	<b>No. of obs.</b>	<b>Mean</b>	<b>Std. dev.</b>	<b>Min</b>	<b>Max</b>
<i>Bank-specific variables</i>					
$\Delta$ in Reserves <sub>t</sub> to Total Assets <sub>t-1</sub> (in %)	1978	-0.01	2.82	-18.42	17.96
$\Delta$ in Liquid Assets <sub>t</sub> (excl. Reserves) to Total Assets <sub>t-1</sub> (in %)	1978	-0.59	6.79	-26.68	29.24
$\Delta$ in Loans <sub>t</sub> to Total Assets <sub>t-1</sub> (in %)	1976	-0.38	7.04	-25.19	33.49
$\Delta$ in Total Assets to Total Assets <sub>t-1</sub> (in %)	1978	-1.54	13.42	-56.71	36.75
Net Interest Margin (in %)	1978	1.99	1.41	0.09	16.35
In Assets	1978	15.91	1.74	9.61	19.69
Deposits to Total Assets (in %)	1977	54.16	23.14	0.49	94.61
Equity to Total Assets (in %)	1978	9.02	6.81	1.48	68.81
Return on Assets (in %)	1978	0.58	1.17	-4.60	8.40
<i>Country-specific variables</i>					
Inflation (in %)	1978	1.51	1.05	-0.94	5.08
GDP Growth (in %)	1978	0.26	2.66	-6.83	7.58
$\Delta$ in Share of ECB Funded Bank Liabilities (in pp)	1959	0.01	1.67	-2.38	5.20
$\Delta$ in 10 Year Government Bond Yield (in pp)	1945	-0.41	0.73	-2.04	2.35
Stock Returns (in %)	1978	6.40	17.75	-55.22	52.30
Std. Dev. Stock Index	1802	516.02	567.11	37.98	3153.44
$\Delta$ in Firms Credit Demand (Index)	1921	2.39	15.60	-31.25	30.00
$\Delta$ in Overall Credit Standards (Index)	1532	-4.85	13.48	-40.00	27.08
$\Delta$ MFI's Cost of Borrowing for Non Financial Corporations (in pp)	1978	-0.42	0.80	-2.59	1.00
<i>Euro area rates</i>					
$\Delta$ in Deposit Facility Rate (in pp)	1978	-0.43	0.83	-2.53	0.25
$\Delta$ in Main Refinancing Rate (in pp)	1978	-0.55	0.82	-2.62	0.25
$\Delta$ in ECB Policy Spread = $\Delta$ [MRR - DFR] (in pp)	1978	-0.12	0.12	-0.31	0.00

**Table 2: Correlation matrix: bank-level variables**

This table shows the correlation matrix for the bank-level variables used in our analysis. The sample period spans 2009-2014. *Source:* Bankscope.

	$\Delta$ in Reserves to Total Assets of t-1 (in %)	$\Delta$ in Liquid Assets (excl. Reserves) to Total Assets of t-1 (in %)	$\Delta$ in Loans to Total Assets of t-1 (in %)	$\Delta$ in Total Assets to Total Assets <sub>t-1</sub> (in %)	Net Interest Margin (in %)	In Assets	Deposits to Total Assets (in %)	Equity / Total Assets (in %)	Return on Assets (in %)
$\Delta$ in Reserves <sub>t</sub> to Total Assets <sub>t-1</sub> (in %)	1.00								
$\Delta$ in Liquid Assets <sub>t</sub> (excl. Reserves) to Total Assets <sub>t-1</sub> (in %)	-0.12	1.00							
$\Delta$ in Loans <sub>t</sub> to Total Assets <sub>t-1</sub> (in %)	0.09	0.03	1.00						
$\Delta$ in Total Assets to Total Assets <sub>t-1</sub> (in %)	0.19	0.53	0.65	1.00					
Net Interest Margin (in %)	0.01	0.05	0.12	0.13	1.00				
In Assets	-0.01	0.02	-0.07	-0.02	-0.29	1.00			
Deposits to Total Assets (in %)	-0.01	0.07	0.12	0.13	0.14	-0.20	1.00		
Equity to Total Assets (in %)	0.00	-0.08	0.04	-0.06	0.28	-0.41	-0.24	1.00	
Return on Assets (in %)	0.04	0.09	0.31	0.28	0.28	-0.02	0.05	0.19	1.00

**Table 3: Correlation matrix: country-level variables**

This table shows the correlation matrix for country-level variables used in our analysis. The sample period spans 2009-2014. *Source:* IMF, OECD, Datastream, ECB.

	Inflation	$\Delta$ GDP	$\Delta$ Share of ECB Funded Bank Liabilities	$\Delta$ 10 Year Government Bond Yields	Stock Returns	Std. Dev. Stock Index	$\Delta$ in Firms Credit Demand	$\Delta$ in Overall Credit Standards	$\Delta$ in MFI's Cost of Borrowing for Non Financial Corporations
Inflation (in %)	1.00								
$\Delta$ GDP (in %)	0.25	1.00							
$\Delta$ Share of ECB Funded Bank Liabilities (in pp)	0.30	-0.40	1.00						
$\Delta$ 10 Year Government Bond Yields (in pp)	0.50	-0.02	0.40	1.00					
Stock Returns (in %)	-0.39	-0.26	-0.05	-0.49	1.00				
Std. Dev. Stock Index	0.08	-0.27	0.13	0.23	-0.14	1.00			
$\Delta$ in Firms Credit Demand (Index)	-0.46	-0.02	-0.36	-0.19	0.03	-0.12	1.00		
$\Delta$ in Overall Credit Standards (Index)	0.44	0.44	0.07	0.13	-0.34	-0.14	-0.30	1.00	
$\Delta$ in MFI's Cost of Borrowing for Non Financial Corporations (in pp)	0.56	0.60	-0.02	0.33	-0.59	-0.10	-0.13	0.58	1.00

**Table 4: Regression result: Reserves**

This table shows regression results obtained from estimating equation (1) for a sample of euro area banks. The estimation period spans 2009-2014. The dependent variable is the change in reserves to assets in the preceding period. Column (1) is our baseline regression, Columns (2)-(3) include controls for the ECB's unconventional monetary policy. Column (4) controls for the change in the reserve ratio in 2012. Column (5) shows results when limiting the sample period to 2012 till 2014. Explanatory variables include bank- and country-level controls. The variables at the bank level are included with a lag. Bank and time fixed effects are included. Standard errors are clustered at the bank level. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% level, respectively.

Explan. Var.\ Dep. Var.	(1)	(2)	(3)	(4)	(5)
	<b><math>\Delta</math> Bank Reserves<sub>t</sub>/Assets<sub>t-1</sub></b>				
$\Delta$ Deposit Facility Rate <sub>t</sub> $\times$ Net Interest Margin <sub>t-1</sub>	0.828** (0.418)	1.683** (0.681)	0.760** (0.376)	0.830** (0.417)	1.505* (0.766)
Net Interest Margin <sub>t-1</sub>	-0.023 (0.111)	0.078 (0.111)	0.010 (0.122)	-0.023 (0.111)	1.491 (1.294)
Deposits to Assets <sub>t-1</sub>	-0.033 (0.023)	-0.037 (0.025)	-0.036 (0.025)	-0.032 (0.024)	0.011 (0.048)
ln Assets <sub>t-1</sub>	-2.702** (1.158)	-2.880** (1.248)	-2.597** (1.262)	-2.699** (1.172)	-2.908 (2.266)
Equity to Assets <sub>t-1</sub>	-0.066* (0.036)	-0.069* (0.038)	-0.060 (0.046)	-0.066* (0.036)	-0.336** (0.158)
Return on Assets <sub>t-1</sub>	-0.140 (0.115)	-0.123 (0.114)	-0.154 (0.123)	-0.140 (0.116)	-0.261 (0.223)
$\Delta$ Main Refinancing Rate <sub>t</sub> $\times$ Net Interest Margin <sub>t-1</sub>	-0.838** (0.401)	-1.680** (0.668)	-0.781** (0.370)	-0.839** (0.400)	3.273 (3.386)
Inflation <sub>t</sub>	0.159 (0.207)	-0.037 (0.230)	0.196 (0.225)	0.160 (0.207)	0.257 (0.538)
GDP Growth <sub>t</sub>	-0.047 (0.065)	-0.069 (0.081)	-0.038 (0.067)	-0.047 (0.065)	-0.097 (0.188)
$\Delta$ 10 Year Government Bond Yield <sub>t</sub> $\times$ Net Interest Margin <sub>t-1</sub>		0.212*** (0.077)			
$\Delta$ 10 Year Government Bond Yield <sub>t</sub>		-0.305 (0.251)			
$\Delta$ Share of ECB Funded Bank Liabilities <sub>t</sub> $\times$ Net Interest Margin <sub>t-1</sub>			-0.039 (0.039)		
$\Delta$ Share of ECB Funded Bank Liabilities <sub>t</sub>			0.050 (0.104)		
Deposits to Assets <sub>t-1</sub> $\times$ Dummy 2012-2014				-0.000 (0.006)	
Constant	44.827** (19.008)	47.643** (20.508)	43.501** (20.833)	44.774** (19.290)	49.443 (36.403)
Bank and Time Fixed Effects	Yes	Yes	Yes	Yes	Yes
Number of Observations	1,978	1,945	1,959	1,978	1,140
R-squared	0.04	0.05	0.04	0.04	0.06
Number of Banks	516	511	515	516	456

**Table 5: Regression result: Liquid assets (excl. reserves)**

This table shows regression results obtained from estimating equation (1) for a sample of euro area banks. The estimation period spans 2009-2014. The dependent variable is the change in liquid assets (excl. reserves) to assets in the preceding period. Column (1) is our baseline regression, Columns (2)-(3) include controls for the ECB's unconventional monetary policy. Column (4) controls for the change in the reserve ratio in 2012. Column (5) shows results when limiting the sample period to 2012 till 2014. Explanatory variables include bank- and country-level controls. The variables at the bank level are included with a lag. Bank and time fixed effects are included. Standard errors are clustered at the bank level. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% level, respectively.

Explan. Var.\ Dep. Var.	(1)	(2)	(3)	(4)	(5)
	<b><math>\Delta</math> Liquid Assets<sub>t</sub>/Assets<sub>t-1</sub></b>				
$\Delta$ Deposit Facility Rate <sub>t</sub> $\times$ Net Interest Margin <sub>t-1</sub>	0.933 (1.407)	0.277 (1.997)	1.123 (1.476)	0.837 (1.395)	1.152 (1.564)
Net Interest Margin <sub>t-1</sub>	0.848*** (0.279)	0.725** (0.300)	0.859*** (0.328)	0.830*** (0.272)	-4.011 (2.851)
Deposits to Assets <sub>t-1</sub>	0.121** (0.060)	0.124** (0.062)	0.060 (0.056)	0.108* (0.060)	0.241*** (0.087)
ln Assets <sub>t-1</sub>	-13.194*** (2.703)	-12.392*** (2.878)	-13.715*** (2.915)	-13.408*** (2.703)	-19.682*** (3.874)
Equity to Assets <sub>t-1</sub>	-0.269* (0.137)	-0.293** (0.133)	-0.331** (0.154)	-0.271** (0.137)	-0.086 (0.135)
Return on Assets <sub>t-1</sub>	0.517** (0.238)	0.445* (0.241)	0.453* (0.242)	0.500** (0.239)	0.424 (0.281)
$\Delta$ Main Refinancing Rate <sub>t</sub> $\times$ Net Interest Margin <sub>t-1</sub>	-1.158 (1.415)	-0.455 (1.990)	-1.239 (1.482)	-1.060 (1.403)	-16.325* (8.519)
Inflation <sub>t</sub>	-0.931** (0.389)	-1.091** (0.430)	-0.945** (0.413)	-0.980** (0.385)	0.054 (0.663)
GDP Growth <sub>t</sub>	-0.086 (0.173)	-0.040 (0.182)	0.045 (0.182)	-0.089 (0.173)	0.270 (0.307)
$\Delta$ 10 Year Government Bond Yield <sub>t</sub> $\times$ Net Interest Margin <sub>t-1</sub>		-0.515** (0.216)			
$\Delta$ 10 Year Government Bond Yield <sub>t</sub>		1.386** (0.642)			
$\Delta$ Share of ECB Funded Bank Liabilities <sub>t</sub> $\times$ Net Interest Margin <sub>t-1</sub>			0.055 (0.098)		
$\Delta$ Share of ECB Funded Bank Liabilities <sub>t</sub>			0.258 (0.325)		
Deposits to Assets <sub>t-1</sub> $\times$ Dummy 2012-2014				0.029 (0.017)	
Constant	200.804*** (43.668)	189.783*** (46.548)	218.330*** (47.455)	204.990*** (43.620)	299.195*** (62.517)
Bank and Time Fixed Effects	Yes	Yes	Yes	Yes	Yes
Number of Observations	1,978	1,945	1,959	1,978	1,140
R-squared	0.12	0.12	0.11	0.12	0.18
Number of Banks	516	511	515	516	456

**Table 6: Regression result: Loans**

This table shows regression results obtained from estimating equation (1) for a sample of euro area banks. The estimation period spans 2009-2014. The dependent variable is the change in loans to assets in the preceding period. Column (1) is our baseline regression, Columns (2)-(3) include controls for the ECB's unconventional monetary policy. Column (4) controls for the change in the reserve ratio in 2012. Column (5) shows results when limiting the sample period to 2012 till 2014. Explanatory variables include bank- and country-level controls. The variables at the bank level are included with a lag. Bank and time fixed effects are included. Standard errors are clustered at the bank level. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% level, respectively.

Explan. Var.\ Dep. Var.	(1)	(2)	(3)	(4)	(5)
	<b><math>\Delta</math> Loans/Assets<sub>t-1</sub></b>				
$\Delta$ Deposit Facility Rate <sub>t</sub> $\times$ Net Interest Margin <sub>t-1</sub>	-2.314*** (0.785)	-2.537** (1.118)	-2.449*** (0.874)	-2.461*** (0.763)	-3.089*** (0.937)
Net Interest Margin <sub>t-1</sub>	0.019 (0.441)	0.091 (0.474)	-0.013 (0.430)	-0.009 (0.424)	5.915*** (1.628)
Deposits to Assets <sub>t-1</sub>	0.071* (0.042)	0.063 (0.044)	0.072 (0.048)	0.050 (0.043)	0.005 (0.054)
ln Assets <sub>t-1</sub>	-2.951* (1.772)	-3.082 (1.887)	-2.412 (1.957)	-3.280* (1.791)	-3.336 (2.433)
Equity to Assets <sub>t-1</sub>	0.203 (0.146)	0.217 (0.150)	0.311* (0.172)	0.198 (0.146)	0.709*** (0.203)
Return on Assets <sub>t-1</sub>	0.421 (0.274)	0.449 (0.277)	0.465* (0.280)	0.395 (0.271)	0.083 (0.233)
$\Delta$ Main Refinancing Rate <sub>t</sub> $\times$ Net Interest Margin <sub>t-1</sub>	2.728*** (0.790)	2.881*** (1.084)	2.830*** (0.855)	2.880*** (0.765)	20.222*** (4.528)
Inflation <sub>t</sub>	0.555 (0.343)	0.484 (0.450)	0.526 (0.386)	0.479 (0.339)	0.110 (0.554)
GDP Growth <sub>t</sub>	0.273* (0.140)	0.134 (0.150)	0.247* (0.149)	0.267* (0.138)	0.461* (0.246)
$\Delta$ 10 Year Government Bond Yield <sub>t</sub> $\times$ Net Interest Margin <sub>t-1</sub>		0.217 (0.158)			
$\Delta$ 10 Year Government Bond Yield <sub>t</sub>		-0.761 (0.474)			
$\Delta$ Share of ECB Funded Bank Liabilities <sub>t</sub> $\times$ Net Interest Margin <sub>t-1</sub>			-0.042 (0.089)		
$\Delta$ Share of ECB Funded Bank Liabilities <sub>t</sub>			-0.067 (0.249)		
Deposits to Assets <sub>t-1</sub> $\times$ Dummy 2012-2014				0.044*** (0.012)	
Constant	48.702* (28.984)	49.929 (30.782)	30.587 (32.452)	55.133* (29.389)	50.087 (39.882)
Bank and Time Fixed Effects	Yes	Yes	Yes	Yes	Yes
Number of Observations	1,976	1,943	1,957	1,976	1,138
R-squared	0.39	0.39	0.39	0.39	0.59
Number of Banks	515	510	514	515	455

**Table 7: Regression result – Robustness: Reserves**

This table shows robustness tests for the baseline specification (Column (1)). In Column (2), the interest rates are interacted with the bank's average net interest margin over the sample period 2009-2014. Column (3) shows results for the baseline model excluding the GIIPS countries. Column (4) and (5) control for stock returns and volatility of the stock market. In Column (6), the change in reserves is scaled by total assets of the current period. The estimation sample covers euro area banks and the period 2009-2014. The dependent variable is the change in reserves to assets in the preceding period. Explanatory variables include bank- and country-level controls. The variables at the bank level are included with a lag. Bank and time fixed effects are included. Standard errors are clustered at the bank level. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% level, respectively.

Explan. Var.\ Dep. Var.	(1)	(2)	(3)	(4)	(5)	(6)
	$\Delta \text{ Bank Reserves}_t / \text{Assets}_{t-1}$					$\Delta \text{ Bank Reserves}_t / \text{Assets}_t$
$\Delta \text{ Deposit Facility Rate}_t \times$						
Net Interest Margin <sub>t-1</sub>	0.828** (0.418)		1.089** (0.493)	0.806* (0.434)	1.075* (0.573)	1.028** (0.478)
Average Net Interest Margin		0.943** (0.470)				
Net Interest Margin <sub>t-1</sub>	-0.023 (0.111)	0.055 (0.111)	0.021 (0.102)	-0.021 (0.111)	0.019 (0.104)	0.019 (0.118)
Deposits to Assets <sub>t-1</sub>	-0.033 (0.023)	-0.033 (0.023)	-0.043 (0.029)	-0.033 (0.023)	-0.022 (0.021)	-0.044* (0.025)
In Assets <sub>t-1</sub>	-2.702** (1.158)	-2.740** (1.163)	-3.137** (1.360)	-2.651** (1.176)	-3.408*** (1.308)	-3.482** (1.425)
Equity to Assets <sub>t-1</sub>	-0.066* (0.036)	-0.068* (0.036)	-0.055 (0.046)	-0.067* (0.035)	-0.080** (0.035)	-0.104** (0.047)
Return on Assets <sub>t-1</sub>	-0.140 (0.115)	-0.137 (0.115)	-0.196 (0.158)	-0.142 (0.116)	-0.037 (0.097)	-0.125 (0.124)
$\Delta \text{ Main Refinancing Rate}_t \times$						
Net Interest Margin <sub>t-1</sub>	-0.838** (0.401)		-1.095** (0.473)	-0.824** (0.414)	-1.102** (0.554)	-1.023** (0.459)
Average Net Interest Margin		-0.933** (0.448)				
Inflation <sub>t</sub>	0.159 (0.207)	0.162 (0.210)	0.273 (0.315)	0.113 (0.226)	0.272 (0.232)	0.103 (0.215)
GDP Growth <sub>t</sub>	-0.047 (0.065)	-0.047 (0.065)	-0.074 (0.086)	-0.028 (0.065)	-0.011 (0.070)	-0.065 (0.073)
Stock Returns <sub>t</sub>				-0.010 (0.010)		
Std. Dev. Stock Index <sub>t</sub>					-0.001*** (0.000)	
Constant	44.827** (19.008)	45.401** (19.099)	52.706** (22.442)	44.320** (19.191)	56.259*** (21.417)	57.869** (23.427)
Bank and Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	1,978	1,978	1,496	1,978	1,802	1,978
R-squared	0.04	0.04	0.05	0.04	0.05	0.05
Number of Banks	516	516	353	516	460	516

**Table 8: Regression result – Robustness: Liquid assets (excl. reserves)**

This table shows robustness tests for the baseline specification (Column (1)). In Column (2), the interest rates are interacted with the bank's average net interest margin of the sample period 2009-2014. Column (3) shows results for the baseline model excluding the GIIPS countries. Column (4) and (5) control for stock returns and volatility of the stock market. In Column (6), the change in liquid assets (excl.reserves) is scaled by total assets of the current period. The estimation sample covers euro area banks and the period 2009-2014. The dependent variable is the change in liquid assets (excl. reserves) to assets in the preceding period. Explanatory variables include bank- and country-level controls. The variables at the bank level are included with a lag. Bank and time fixed effects are included. Standard errors are clustered at the bank level. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% level, respectively.

Explan. Var. \ Dep. Var.	(1)	(2)	(3)	(4)	(5)	(6)
	$\Delta$ Liquid Assets <sub>t</sub> /Assets <sub>t-1</sub>					Liquid Assets <sub>t</sub> /Assets <sub>t</sub>
$\Delta$ Deposit Facility Rate <sub>t</sub> ×						
Net Interest Margin <sub>t-1</sub>	0.933 (1.407)		1.616 (1.465)	0.931 (1.409)	2.960* (1.775)	0.812 (1.472)
Average Net Interest Margin		1.054 (1.496)				
Net Interest Margin <sub>t-1</sub>	0.848*** (0.279)	1.041*** (0.270)	0.692*** (0.250)	0.848*** (0.278)	0.907*** (0.283)	0.868*** (0.305)
Deposits to Assets <sub>t-1</sub>	0.121** (0.060)	0.123** (0.060)	0.182** (0.073)	0.121** (0.060)	0.135** (0.061)	0.158** (0.068)
ln Assets <sub>t-1</sub>	-13.194*** (2.703)	-13.215*** (2.685)	-15.782*** (3.181)	-13.191*** (2.701)	-9.961*** (2.792)	-13.879*** (3.055)
Equity to Assets <sub>t-1</sub>	-0.269* (0.137)	-0.267* (0.138)	-0.134 (0.193)	-0.269* (0.138)	-0.210 (0.129)	-0.353** (0.144)
Return on Assets <sub>t-1</sub>	0.517** (0.238)	0.523** (0.238)	0.642** (0.282)	0.517** (0.238)	0.307 (0.242)	0.595** (0.258)
$\Delta$ Main Refinancing Rate <sub>t</sub> ×						
Net Interest Margin <sub>t-1</sub>	-1.158 (1.415)		-1.806 (1.480)	-1.158 (1.416)	-3.213* (1.817)	-1.103 (1.474)
Average Net Interest Margin		-1.286 (1.518)				
Inflation <sub>t</sub>	-0.931** (0.389)	-0.912** (0.393)	-0.673 (0.519)	-0.934** (0.394)	-0.814* (0.424)	-1.038** (0.422)
GDP Growth <sub>t</sub>	-0.086 (0.173)	-0.074 (0.173)	-0.111 (0.217)	-0.085 (0.182)	-0.133 (0.169)	-0.137 (0.193)
Stock Returns <sub>t</sub>				-0.001 (0.021)		
Std. Dev. Stock Index <sub>t</sub>					-0.002** (0.001)	
Constant	200.804*** (43.668)	200.704*** (43.234)	240.918*** (51.658)	200.774*** (43.649)	148.884*** (44.901)	209.236*** (49.494)
Bank and Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	1,978	1,978	1,496	1,978	1,802	1,978
R-squared	0.12	0.12	0.16	0.12	0.11	0.13
Number of Banks	516	516	353	516	460	516

**Table 9: Regression result – Robustness: Loans**

This table shows robustness tests for the baseline specification (Column (1)). In Column (2), the interest rates are interacted with the bank's average net interest margin of the sample period 2009-2014. Column (3) shows results for the baseline model excluding the GIIPS countries. Column (4) and (5) control for stock returns and volatility of the stock market. In Column (6), the change in loans is scaled by total assets of the current period. The estimation sample covers euro area banks and the period 2009-2014. The dependent variable is the change in loans to assets in the preceding period. Explanatory variables include bank- and country-level controls. The variables at the bank level are included with a lag. Bank and time fixed effects are included. Standard errors are clustered at the bank level. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% level, respectively.

Explan. Var.\ Dep. Var.	(1)	(2)	(3)	(4)	(5)	(6)
	$\Delta \text{ Loans}_t / \text{Assets}_{t-1}$					$\Delta \text{ Loans}_t / \text{Assets}_t$
$\Delta$ Deposit Facility Rate <sub>t</sub> ×						
Net Interest Margin <sub>t-1</sub>	-2.314*** (0.785)		-2.556*** (0.800)	-2.429*** (0.781)	-2.310** (0.926)	-1.833** (0.921)
Average Net Interest Margin		-2.246*** (0.803)				
Net Interest Margin <sub>t-1</sub>	0.019 (0.441)	-0.370 (0.340)	-0.297 (0.277)	0.030 (0.442)	-0.062 (0.399)	0.035 (0.491)
Deposits to Assets <sub>t-1</sub>	0.071* (0.042)	0.064 (0.042)	0.081 (0.051)	0.069 (0.042)	0.069 (0.046)	0.086* (0.049)
In Assets <sub>t-1</sub>	-2.951* (1.772)	-3.125* (1.756)	-2.817 (1.972)	-2.693 (1.774)	-3.408* (1.896)	-1.512 (2.260)
Equity to Assets <sub>t-1</sub>	0.203 (0.146)	0.198 (0.144)	0.101 (0.171)	0.194 (0.147)	0.154 (0.149)	0.193 (0.158)
Return on Assets <sub>t-1</sub>	0.421 (0.274)	0.408 (0.266)	0.408 (0.345)	0.409 (0.271)	0.523* (0.280)	0.582* (0.296)
$\Delta$ Main Refinancing Rate <sub>t</sub> ×						
Net Interest Margin <sub>t-1</sub>	2.728*** (0.790)		2.995*** (0.810)	2.800*** (0.778)	2.740*** (0.938)	2.243** (0.917)
Average Net Interest Margin		2.782*** (0.816)				
Inflation <sub>t</sub>	0.555 (0.343)	0.504 (0.339)	0.483 (0.507)	0.317 (0.361)	0.537 (0.372)	0.482 (0.391)
GDP Growth <sub>t</sub>	0.273* (0.140)	0.254* (0.141)	0.097 (0.152)	0.367** (0.143)	0.204 (0.166)	0.237 (0.162)
Stock Returns <sub>t</sub>				-0.049** (0.023)		
Std. Dev. Stock Index <sub>t</sub>					0.001 (0.001)	
Constant	48.702* (28.984)	53.107* (28.689)	46.928 (32.311)	46.110 (28.916)	55.791* (30.986)	24.165 (37.023)
Bank and Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	1,976	1,976	1,494	1,976	1,800	1,976
R-squared	0.39	0.39	0.39	0.39	0.43	0.36
Number of Banks	515	515	352	515	459	515

**Table 10: Regression result – Further robustness: Loans**

This table shows robustness tests for the baseline specification (Column (1)). In Column (2), firms' credit demand (backward looking) from the ECB Bank Lending Survey (BLS) is controlled for. In Column (3), overall credit standards (backward looking) from the ECB Bank Lending Survey (BLS) are controlled for. Column (4) includes the change in MFI's cost of borrowing for non-financial corporations. The estimation sample covers euro area banks and the period 2009-2014. The dependent variable is the change in loans to assets in the preceding period. Explanatory variables include bank- and country-level controls. The variables at the bank level are included with a lag. Bank and time fixed effects are included. Standard errors are clustered at the bank level. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% level, respectively.

Explan. Var.\ Dep. Var.	(1)	(2)	(3)	(4)
		$\Delta \text{ Loans/Assets}_{t-1}$		
$\Delta \text{ Deposit Facility Rate}_t \times \text{Net Interest Margin}_{t-1}$	-2.314*** (0.785)	-3.612*** (1.125)	-4.625*** (1.396)	-2.314*** (0.787)
Net Interest Margin <sub>t-1</sub>	0.019 (0.441)	-0.132 (0.389)	1.154 (0.823)	0.019 (0.441)
Deposits to Assets <sub>t-1</sub>	0.071* (0.042)	0.031 (0.048)	0.035 (0.049)	0.070* (0.042)
ln Assets <sub>t-1</sub>	-2.951* (1.772)	-2.798 (1.902)	-2.316 (1.952)	-2.950* (1.772)
Equity to Assets <sub>t-1</sub>	0.203 (0.146)	0.258* (0.152)	0.212 (0.167)	0.202 (0.146)
Return on Assets <sub>t-1</sub>	0.421 (0.274)	0.375 (0.287)	0.365 (0.310)	0.420 (0.274)
$\Delta \text{ Main Refinancing Rate}_t \times \text{Net Interest Margin}_{t-1}$	2.728*** (0.790)	3.568*** (1.048)	4.666*** (1.313)	2.725*** (0.789)
Inflation <sub>t</sub>	0.555 (0.343)	0.411 (0.362)	0.841** (0.356)	0.568 (0.411)
GDP Growth <sub>t</sub>	0.273* (0.140)	0.255* (0.150)	0.170 (0.169)	0.271* (0.142)
$\Delta \text{ Firms Credit Demand backward looking (ECB BLS)}_t$		-0.003 (0.011)		
$\Delta \text{ Overall Credit Standards backward looking (ECB BLS)}_t$			0.004 (0.014)	
$\Delta \text{ MFI's Cost of Borrowing for Non Financial Corporations}_t$				-0.063 (0.713)
Constant	48.702* (28.984)	46.144 (31.321)	35.499 (32.003)	48.524* (28.988)
Bank and Time Fixed Effects	Yes	Yes	Yes	Yes
Number of Observations	1,976	1,919	1,530	1,976
R-squared	0.39	0.40	0.37	0.39
Number of Banks	515	505	402	515

**Table 11: Regression result – Simultaneous Equations (3SLS)**

This table shows regression results obtained from estimating the baseline specification (Table 4 to 6, Column (1)) in a set up of simultaneous equations. In Column (1), the estimates of the first stage regression with reserves as dependent variable are shown. Columns (2) and (3) show the estimates for the second stage estimations with loans and liquid assets (excl. reserves) as dependent variables. Hereby, the predicted value for reserves as derived from the first stage regression is included. The estimates for loans and liquid assets are obtained by running two separate 3SLS estimations. While the first three columns cover the whole sample period, Columns (4) to (6) show estimates for the sample of banks from non-GIIPS countries only. The estimation sample covers euro area banks and the period 2009-2014. Explanatory variables include bank- and country-level controls. The variables at the bank level are included with a lag. Bank and time fixed effects are included. Standard errors are clustered at the bank level. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% level, respectively.

Explan. Var.\ Dep. Var.	(1)	(2)	(3)	(4)	(5)	(6)
	<i>Full sample</i>			<i>Non-GIIPS sample</i>		
	$\Delta$ Bank Reserves <sub>t</sub> / Assets <sub>t-1</sub>	$\Delta$ Loans <sub>t</sub> / Assets <sub>t-1</sub>	$\Delta$ Liquid Assets <sub>t</sub> / Assets <sub>t-1</sub>	$\Delta$ Bank Reserves <sub>t</sub> / Assets <sub>t-1</sub>	$\Delta$ Loans <sub>t</sub> / Assets <sub>t-1</sub>	$\Delta$ Liquid Assets <sub>t</sub> / Assets <sub>t-1</sub>
$\Delta$ Deposit Facility Rate <sub>t</sub> $\times$ Net Interest Margin <sub>t-1</sub>	0.743* (0.386)			1.045** (0.434)		
Net Interest Margin <sub>t-1</sub>	-0.011 (0.146)	-0.185 (0.430)	0.603 (0.367)	0.025 (0.164)	-0.339 (0.414)	0.445 (0.457)
Deposits to Assets <sub>t-1</sub>	-0.037*** (0.013)	-0.004 (0.067)	0.135** (0.057)	-0.051*** (0.016)	0.008 (0.063)	0.226*** (0.069)
In Assets <sub>t-1</sub>	-2.718*** (0.567)	-8.937** (4.153)	-10.385*** (3.550)	-3.203*** (0.663)	-8.366** (3.346)	-11.024*** (3.694)
Equity to Assets <sub>t-1</sub>	-0.042 (0.045)	0.114 (0.145)	-0.156 (0.124)	0.005 (0.061)	0.135 (0.153)	0.078 (0.169)
Return on Assets <sub>t-1</sub>	-0.158* (0.083)	0.054 (0.345)	0.590** (0.295)	-0.254** (0.111)	-0.044 (0.380)	0.778* (0.419)
$\Delta$ Main Refinancing Rate <sub>t</sub> $\times$ Net Interest Margin <sub>t-1</sub>	-0.731* (0.382)	0.207 (0.245)	-0.619*** (0.209)	-1.035** (0.429)	0.311 (0.259)	-0.592** (0.286)
Inflation <sub>t</sub>	0.150 (0.143)	1.029** (0.458)	-1.154*** (0.391)	0.258 (0.192)	1.188** (0.520)	-1.123* (0.574)
GDP Growth <sub>t</sub>	-0.046 (0.057)	0.169 (0.186)	-0.070 (0.159)	-0.071 (0.071)	-0.023 (0.195)	-0.012 (0.215)
est( $\Delta$ Bank Reserves <sub>t</sub> / Assets <sub>t-1</sub> )		-2.304 (1.534)	1.016 (1.311)		-1.809* (1.037)	1.529 (1.144)
Constant	50.191*** (10.241)	162.490** (76.422)	168.748*** (65.323)	59.415*** (11.944)	59.415*** (11.944)	174.155** (67.988)
Bank and Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	1,976	1,976	1,976	1,494	1,494	1,494
P-value of chi2-test	0.1300	0.0000	0.0000	0.0195	0.0000	0.0000
Number of Banks	515	515	515	353	353	353

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