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Do conventional monetary policy instruments matter in unconventional times?

Manuel Buchholz
(Deutsche Bundesbank)

Kirsten Schmidt
(Halle Institute for Economic Research (IWH))

Lena Tonzer
(University of Halle and Halle Institute for Economic Research (IWH))

Deutsche Bundesbank, Wilhelm-Epstein-Straße 14, 60431 Frankfurt am Main,
Postfach 10 06 02, 60006 Frankfurt am Main

Tel +49 69 9566-0

Please address all orders in writing to: Deutsche Bundesbank,
Press and Public Relations Division, at the above address or via fax +49 69 9566-3077

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Non-technical summary

Research Question

Since the recent financial and sovereign debt crisis, the euro area has faced continued distress in financial markets and the hampered transmission of monetary policy. To counter these developments, the European Central Bank (ECB) has implemented conventional and unconventional policy measures. This paper studies the effects of a conventional monetary policy instrument, the deposit facility rate, on euro area banks' portfolio management, while taking into account the interest sensitivity of banks' business model. We ask whether lowering the deposit facility rate reduces banks' incentives to hold reserves at the central bank and induces portfolio reallocation.

Contribution

An expanding strand of literature has considered the effects of *unconventional* monetary policy on bank behavior. However, our paper is among the first to assess the effects of a *conventional* policy tool on banks across euro area countries. We focus on the effect of the deposit facility rate on bank reserves and ask whether the reduction in the policy rate has successfully prevented banks from storing liquidity as reserves at the ECB. We test the effectiveness across banks' business models and different countries for the period 2009-2014.

Results

The results suggest that, for banks with a more interest-sensitive business model, declines in the deposit facility rate can succeed in shifting central bank reserves into loans. However, there are limitations to this conventional policy instrument because the results mainly apply to banks that are well-capitalized and located in the non-GIIPS countries. Thus, our findings contribute to the policy debate on the effectiveness of conventional versus unconventional monetary policy across euro area countries.

Nichttechnische Zusammenfassung

Fragestellung

Im Verlauf der globalen Finanzkrise und der europäischen Schuldenkrise kam es an den Finanzmärkten im Euroraum mehrfach zu Phasen erhöhter Anspannung. Dies hat auch die Wirkung geldpolitischer Maßnahmen beeinflusst. Um die ungestörte Transmission der Geldpolitik zu gewährleisten, hat die Europäische Zentralbank (EZB) sowohl auf konventionelle als auch unkonventionelle geldpolitische Maßnahmen zurückgegriffen. Im vorliegenden Forschungspapier wird untersucht, wie eines der konventionellen geldpolitischen Instrumente – der Zinssatz der Einlagefazilität – auf das Portfolio-Management der Banken im Euroraum wirkt. Dabei wird berücksichtigt, inwieweit die Banken über ein zinsabhängiges Geschäftsmodell verfügen. Die zentrale Frage ist, ob ein Absenken des Zinses der Einlagefazilität den Anreiz setzt, dass Banken weniger Reserven bei der Zentralbank halten und ihr Portfolio hin zu anderen Aktiva umschichten.

Beitrag

In einer wachsenden Zahl an Studien wird untersucht, wie *unkonventionelle* Geldpolitik auf das Verhalten von Banken wirkt. Im vorliegenden Forschungspapier wird dagegen betrachtet, wie ein *konventionelles* geldpolitisches Instrument auf Banken in den unterschiedlichen Ländern des Euroraums wirkt. Der Fokus liegt dabei auf der Frage, inwiefern Banken durch ein Absenken des Zinssatzes der Einlagefazilität davon abgehalten werden, Reserven bei der Zentralbank zu halten. Die Analyse berücksichtigt die unterschiedlichen Geschäftsmodelle der Banken und die zugrundeliegende Stichprobe umfasst Banken im Euroraum für den Zeitraum 2009 bis 2014.

Ergebnisse

Die vorliegende Analyse zeigt, dass ein Absenken des Zinssatzes der Einlagefazilität dazu führt, dass besonders Banken mit einem zinsabhängigen Geschäftsmodell ihre Reserven reduzieren und mehr Kredite vergeben. Allerdings beschränkt sich diese Wirkung des Instruments auf diejenigen Banken, die über ausreichend Eigenkapital verfügen und sich nicht in einem der GIIPS-Länder befinden. Die Ergebnisse bieten Ansatzpunkte für die Diskussion zur Wirkung von konventionellen und unkonventionellen geldpolitischen Maßnahmen in den Ländern des Euroraums.

BUNDESBANK DISCUSSION PAPER NO 27/2019

Do Conventional Monetary Policy Instruments Matter in Unconventional Times?[1]

Manuel Buchholz
Deutsche Bundesbank

Kirsten Schmidt
Halle Institute for Economic Research (IWH)

Lena Tonzer
University of Halle, Halle Institute for Economic Research (IWH)

Abstract

This paper investigates how declines in the deposit facility rate set by the ECB affect euro area banks' incentives to hold reserves at the central bank. We find that, in the face of lower deposit rates, banks with a more interest-sensitive business model are more likely to reduce reserve holdings and allocate freed-up liquidity to loans. The result is driven by well-capitalized banks in the non-GIIPS countries of the euro area. This reveals that conventional monetary policy instruments have limited effects in restoring monetary policy transmission during times of crisis.

Keywords: Bank portfolio, central bank reserves, monetary policy

JEL-Classification: E52, G11, G21

[1] Contact address: Manuel Buchholz: Deutsche Bundesbank, Wilhelm-Epstein-Straße 14, 60431 Frankfurt am Main, Germany, E-mail: manuel.buchholz@bundesbank.de. Special thanks go to Thorsten Beck and Isabel Schnabel for their very helpful suggestions. We also thank Jaap Bos, Ralph de Haas, Florian Heider, Deeksha Kale, Konstantin Kiesel, Michael Koetter, Christian Leuz, Thomas Link, Christoph Memmel, Karol Paludkiewicz, Ornella Ricci, Judit Temesvary, Johannes Tischer, Benjamin Weigert, and Andreas Worms for their useful comments. The paper benefited from comments by seminar and conference participants at the Deutsche Bundesbank, the 2018 ASSA annual meeting, the IBEFA meeting in San Diego, the 2017 FINEST conference, the University of Groningen, the Annual Meeting of the German Economic Association, the Halle Institute for Economic Research, the 6th Workshop on Banks and Financial Markets, and the 4th European Conference on Banking and the Economy. Friederike Güttner and Viktoria Samp provided efficient research assistance. All errors and inconsistencies are solely our own responsibility. Discussion Papers represent the authors' personal opinions and do not necessarily reflect the views of the Deutsche Bundesbank.

1. Introduction

Since the recent financial and sovereign debt crisis, the euro area has faced continued distress in financial markets and the hampered transmission of monetary policy. To counter these developments, the European Central Bank (ECB) has implemented conventional and unconventional policy measures.[2] These measures include, among others, low interest rates, long-term refinancing operations, and the implementation of asset purchase programs. Some of these measures such as the Securities Markets Program (SMP) aim primarily to maintain the functioning of monetary policy transmission. Banks have a pivotal role in the transmission mechanism, and they react to improved credit conditions and other incentives to increase loan supply. In this regard, whether the ECB succeeds in maintaining the functioning of monetary policy transmission not least depends on how banks respond to these measures.

In this paper, we test the effectiveness of *conventional* monetary policy during the recent distress period. While an expanding strand of literature has considered the effects of *unconventional* monetary policy on bank behavior, our paper is among the first to assess conventional policy tools across euro area countries. We focus on the effect of the deposit facility rate on bank reserves and ask whether the reduction in the policy rate has successfully prevented banks from storing liquidity as reserves at the ECB. Importantly, we test the effectiveness across banks' business models and different countries for the period 2009-2014 using the identification strategy applied by Cornett et al. (2011).

Recent developments suggest that there is good reason to assess the effects of conventional monetary policy. The decline in the deposit facility rate has been accompanied by a steady increase in banks' reserve holdings. Our study shows that, for banks with a more interest-sensitive business model, declines in the deposit facility rate can succeed in shifting central

[2] More specifically, monetary policy in the euro area is implemented by the Eurosystem, The Eurosystem comprises the European Central Bank (ECB) and the national central banks (NCBs) of those countries that have adopted the euro. For the sake of brevity, we use the acronym ECB henceforth.

bank reserves into loans. However, there are limitations to this conventional policy instrument because the results mainly apply to banks that are well-capitalized and located in the non-GIIPS[3] countries. Thus, our findings contribute to the policy debate on the effectiveness of conventional versus unconventional monetary policy across euro area countries.

The reserve management of euro area banks has been a particularly interesting topic in recent years. Before the financial crisis, bank reserves were almost entirely attributable to mandatory reserves. These are determined by multiplying the reserve ratio by the reserve base. The reserve ratio is set by the ECB, which also defines the balance sheet items included in the reserve base. Hence, prior to 2008, the main determinant of reserves was – conditionally on the reserve base defined by the respective liabilities of banks – the ECB's policy regarding reserve requirements. By contrast, Figure 1 shows that since 2008, bank reserves have increased above mandatory requirements and become considerably more volatile. A similar increase in aggregate excess reserves has been documented for the U.S. banking system (Kandrac and Schlusche (2017), Keister and McAndrews (2009), Martin et al. (2016)). Although the amount of aggregate reserves in the system is outside of control of the individual bank, the appearance of excess reserves raises the question of whether a bank engages in an active (excess) reserve management.

Lowering the deposit facility rate should reduce banks' incentives to hold liquidity at the central bank (Arseneau (2017), Lee (2016)). Large volumes of excess reserves indicate that banks are withholding or even hoarding liquidity at the central bank. For the individual bank, these funds might alternatively be channeled into the real sector and consequently foster economic activity. Therefore, the ECB has lowered the deposit facility rate repeatedly since the start of the financial crisis to alter the stance of monetary policy and restore the monetary transmission mechanism, e.g., through encouraging the loan supply. A decrease in the deposit

[3] Euro area countries excluding Greece, Ireland, Italy, Portugal, and Spain.

facility rate can induce cost pressure for the individual bank and create a *"hot potato effect"* for liquidity, as reserves are liquidity holdings that earn very low or negative interest rates (Keister et al. (2008)). Therefore, banks have an incentive to shift liquidity into more profitable assets – that do not move one-to-one with the deposit facility rate – rather than to hold reserves. If the deposit facility rate is effective at altering banks' incentives to hold reserves, it can be a useful and transparent tool for reallocating liquidity and fostering monetary policy transmission.[4]

However, uniform policy rates across euro area countries can have different effects across banks, leading to heterogeneous and unforeseen responses.[5] In particular, banks with a strong focus on interest-sensitive activities, that is, banks that are more reliant on net interest income – for instance, due to a higher share of loans and deposits – should be more concerned with the ECB's interest rate policy. The reason is that these banks are more involved in interest-bearing activities, more dependent on the related income sources, and should therefore be 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, 2018)). The latter point gains in importance in the presence of the zero lower bound, because negative interest rates cannot be passed through one-to-one to depositors. Banks with an interest-sensitive business model are thus likely to be more concerned about depressed margins.

For identification purposes, and in the spirit of Cornett et al. (2011), we specify an interaction model exploiting the fact that banks' responses to policy rates should depend on the interest sensitivity of the business model. Given that individual banks are unlikely to influence the

[4] While depressed margins resulting from 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'Ariccia et al. (2017), Heider et al. (2017), Ioannidou et al. (2015), Jiménez et al. (2014), Lambert and Ueda (2014), Lamers et al. (2016), Maddaloni and Peydró (2011)).

[5] 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.

ECB's policy decisions, concerns of reverse causality are reduced.[6] Another potential source of endogeneity is that banks might simply increase loans (and reduce reserves) as they respond to higher demand for loans following a decline in interest rates. However, in our specification, such a demand-side effect is ruled out as long as bank-specific demand for loans does not vary systematically with the net interest margin of banks.[7] Therefore, our results show that banks adjust their reserve holdings in *direct response* to changes in the deposit facility rate and depending on the interest sensitivity of their business model. Importantly, the effect is heterogeneous across banks: banks with high net interest margins reduce reserve holdings by more if the deposit facility rate is reduced. This is in line with the rational that a high net interest margin can be associated with a high exposure to a potential decrease of the very same. It is also consistent with recent discussions about the sustainability of interest-sensitive business models in a low interest rate environment.

As concerns portfolio reallocations, we find that this liquidity freed up due to declining reserves benefits the loan supply, thus supporting the functioning of monetary policy. These results remain robust when accounting for simultaneous adjustments of balance sheet positions and an array of other tests. In sum, the results provide important evidence that conventional monetary policy can work during unconventional times. However, there are limitations to the effectiveness of the unconventional monetary policy instrument regarding banks' loan supply: We show that banks' responsiveness can be attributed to well-capitalized banks and banks in non-GIIPS countries.

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

[6] Furthermore, we show that there are parallel trends across country groups in the evolution of the interest sensitivity of banks' business model, which reduces concerns that our results might be driven by systematic differences across countries.

[7] To further rule out that demand-side effects drive our result regarding the shift from reserves to loans, we include several variables to extract effects stemming from the demand side in a robustness exercise in Section 4.5.

effects on bank behavior (e.g. Acharya et al. (2019), Chodorow-Reich (2014), Lambert and Ueda (2014), Mamatzakis and Bermpei (2016)). Acharya et al. (2019) find a recapitalizing effect for banks through the Outright Monetary Transactions (OMT) programs. This effect is particularly strong for banks from GIIPS countries, which have benefited 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 poorly capitalized banks and low-quality borrowers. Kandrac and Schlusche (2017) assess the relationship between unconventional monetary policy in the U.S. and banks' reserves holdings as well as loan and risk-taking behavior. We complement their work by studying the role of the deposit facility rate for banks' reserve holdings, and thereby the effectiveness of a policy instrument in the hand of central banks, and portfolio reallocation.[8]

Furthermore, our paper contributes to the literature on the (heterogeneous) transmission of unconventional monetary policy (Cycon and Koetter (2015), Hristov et al. (2014)).[9] Acharya et al. (2015) provide evidence of an impaired transmission of monetary policy conditional on banks' riskiness. The effect of negative interest rates in the euro area on banks' risk-taking behavior was recently analyzed by Heider et al. (2019). These 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 onto their depositors. This is in line with the reasoning put forward by Arseneau (2017), who shows for the U.S. that banks expect a decline in profits in a low interest rate environment. We contribute to this literature by

[8] Price or yield induced portfolio rebalancing in the context of liquidity are considered by Albertazzi et al. (2018), Paludkiewicz (2018), Rodnyansky and Darmouni (2017) and Tischer (2018).
[9] Key studies on 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).

focusing on the effectiveness of the deposit facility rate regarding banks' balance sheet management and depending on bank heterogeneities.

Also, our paper contributes to the literature on banks' liquidity management. Given liquidity strains in the interbank market, mainly due to a lack of counterparties considered as solvent, banks might park liquidity as reserves at the central bank (Heider et al. (2015)). 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. (2017) find that following the Lehman collapse, banks shifted to highly liquid assets, which can be readily converted into central bank liquidity. Thus, reserve holdings at the central bank can be part of banks' liquidity management during times of crisis. Cornett et al. (2011) analyze U.S. 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. By linking liquidity management back to monetary policy, 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 present the regression framework and provide an overview of our sample and data. Section 4 discusses 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. Bank reserves are assets held by banks at the central bank.

In the pre-crisis period, aggregated bank reserve holdings within the euro area remained stable by below 1% of the total assets of monetary financial institutions (MFIs). They roughly matched the mandatory reserves.[10] This has changed since the start of the financial crisis. As shown by Figure 1, bank reserves have increased above mandatory requirements and become considerably more volatile. These *excess reserves* are the bank reserves we are interested in.

Liquidity-providing factors

The underlying reasons for the increase in bank reserves and the evolution of excess reserves are fundamental changes in the liquidity-providing factors of the euro area 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)). 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.

Current account, deposit facility, and the deposit facility rate

The emergence of excess reserves also becomes visible when considering the accounts bank reserves are held at. 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 (excess) reserves.[11] The deposit facility covers only *voluntary reserves*. 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 MFIs of the euro area.

[10] Also, for the U.S., Kroeger et al. (2018) find evidence of a "reserve-scarcity regime" before the crisis.
[11] 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.

For the time period before 2012, we can reasonably assume that excess reserves were held (preferably) in the deposit facility because its yield, the deposit facility rate, was higher than the yield on excess reserves in the current account, which does not bear any interest. Therefore, we can differentiate approximately 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 gray 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. 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.[12] Nevertheless, this is no longer crucial for our research because we know for sure that regardless of the account in which banks place their voluntary reserves, they earn the same rate of interest, the deposit facility rate. Before the ECB reduced the deposit facility rate even further in 2014, the equal yield of the two accounts became contractual.[13] Figure 2 provides a timeline that marks key changes in these policy instruments.

[12] This also explains the sharp increase in excess reserves in the current account as shown in the supplementary material, available upon request from the authors (Figure A1).

[13] 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).

Costs of reserves

The economic significance of reserves becomes clear when one considers 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.[14] While these numbers might be small relative to the size of the overall banking system, it is reasonable for each individual bank to want to minimize its share of these costs. The opportunity cost or *"hot potato effect"* of holding reserves is also addressed by Keister et al. (2008) as well as Lee (2016).

The role of the interbank market

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 shown. The figure also shows the Eonia rate, which is the average rate at which banks can borrow money overnight in the interbank market. Prior to the financial crisis, the Eonia rate fluctuated around the main refinancing rate and thereby symbolized the transmission of (conventional) monetary policy via the interbank market. However, for the past eight years, it 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".[15] This development does not necessarily mean that banks are now able to obtain refinancing at a

[14] Calculations are based on period averages of daily positions.
[15] The partial breakdown of interbank markets is also reflected by a decline in the Eonia volume, as shown in the supplementary material, available upon request from the authors (Figure A2).

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. Since the introduction of the full allotment policy in October 2008, banks have been able to receive liquidity directly from the ECB's open market operations at the main refinancing rate. Banks with sufficient central bank collateral, therefore, have no incentive to pay interest rates higher than the main refinancing rate, which exerts downward pressure on interbank rates and limits the demand for central bank money among banks (Garcia-de-Andoain et al. (2016)). Banks with insufficient collateral are unlikely to receive liquidity via the interbank market.[16] The proximity of Eonia and the deposit facility rate shows that the interbank market is frequented only by very few, highly secure banks – while many other banks that are not considered as secure counterparts any more have lost access to funding through the interbank market.

Macroeconomic evidence of liquidity reallocation

From a macroeconomic perspective, the amount of liquidity within the euro area is mostly determined by the monetary policy operations of the ECB.[17] 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, in some countries, the demand for liquidity provided by the ECB via its main and longer-term refinancing operations changed considerably over time (Figure A3). Banks in countries such as Germany and Luxembourg, where banks find it easier to attract liquidity

[16] Given the broad collateral framework of the ECB, scarcity of central bank collateral is an indicator for solvency problems.
[17] Keister and McAndrews (2009) give a very good explanation on this for the U.S.

through the interbank market, have reduced their demand for central bank liquidity, while banks in the GIIPS[18] countries have increased their demand considerably.

Summary

In sum, three main observations can be made. First, bank (excess) reserves have increased significantly in recent years, due to fundamental changes in monetary policy operations and distress in the interbank market. Second, 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 reserve holdings of the individual bank.[19] 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.

3. Estimation Framework

To test our research question, we need data on banks' reserve holdings and the deposit facility rate over a reasonably long time period for a cross-section of countries. We thus make use of bank-level data from Bankscope for 17 euro area countries, having the advantage that distorting effects resulting from different central bank policies are eliminated.[20] The sample period spans 2009-2014 because a fundamental change in the set-up of the main refinancing operations occurred in 2008, when the ECB switched to the fixed-rate, full allotment policy. More details on the regression model and the data are provided in the following.

[18] Greece, Ireland, Italy, Portugal and Spain
[19] In the aggregate, the deposit facility rate can affect bank reserves only indirectly via the demand of liquidity.
[20] 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.

3.1. Regression Model

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

$$\frac{\Delta\, Balance\ Sheet\ Position_{ijt}}{Total\ Assets_{ijt-1}} = \nu_i + \nu_t + \alpha_1 \Delta\, DFR_t \times NIM_{ijt-1} + \alpha_2 Bank\ Controls_{ijt-1} + \alpha_3 Country\ Controls_{jt} + \varepsilon_{ijt} \quad (1)$$

The empirical model measures the change in the balance sheet position (Δ *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* (*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 (see also, Schandlbauer (2017)).[21] Once we find that banks adapt their reserve holdings, we analyze whether and to what extent they rebalance their portfolios towards alternative balance sheet positions, such as liquid assets or loans.[22]

To identify the influence of the ECB's deposit facility rate, we exploit the fact that the effect of the deposit facility rate should be heterogeneous across banks. In particular, banks' responsiveness to changes in interest rates should depend on the interest sensitivity of the business model, which we proxy by the net interest margin and explain in greater detail in Section 3.2. Therefore, the empirical model includes an interaction term of the change in the deposit facility rate (Δ *DFR*$_t$) with the bank-specific net interest margin (*NIM*$_{ijt-1}$). The main coefficient of interest, α_1, reflects banks' sensitivity to changes in the deposit facility rate depending on the net interest margin. Hence, similar to Cornett et al. (2011), we are interested

[21] Regardless of the choice of the balance sheet position used as the dependent variable, we base all regressions on the sample of banks for which we have data on bank reserves.

[22] To account for simultaneity among balance sheet positions, we check the robustness of our results by estimating 3SLS regressions in Section 4.4.

in the responsiveness across banks rather than the aggregate effect of changes in the policy rate.

The ECB's policy is 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. By adding 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. To control for other determinants of banks' balance sheet decisions, 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. The net interest margin and all other bank-specific controls are lagged by one period to reduce simultaneity concerns. Standard errors are clustered at the bank level.

Furthermore, the macroeconomic environment at the country level can influence bank balance sheet management. To account for this, we add country-specific control variables ($Country\ Controls_{jt}$) that include the growth rate of GDP and the inflation rate. The time span analyzed is characterized by further changes in (non-)conventional monetary policy tools, such as the main refinancing rate. While simultaneous changes affecting all countries alike are absorbed by time fixed effects, we extend our model to capture the ECB's unconventional monetary policy as explained in Section 3.3. In robustness tests, we add further variables to control for stock market developments and demand-side effects in credit markets.

3.2. Bank-Level Data

Sample and data cleaning

The yearly bank-level data for 17 euro area countries over the period 2009-2014 are taken from Bankscope and our baseline sample is determined by the banks in the euro area for

which we obtain information on central bank reserves.[23] This produces a sample of larger banks that have, on average, lower net interest margins.[24] 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 reliant on interest-bearing activities (Demirgüç-Kunt and Huizinga (2010), Kasman et al. (2010)). 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 retain banks whose specialization type is indicated as bank holding company, commercial bank, cooperative bank or savings bank.[25] We drop bank observations with missing assets, zero assets or zero equity as well as 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. A detailed description of the data sources is provided in the appendix, and summary statistics can be found in Table 1.[26]

[23] The sample stops in 2014 due to the discontinuation of our main data source (Bankscope).
[24] In total, the banks in our sample cover 42% of all monetary financial institutions' assets in the euro area. Data on euro area MFI's total assets have been taken from the ECB.
[25] We also conducted regressions excluding cooperative banks and savings banks from our sample to exclude potential network effects in banks' reserve management. Results can be provided upon request.
[26] Summary statistics of the key bank-level variables for the subsample of banks in GIIPS versus non-GIIPS countries can be found in the supplementary material, available upon request from the authors (Table A1).

Balance sheet positions

We use three different balance sheet positions as the dependent variable in equation (1): (i) bank reserves, (ii) liquid assets, and (iii) total loans.

(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 held either in the ECB's deposit facility or in the current account of the national central banks. From Bankscope, we obtain the composite position. Given that mandatory reserves are determined by regulation, banks can only actively manage excess reserves if we assume that the funding side is relatively stable over time. Hence, excess reserves are the main component to be 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. Rather, they are 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 as explanatory variable in the 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 January 2012 from two to one percent. We control for this change in the following regression analysis. Figure 4 shows that despite this decline in the reserve ratio, the average share of reserves for the banks in our sample has remained rather stable.

If banks respond to the ECB's policy rate and change their reserve holdings, the immediate question is this: to which other asset position is this freed-up liquidity allocated? Hence, we consider portfolio positions that are crucial for the transmission of monetary policy, including liquid assets (excluding reserves) and total loans.

(ii) ***Liquid assets***: Bank reserves are a subcomponent of the position "liquid assets" and can even be considered 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 banks would not reallocate the liquidity from reserves to loans.

(iii) ***Total loans***: Finally, we consider the portfolio position the ECB wants to indirectly affect with its policy interventions, that is, bank loans. By considering 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.

Net interest margin

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). From Figure 5, it can be observed that the average net interest margin has been relatively constant over the sample period, with some evidence of a downward trend. Banks in GIIPS countries show, on average, a higher net interest margin than banks in non-GIIPS countries. [27]

We expect banks to be affected differentially by changes in the deposit facility rate depending on their reliance on interest-bearing activities like traditional lending and deposit-taking and the relevance of the income accrued therefrom (Arseneau (2017), Borio et al. (2017), Busch and Memmel (2017), Claessens et al. (2016), Gambacorta and Marqués-Ibáñez (2011), Genay and Podjasek (2014), Nucera et al. (2017)). If banks rely more on net income from interest-

[27] See also the summary statistics by country group in the supplementary material, available upon request from the authors.

bearing activities relative to average earning assets, they should be more concerned with changes in the underlying policy rates. Obviously, the net interest margin as a proxy for the interest sensitivity of the business model is not free of critique, and in Section 4.3, we conduct robustness tests with alternative proxies. Nevertheless, its usage is supported by the following considerations.

First, 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 declining interest rates because lending rates are more elastic than deposit rates. This is even more true if banks are faced with interest rates at the zero lower bound or even extending into negative territory. As such, Dombret et al. (2019) 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 from average earning assets; it should also cause differential responses to the ECB's interest rate policy.

Second, the interpretation of the net interest margin as a proxy for the interest sensitivity of 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. Nguyen (2012) accounts for potential endogeneity between non-interest income and the 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).[28] Hence, the higher the level of the net interest margin, the higher the exposure to a potential decrease

[28] 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
http://www.faz.net/aktuell/finanzen/meine-finanzen/sparen-und-geld-anlegen/abhaengigkeit-von-zinserstraegen-aufseher-erhoehen-den-druck-auf-die-banken-14291634.html

of the very same and thus the need to defend the margin level through a more sensitive reaction to changes in policy rates.

Finally, the net interest margin relates well to other proxies capturing banks' reliance on interest-sensitive business activities. To compare the net interest margin to alternative measures of banks' reliance on interest-dependent activities, we define two groups of banks: 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 and without a strong reliance on an interest-sensitive business model. Figure 6 depicts the average of the a) net interest margin, b) loan share, c) net interest income share, and d) bank size, differentiating between banks with an – on average – high net interest margin (dummy variable equals one) and banks for which the dummy variable equals zero.

The rather stable pattern of the net interest margin from Figure 5 can also be observed within the two groups of banks with on average higher or lower net interest margins (Panel a). Similar to Figure 5 focusing on the evolution of the net interest margin across different country groups and despite the difference in levels, there seems to be a parallel trend in the averaged series. This reduces concerns that systematic differences over time between more and less affected banks drive our results. Banks that are – on average – more dependent on interest-generating activities captured by a higher net interest margin are – on average – more involved in the traditional lending business, have a higher share of net interest income to total assets, and are smaller regarding balance sheet size as commonly observed. 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 7. These banks show a larger share of loans to total assets. In contrast, banks with lower net interest margins tend to have a higher share of liquid assets on their balance sheets.

Further bank controls

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. The correlations in Table 2 show that larger banks seem to have a lower net interest margin (Demirgüç-Kunt and Huizinga (2010), Kasman et al. (2010)). Furthermore, changes in one of the subcomponents of banks' portfolios correlate positively with changes in the total balance sheet scaled by total assets in the previous period.

3.3. 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.[29] 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. The deposit facility rate has also got public attention more recently. For instance, the Financial Times (2016) stated 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."[30]

We complement the data set by adding the main refinancing rate because it might also affect banks' balance sheet decisions. The inclusion of the main refinancing rate helps monitor the effects of changes in lending rates and control for potential effects of changes in the spread between the borrowing and the lending rate. The main refinancing rate is preferred over the

[29] The policy rates are included in the regression analysis as first difference. To aggregate policy rates to the yearly frequency, we calculate weighted averages, where the weights are based on the fraction of days for which a rate has been set.

[30] 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. See e.g. http://bruegel.org/2014/06/negative-deposit-rates-the-danish-experience/

lending "counterpart" 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. It is important to note that the main refinancing rate has an indirect effect on banks' reserves holdings due to its effect on the aggregated supply of reserves within the system. However, the weekly accessible and (nearly) unlimited liquidity supply by the ECB via its open market operations makes it unlikely that the same banks that constantly hold excess reserves request additional funding via the main refinancing rate at the same time.

Controls for unconventional monetary policy include the share of ECB-funded bank liabilities to total liabilities[31] and the 10-year government bond yield. By including the share of ECB-funded bank liabilities capturing the aggregate usage of ECB liquidity across all monetary financial institutions in a country, we control for 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.[32]

The change in the government bond yield controls for the effects of the extensive securities markets programs or public sector purchase programs of the ECB. When the ECB buys extensive amounts of government bonds – also through the national central banks in the euro area – banks are affected in two ways. First, the value of the government bonds increases because there is additional demand. This drives up the price of government bonds already held by banks. Acharya et al. (2019) describe this development observed after the announcement of the Outright Monetary Transactions (OMT) program as "backdoor

[31] 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. Source: http://sdw.ecb.europa.eu/reports.do?node=1000003383

[32] 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.

recapitalization". The second way in which the public sector purchase programs affect banks is by depressing the yield of government bonds. This makes them less attractive for future investment and might induce banks to reallocate their portfolios. Figure 8 shows that these proxy variables for unconventional monetary policy not only vary substantially over time but also do so across country groups when comparing the average pattern of GIIPS countries to the other countries in the sample.

We include additional macro controls, such as GDP growth and inflation, taken from the International Financial Statistics of the IMF and stock market data obtained from Datastream. Summary statistics are provided in Table 1. A correlation table of the country-level variables can be found in Table 3.

4. Empirical Analysis

In this section, we first show that changing the deposit facility rate results in portfolio reallocations depending on the interest sensitivity of banks' business models. We then investigate which banks in which countries drive our results and conduct further robustness tests to account for alternative business model measures, simultaneity of balance sheet positions, and potentially confounding factors.

4.1. Baseline Results

The results in Table 4 show that, in the face of lower deposit rates, banks with a more interest-sensitive business model, as reflected by a higher net interest margin, reduce *reserves* by more than banks with a lower net interest margin. Thus, banks with a higher net interest margin are more sensitive to changes in the deposit facility rate, that is, banks' liquidity holdings in the form of reserves at the central bank increase less (more) in response to negative (positive) changes in the deposit facility rate. This is in line with the hypothesis that banks with an interest-sensitive business model are hit more severely by – and are thus 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 (e.g. Acharya et al. (2018)).[33]

A noteworthy feature is that the heterogeneous effect seems unsurprising in the context of unconventional monetary policies, as those policies can be differentially applied across banks. By 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 study by Heider et al. (2019), who focus on the introduction of negative deposit rates and find that effects are heterogeneous along the distribution of banks' deposit ratio.

Based on the size of the coefficient in Column (1), we can assess the economic significance of the effect. For a 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).[34]

It is important to note that banks' sensitivity to the deposit facility rate depending on the net interest margin is almost negligible in economic terms if the change in the deposit facility and the main refinancing rate coincide. The reason is the similar size of the coefficients of the interaction terms. Considering the time period on which our analysis is based, rates have been changed 13 times and four times, i.e., in about 30% of the cases, these changes did not

[33] To evaluate whether the effect of a change in the deposit facility rate goes in a reasonable direction, we rerun the regression model excluding time fixed effects but including the deposit facility rate as such. Figure A4 in the supplementary material (available upon request from the authors) depicts the marginal effect of a change in the deposit facility rate on reserves conditional on banks' net interest margin. 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 relatively high net interest margin. However, given that no time fixed effects are included, this estimation has to be taken with caution.

[34] The result is also economically significant bearing in mind that reserve holdings were almost constant before the crisis.

coincide.[35] From a statistical point of view, the coefficients estimates are identified based on the dissimilar variation in the two rates. From a policy perspective, this implies the important result that only dissimilar changes in the borrowing and the lending rate, leading to an increase or decrease in the interest rate corridor, have economically significant effects.[36]

The result holds while controlling for bank-specific features and macro developments (Column (1)), and adding alternative measures for monetary policy such as 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 or whether our results arise solely due to the change in the reserve ratio in January 2012 (Column (5)).

Given that banks change their reserve holdings as a response to changes in the deposit facility rate and conditional on their business model, we are interested to know which asset positions the liquidity is reallocated into. In line with this consideration, Christensen and Krogstrup (2019) discuss the evidence of a "reserve-induced portfolio balance channel". 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).[37]

[35] In our sample period, DFR and MRR were changed differently on 21 January 2009, 13 May 2009, 8 May 2013, and 13 Nov 2013. Given that we calculate weighted averages for the DFR and the MRR, where the weights are based on the fraction of days for which a rate has been set, the *changes* in both rates entering the regression differ four times (2009 and 2013 because DFR and MRR were changed differently and 2010 and 2014 because we use the weighted average annual rate).

[36] We also conducted regressions including the interaction of the change in the interest rate spread between the two policy rates with the net interest margin, instead of the two rates separately. Also, the coefficient of the interaction term was significantly different from zero. Results can be provided upon request.

[37] 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 portfolio rebalancing or due to a change in total assets. The results can be found in the supplementary material, available upon request from the authors.

Opposite to reserves, we find that changes in the deposit facility rate do not significantly influence banks' sensitivity regarding their decisions to hold *liquid assets*. 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. Hence, we do not find significant evidence that monetary policy transmission is impeded. Also, the result does not yield any evidence for the hypothesis that banks, which cannot pass on declines in interest margins to customers due to competitive pressure, invest in more profitable and liquid assets other than loans, thereby generating risks in the financial system, for example, by fueling asset price bubbles.

By contrast, banks with a more interest-sensitive business model tend to increase (decrease) their *loans* by more given a decrease (increase) in the deposit facility rate, as reflected by the negative and significant coefficient of the interaction term (Table 6). This finding implies that a reduction in the deposit facility rate can eventually translate into changes in the loan supply by banks. The results are in line with the finding of a "reserve-induced portfolio balance channel" by Kandrac and Schlusche (2017), who show for the U.S. that loan growth has been higher in regions with higher reserve holdings. Furthermore, it 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 manner in which a reduction in the deposit facility rate translates into a 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.

As a side result, 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 (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.

4.2. Heterogeneities

Market fragmentation in the euro area that is mirrored, for example, by diverging risk premia across countries, has been a key concern for policymakers since the start of the sovereign debt crisis. This might result in differential access to liquidity. For example, Abbassi et al. (2014) find that the sovereign debt crisis made it more difficult for banks located in peripheral countries to access liquidity in interbank markets. To test for heterogeneities across euro area countries, Table 7 shows the results for the baseline model estimated separately for the subsample of non-GIIPS and GIIPS countries. Interestingly, banks with a more interest-sensitive business model show a higher sensitivity to changes in the deposit facility rate as concerns their *reserves* for the sample excluding the GIIPS countries (Column (1)). By contrast, the effect vanishes for the sample of GIIPS countries only (Column (4)).

Various reasons may be driving this result. From a statistical viewpoint, the sample of GIIPS countries contains a lower number of observations, which might explain the lack of significance for the sample of GIIPS countries. From an economic viewpoint, market fragmentation, in particular the divergence of borrowing costs across countries and differences in liquidity needs, might explain the increasing magnitude of the coefficient for the sample of non-GIIPS countries.

Banks in GIIPS countries might suffer from weak fundamentals that reduce the extent to which they can access interbank markets and crimp their flexibility to adjust to the ECB's monetary policy. Thus, banks in non-GIIPS countries will behave differently than those 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.[38] In addition, many banks in those countries might be closer to regulatory constraints.

Additionally, the significant result for the change in *loans* scaled by total assets of the previous period is retained and larger for the sample excluding the GIIPS countries (Column (3)). This suggests that the effects are mainly driven by banks in countries that have only been affected by the recent financial and sovereign debt crisis to a minor extent, and it 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 is hampered in stressed countries of the euro area.

Hence, the deposit facility rate seems to be effective in non-GIIPS countries only. One obvious reason, as discussed above, is that banks in those countries have a higher share of reserves and are thus more affected by declines in the respective yield. Another reason may be that banks are less capital-constrained in those countries, with the result that they are able to transform reserves into loans with the objective of earning higher interest but without fearing that they may become constrained by regulatory capital requirements.

Along these lines, we test whether our results differ for a subsample of banks with a regulatory capital ratio below or above the sample mean. Table 8 (Panel a) reveals that capitalization does indeed matter. Depending on banks' net interest margin, changing the

[38] Figure A3 shows different uses of central bank liquidity across euro area countries. Figure A5 in the supplementary material (available upon request from the authors) provides some additional evidence of these differences by showing reserve holdings/borrowing of domestic MFIs at/from the national central bank for Germany and Spain (see also Vari (2019)).

deposit facility rate has effects only for well-capitalized banks. This is in line with literature on the transmission of monetary policy emphasizing the role of banks' capital holdings. Hence, declines in the deposit facility rate as observed during the recent period stimulate a reallocation of reserves into loans all the more so for banks with an interest-sensitive business model but without being capital-constrained.

Redoing the exercise for the non-GIIPS sample (Table 8, Panel b), this result remains robust, and coefficients even gain in magnitude (Table 8). This implies that, depending on the interest sensitivity of the business model, banks are more responsive to changes in the deposit facility rate in cases where they hold more reserves as observed for non-GIIPS countries and when they are simultaneously better capitalized. Hence, while there is evidence that unconventional monetary policy affects the loan supply by poorly capitalized banks (Acharya et al. 2019), our results suggest that conventional monetary policy applied during times of crisis has effects for well-capitalized banks.

4.3. Alternative Proxies for Interest Sensitivity of Banks' Business Model

In this section, we test whether the results depend on the choice of the net interest margin as a proxy for the interest sensitivity of banks' business model. We replace the net interest margin with three alternative measures. First, the loan share is a direct measure to capture reliance on traditional lending business, and indirectly interest income. Second, the net interest income share in total assets reflects the importance of net interest income relative to banks' balance sheet size. Third, we use the ratio of net fees and commissions to total assets, whereas banks with higher values might find it easier to recur to alternative sources of income excluding net interest income and would thus be less sensitive to interest rate changes.

The results in Table 9 reveal that despite changing the proxy for the interest sensitivity of banks' business model, our main conclusions remain valid. Following a *decrease* in the

deposit facility rate, banks with a higher loan share, and respectively, a higher net interest income share, decrease reserve holdings and increase lending. We find opposite effects when interacting the deposit facility rate with banks' net fees and commissions ratio. This corroborates the previous results because the variable is defined such that higher values would indicate a less interest-sensitive business model.

4.4. Simultaneous Equations

To account for the simultaneity between the individual balance sheet positions, we repeat the previous calculation by running 3SLS estimations.[39] 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 approach 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 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 total assets by including the predicted value of reserves that has been obtained by the first stage regression.

[39] This estimation method has been applied by, e.g., Elyasiani and Zhang (2015), Horváth (2013) and Shim (2013). An IV approach has also been chosen by Kandrac and Schlusche (2017) for a related question based on U.S. data.

The results of these estimations can be found in Table 10. 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 the 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)).[40]

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-up 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 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 4.2, 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 is reasonable as excess reserves are mostly located in

[40] We cannot apply overidentification tests to evaluate the validity of the instrument because we have only one instrument for the endogenous variable.

non-GIIPS countries, and the reallocation of reserves towards loans is more likely for banks with a positive amount of excess reserves.

4.5. Further Robustness Tests

We conduct further robustness tests for our baseline model (corresponding to Column (1) of Tables 4-6) with *reserves* (Table A2), *liquid assets* (Table A3), and *loans* (Table A4) as the dependent variables.[41]

First, we interact interest rates with a bank's average net interest margin over the sample period 2009-2014 instead of the continuous version of the variable (Column (2)). This helps reduce concerns that our results are driven solely by declining net interest margins over the sample period. For example, Claessens et al. (2018) show that low policy rates reduce net interest margins as interest expenses decline by less than interest income. Second, we include stock market returns and volatilities as additional country-level controls (Columns (3)-(4)). 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)). Third, 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 (Column (5)).

Across all dependent variables and specifications, we obtain robust results regarding the sign and significance of the coefficient of the interaction term. The significant result for the change in *reserves* as well as *loans* scaled by total assets of the previous period is retained. The results are also robust to excluding countries showing outlier values regarding banks' net interest margins and the amount of reserves.[42] For example, the variable net interest margins has an overall sample mean of two percent. By contrast, Estonia and Cyprus show yearly

[41] These robustness tests can be found in the supplementary material, available upon request from the authors.
[42] For brevity, these regression results are not reported but can be obtained upon request.

averages of over four percent of the net interest margin. Regarding reserve holdings, Estonia, Greece and Slovakia show the strongest fluctuations.

Finally, we also address concerns of demand-side effects for *loans*. 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 by 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 11, 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.

5. Concluding Remarks

This paper studies the effects of a conventional monetary policy instrument, the deposit facility rate, on euro area banks' portfolio management over the period 2009-2014, while taking into account the interest sensitivity of banks' business model. Lowering the deposit facility rate should reduce banks' incentives to hold reserves at the central bank due to lower interest earnings and can thus induce portfolio reallocation.

Our results show that, first, the higher the interest sensitivity of banks' business model, captured by the net interest margin, the more banks reduce reserve holdings when facing a decline in the deposit facility rate. This shows that a common monetary policy can result in different outcomes across banks and thereby across countries depending on the characteristics of the banking sector.

Second, in the presence of excess reserves, 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 positive sensitivity to decreasing policy rates regarding changes in the loan position.

Third, effects are most pronounced for well-capitalized banks in non-GIIPS countries of the euro area. This reveals that conventional monetary policy instruments have limited effects in restoring monetary policy transmission during times of crisis.

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Data Appendix

Variable	Description	Data Source
Bank-specific variables		
Δ Reserves to Total Assets of t-1 (in %)	Change in a bank's reserve holdings between period t and t-1 relative to total assets of period t-1	Bankscope
Δ Liquid Assets (excl. Reserves) to Total Assets of t-1 (in %)	Change in a bank's liquid assets (excl. bank reserves) between period t and t-1 relative to total assets of period t-1	Bankscope
Δ Loans to Total Assets of t-1 (in %)	Change in a bank's loans between period t and t-1 relative to total assets of period t-1	Bankscope
Δ Assets to Total Assets of t-1 (in %)	Annual growth of total bank assets	Bankscope
Net Interest Margin (in %)	Net interest income / average earning assets	Bankscope
ln Assets	Log of total assets (in US$ million)	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 assets	Bankscope
Net Fees and Commissions to Total Assets (in %)	Net fees and commissions / total assets	Bankscope
Net Interest Income to Total Assets (in %)	Net interest income / total assets	Bankscope
Total Regulatory Capital (in %)	Total regulatory capital / total assets	Bankscope
Loans to Total Assets (in %)	Loans / total assets	Bankscope
Country-specific variables		
Inflation (in %)	Annual inflation rate	International Financial Statistics, IMF
GDP Growth (in %)	Annual growth of GDP	International Financial Statistics, IMF
Δ 10 Year Government Bond Yield (in percentage points)	First difference of the yield for 10-year government bonds	Main Economic Indicator, OECD
Δ 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
Δ Firms' Credit Demand (diffusion index)	First difference of firms overall credit demand for past quarter, annual average, diffusion index where positive values correspond to increase in demand	Bank Lending Survey, ECB
Δ Overall Credit Standards (diffusion index)	First difference of overall credit standards for firms for past quarter, annual average, diffusion index where positive values correspond to tightening of standards	Bank Lending Survey, ECB
Δ 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
Euro area rates		
Δ Deposit Facility Rate (in percentage points)	First difference of the deposit facility rate, a policy rate of the ECB	ECB
Δ Main Refinancing Rate (in percentage points)	First difference of the main refinancing rate, a policy rate of the ECB	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 from January 2005 to April 2016. Bank reserves can be decomposed into the current account holdings (depicted in black) and the deposit facility holdings (depicted in gray). 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 MFIs in the euro area. *Source*: Datastream

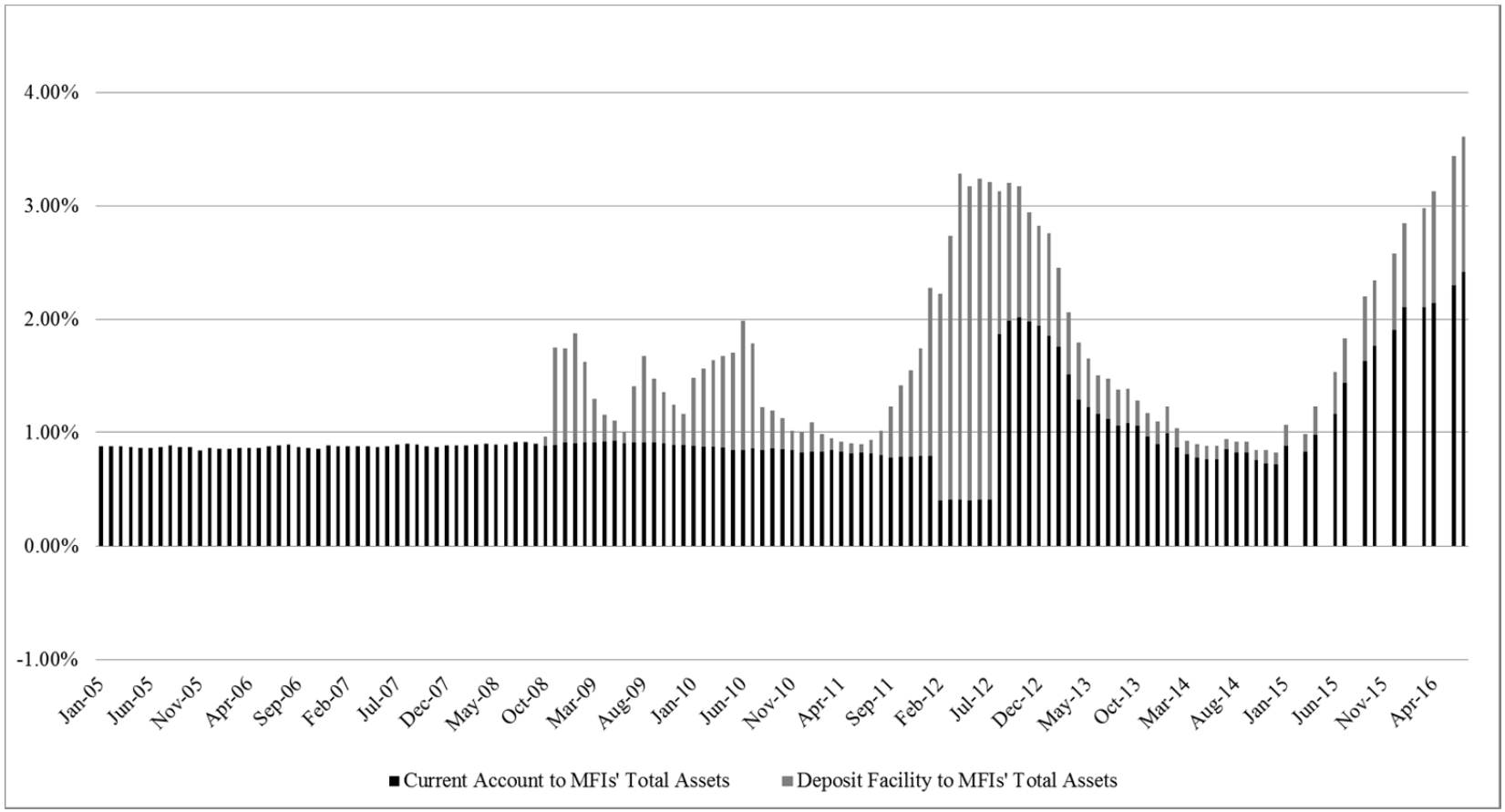


Figure 2: Timeline of the ECB's reserve policy

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. *Source*: Own illustration.

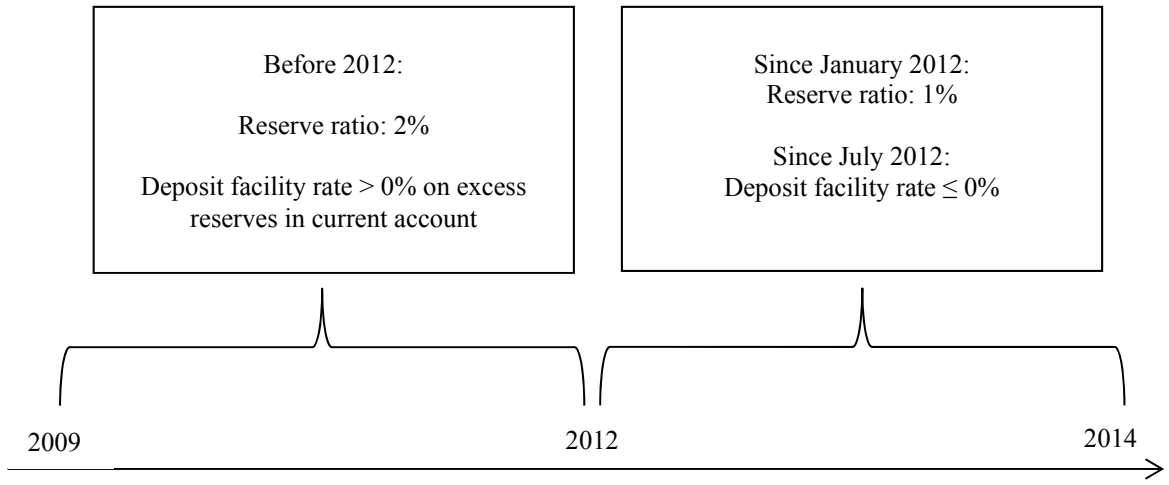


Figure 3: Key interest rates in the euro area

This graph shows the evolution of ECB policy rates (in %) 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). Eonia is a reference rate for uncollateralized overnight interbank lending. The vertical line marks October 2008, the month when the ECB introduced its fixed rate, full allotment policy. It also highlights the beginning of a period of continuously decreasing policy rates, which was only temporarily interrupted in 2011. *Source*: ECB.

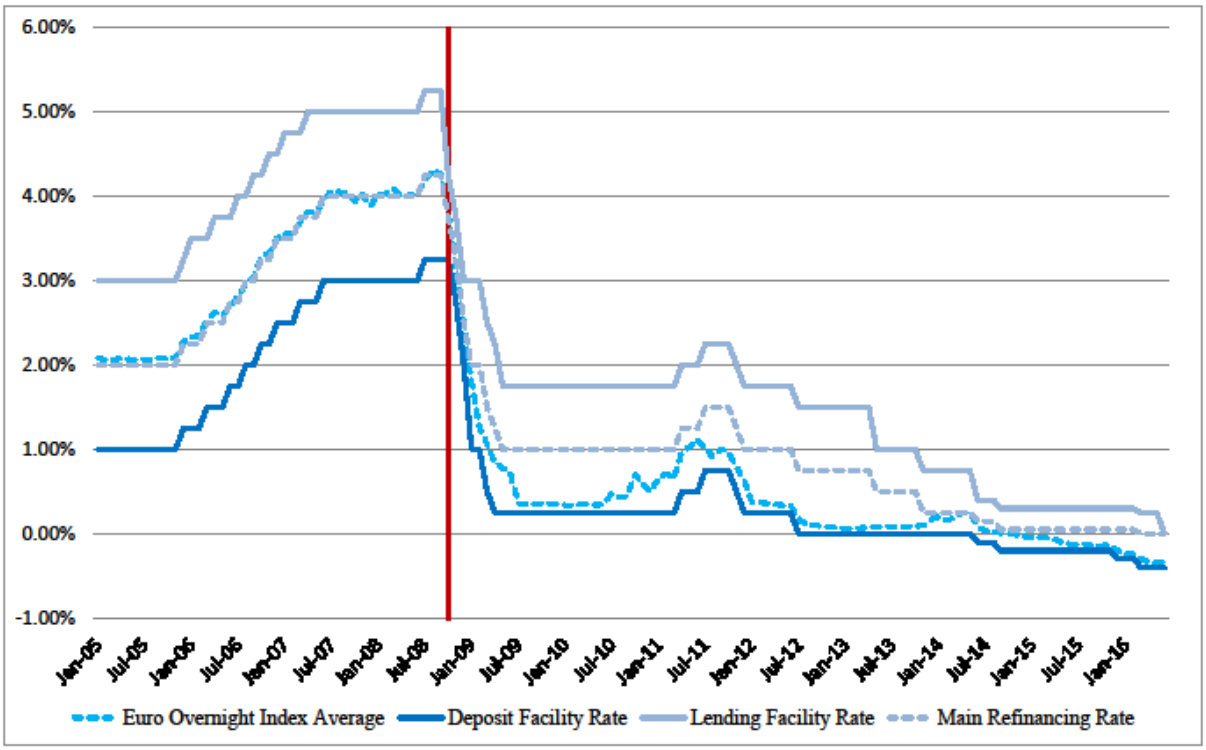


Figure 4: Evolution of the average reserve ratio

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

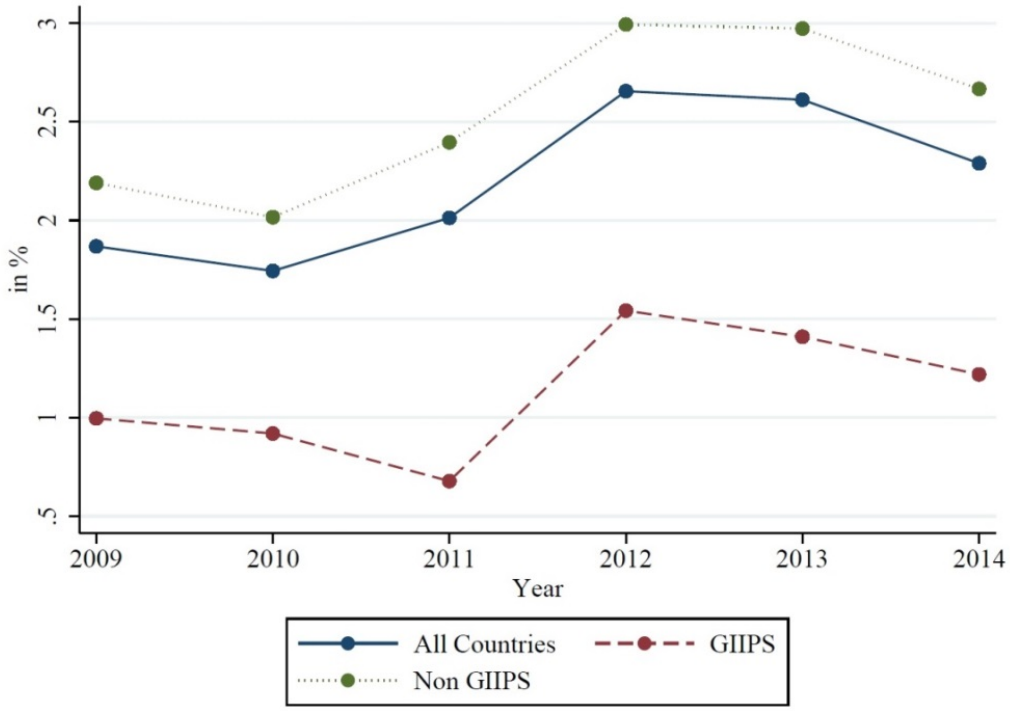


Figure 5: Net interest margin over time

This graph shows the average net interest margin (NIM, in %) of our sample of banks for the 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*: Bankscope.

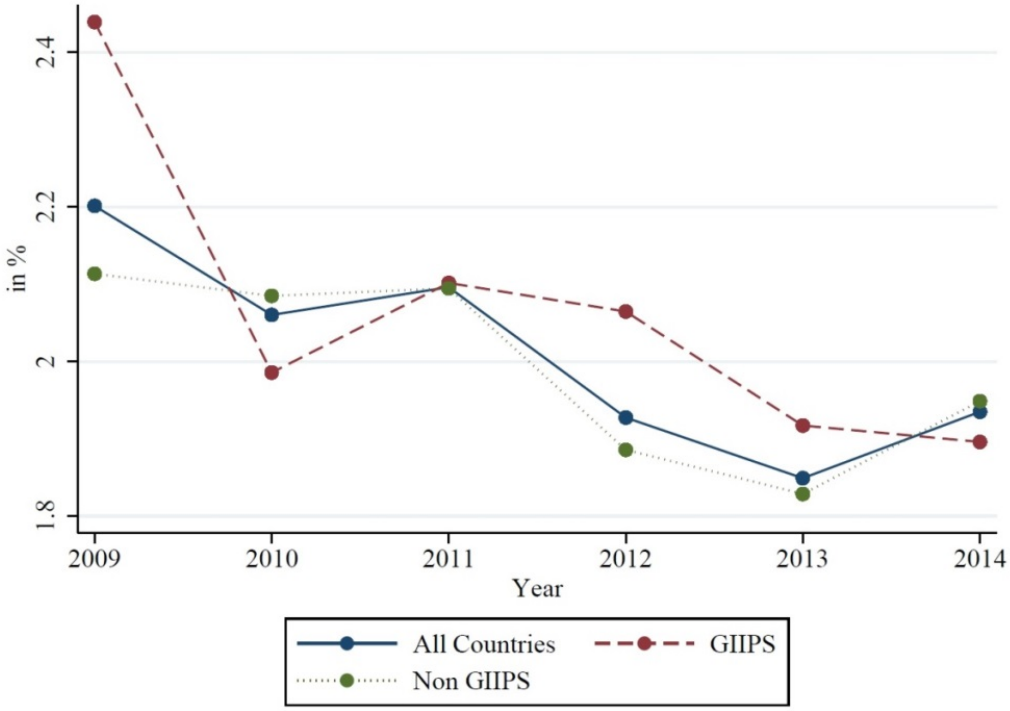


Figure 6: Heterogeneity of banks by net interest margin

This graph shows the average amount of a) the net interest margin, b) the loan share, c) the net interest income share, and d) bank size (total assets in billion USD) of our sample of banks and the period from 2009 to 2014. The sample is decomposed into banks with an average net interest margin (NIM) below (0) or equal to/above (1) the sample mean of the net interest margin. *Source*: Bankscope.

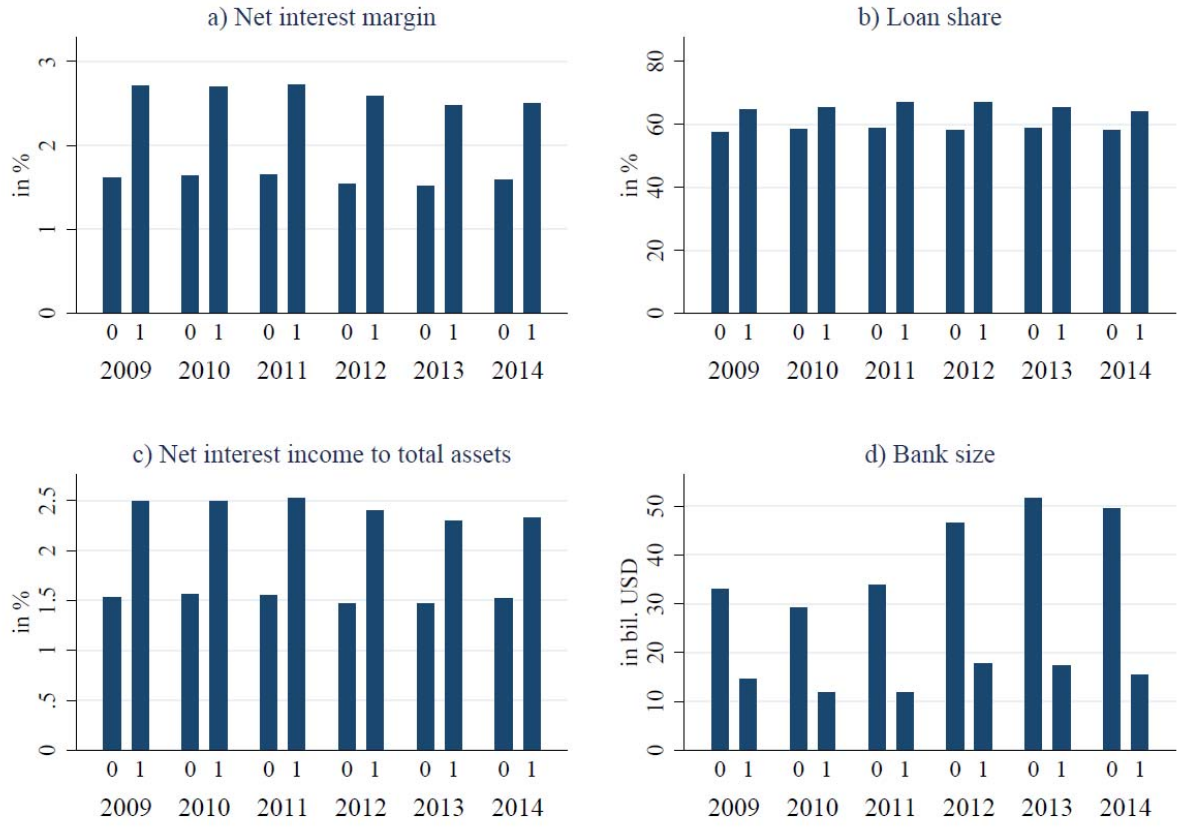


Figure 7: Bank portfolio composition by net interest margin

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

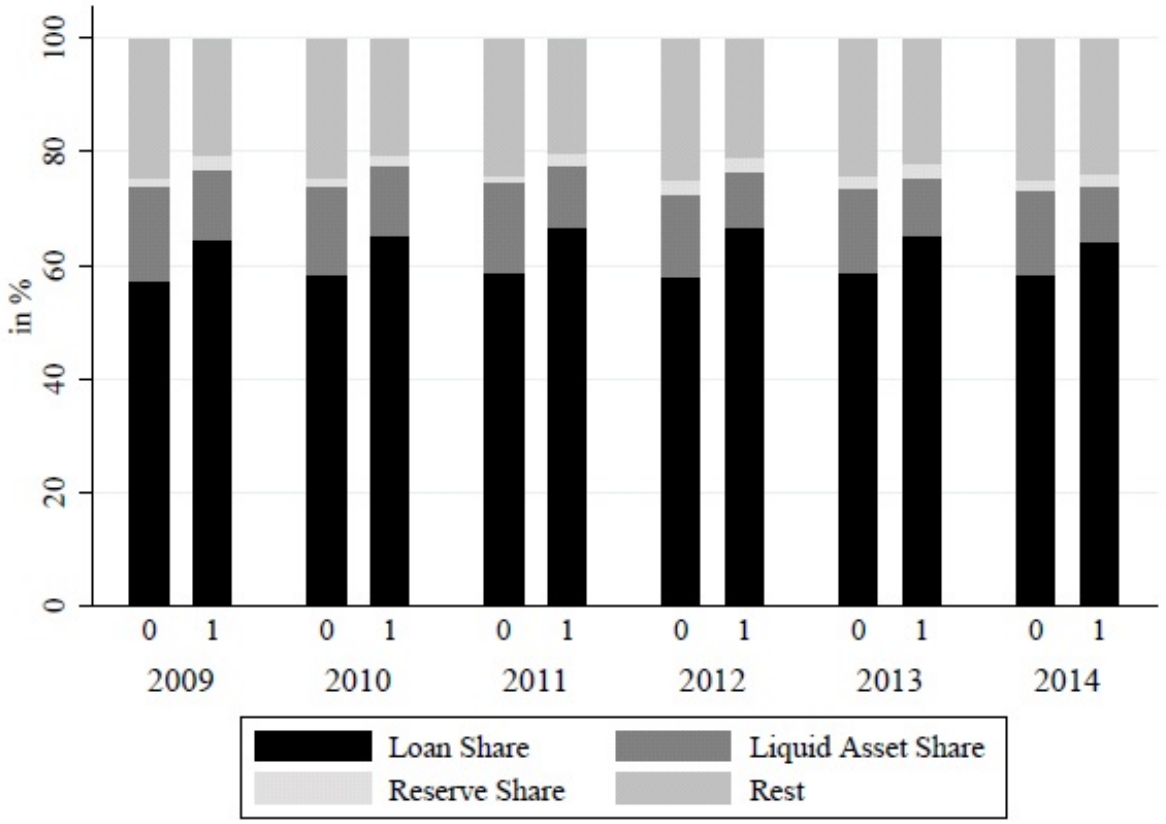
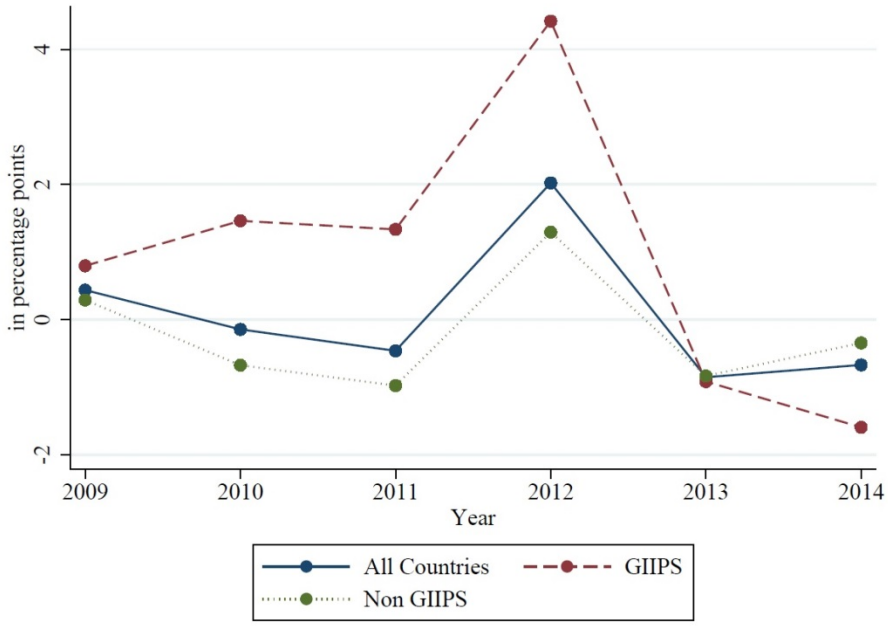


Figure 8: Controls for unconventional monetary policy

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

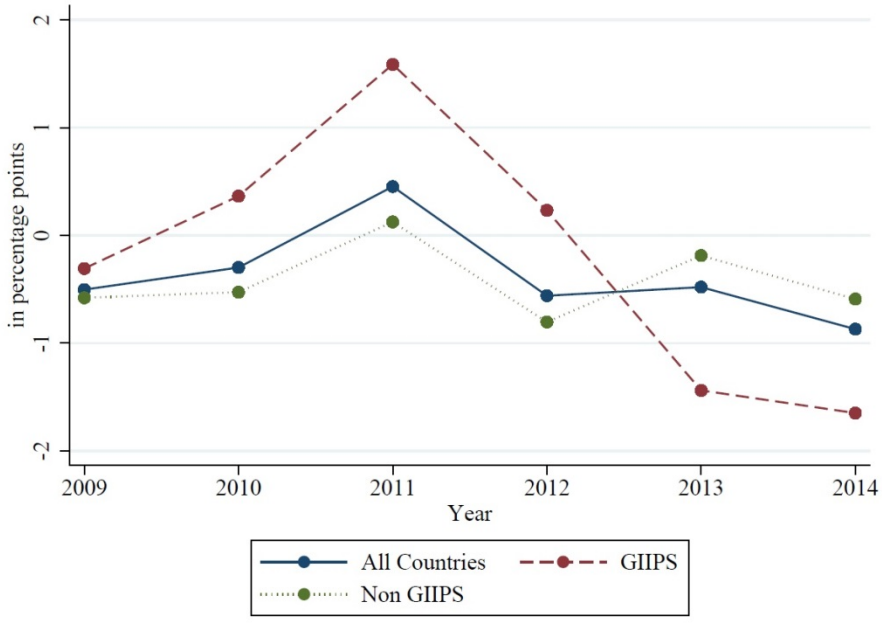


Table 1: Summary statistics

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.

Variable	No. of obs.	Mean	Std. dev.	Min	Max
Bank-specific variables					
Δ Reserves$_t$ to Total Assets$_{t-1}$ (in %)	1978	-0.01	2.82	-18.42	17.96
Δ Liquid Assets$_t$ (excl. Reserves) to Total Assets$_{t-1}$ (in %)	1978	-0.59	6.79	-26.68	29.24
Δ Loans$_t$ to Total Assets$_{t-1}$ (in %)	1976	-0.38	7.04	-25.19	33.49
Δ Total Assets$_t$ to Total Assets$_{t-1}$ (in %)	1978	-1.54	13.42	-56.71	36.75
Net Interest Margin (in %)	1978	1.99	1.41	0.09	16.35
ln 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
Net Fees and Commissions to Total Assets (in %)	1975	0.84	0.92	-0.36	9.20
Net Interest Income to Total Assets (in %)	1978	1.85	1.20	0.08	12.58
Total Regulatory Capital (in %)	1355	16.59	7.99	6.78	62.81
Loans to Total Assets (in %)	1976	57.67	20.56	2.06	92.40
Country-specific variables					
Inflation (in %)	1978	1.51	1.05	-0.94	5.08
GDP Growth (in %)	1978	0.26	2.66	-6.83	7.58
Δ Share of ECB-Funded Bank Liabilities (in pp)	1959	0.01	1.67	-2.38	5.20
Δ 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
Δ Firms' Credit Demand (Index)	1921	2.39	15.60	-31.25	30.00
Δ Overall Credit Standards (Index)	1532	-4.85	13.48	-40.00	27.08
Δ MFIs' Cost of Borrowing for Non-Financial Corporations (in pp)	1978	-0.42	0.80	-2.59	1.00
Euro area rates					
Δ Deposit Facility Rate (in pp)	1978	-0.43	0.83	-2.53	0.25
Δ Main Refinancing Rate (in pp)	1978	-0.55	0.82	-2.62	0.25

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.

	Δ Reserves to Total Assets of t-1 (in %)	Δ Liquid Assets (excl. Reserves) to Total Assets of t-1 (in %)	Δ Loans to Total Assets of t-1 (in %)	Δ Total Assets to Total Assets t-1 (in %)	Net Interest Margin (in %)	ln Assets	Deposits to Total Assets (in %)	Equity / Total Assets (in %)	Return on Average Equity (in %)	Net Fees and Commissions to Total Assets (in %)	Net Interest Income to Total Assets (in %)	Total Regulatory Capital (in %)	Loans to Total Assets (in %)
Δ $Reserves_t$ to Total $Assets_{t-1}$ (in %)	1.00												
Δ $Liquid\ Assets_t$ (excl. Reserves) to Total $Assets_{t-1}$ (in %)	-0.12	1.00											
Δ $Loans_t$ to Total $Assets_{t-1}$ (in %)	0.09	0.03	1.00										
Δ $Assets_t$ to Total $Assets_{t-1}$ (in %)	0.19	0.53	0.65	1.00									
Net Interest Margin (in %)	0.01	0.05	0.12	0.13	1.00								
ln 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						
Return on Assets (in %)	0.04	0.09	0.31	0.28	0.28	-0.02	0.05	1.00					
Return on Average Equity (in %)	0.00	-0.08	0.04	-0.06	0.28	-0.41	-0.24	0.19	1.00				
Net Fees and Commissions to Total Assets (in %)	0.00	-0.02	-0.01	-0.04	-0.02	-0.19	0.02	0.14	0.19	1.00			
Net Interest Income to Total Assets (in %)	0.00	0.01	0.07	0.07	0.97	-0.30	0.13	0.24	0.28	-0.05	1.00		
Total Regulatory Capital (in %)	-0.03	-0.09	-0.01	-0.16	0.11	-0.30	-0.15	0.13	0.66	0.12	0.13	1.00	
Loans to Total Assets (in %)	0.01	0.04	0.02	0.08	0.26	0.08	-0.07	0.01	-0.02	-0.21	0.30	-0.31	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 (in %)	Δ GDP (in %)	Δ Share of ECB-funded bank liabilities (in %)	Δ 10-Year Government Bond Yields (in %)	Δ of Country's Stock Index (in %)	Std. Dev. of Country's Stock Index (in %)	Δ Firms' Credit Demand	Δ Overall Credit Standards	Δ MFIs' Cost of Borrowing for Non-Financial Corporations (in %)
Inflation (in %)	1.00								
Δ GDP (in %)	0.25	1.00							
Δ Share of ECB-funded bank liabilities (in %)	0.30	-0.40	1.00						
Δ 10-Year Government Bond Yields (in %)	0.50	-0.02	0.40	1.00					
Δ of Country's Stock Index (in %)	-0.39	-0.26	-0.05	-0.49	1.00				
Std. Dev. of Country's Stock Index (in %)	0.08	-0.27	0.13	0.23	-0.14	1.00			
Δ Firms' Credit Demand	-0.46	-0.02	-0.36	-0.19	0.03	-0.12	1.00		
Δ Overall Credit Standards	0.44	0.44	0.07	0.13	-0.34	-0.14	-0.30	1.00	
Δ MFIs' Cost of Borrowing for Non-Financial Corporations (in %)	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 the 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 until 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.

	(1)	(2)	(3)	(4)	(5)
Explan. Var.\ Dep. Var.	**Δ Bank Reserves$_t$/Assets$_{t-1}$**				
Δ Deposit Facility Rate$_t$ × Net Interest Margin$_{t-1}$	0.828**	1.683**	0.760**	0.830**	1.505*
	(0.418)	(0.681)	(0.376)	(0.417)	(0.766)
Net Interest Margin$_{t-1}$	-0.023	0.078	0.010	-0.023	1.491
	(0.111)	(0.111)	(0.122)	(0.111)	(1.294)
Deposits to Assets$_{t-1}$	-0.033	-0.037	-0.036	-0.032	0.011
	(0.023)	(0.025)	(0.025)	(0.024)	(0.048)
ln Assets$_{t-1}$	-2.702**	-2.880**	-2.597**	-2.699**	-2.908
	(1.158)	(1.248)	(1.262)	(1.172)	(2.266)
Equity to Assets$_{t-1}$	-0.066*	-0.069*	-0.060	-0.066*	-0.336**
	(0.036)	(0.038)	(0.046)	(0.036)	(0.158)
Return on Assets$_{t-1}$	-0.140	-0.123	-0.154	-0.140	-0.261
	(0.115)	(0.114)	(0.123)	(0.116)	(0.223)
Δ Main Refinancing Rate$_t$ × Net Interest Margin$_{t-1}$	-0.838**	-1.680**	-0.781**	-0.839**	3.273
	(0.401)	(0.668)	(0.370)	(0.400)	(3.386)
Inflation$_t$	0.159	-0.037	0.196	0.160	0.257
	(0.207)	(0.230)	(0.225)	(0.207)	(0.538)
GDP Growth$_t$	-0.047	-0.069	-0.038	-0.047	-0.097
	(0.065)	(0.081)	(0.067)	(0.065)	(0.188)
Δ 10-Year Government Bond Yield$_t$ × Net Interest Margin$_{t-1}$		0.212***			
		(0.077)			
Δ 10-Year Government Bond Yield$_t$		-0.305			
		(0.251)			
Δ Share of ECB-Funded Bank Liabilities$_t$ × Net Interest Margin$_{t-1}$			-0.039		
			(0.039)		
Δ Share of ECB-Funded Bank Liabilities$_t$			0.050		
			(0.104)		
Deposits to Assets$_{t-1}$ × Dummy 2012-2014				-0.000	
				(0.006)	
Constant	44.827**	47.643**	43.501**	44.774**	49.443
	(19.008)	(20.508)	(20.833)	(19.290)	(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 (excluding 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 the 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 until 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.

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

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

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 given in the column header. Columns (1)-(3) contain results for the subsample of banks in non-GIIPS countries. Columns (4)-(6) contain results for the subsample of banks in GIIPS countries. Unreported 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.

	(1)	(2)	(3)	(4)	(5)	(6)
Explan. Var.\ Dep. Var.	**Δ Bank Reserves$_t$ /Assets$_{t-1}$**	**Δ Liquid Assets$_t$ /Assets$_{t-1}$**	**Δ Loans$_t$ /Assets$_{t-1}$**	**Δ Bank Reserves$_t$ /Assets$_{t-1}$**	**Δ Liquid Assets$_t$ /Assets$_{t-1}$**	**Δ Loans$_t$ /Assets$_{t-1}$**
	Non-GIIPS sample			*GIIPS sample*		
Δ Deposit Facility Rate$_t$ ×						
Net Interest Margin$_{t-1}$	1.089**	1.616	-2.556***	-0.370	-2.653	-2.116
	(0.493)	(1.465)	(0.800)	(1.158)	(5.067)	(3.207)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank and Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	1,496	1,496	1,494	482	482	482
R-squared	0.05	0.16	0.39	0.05	0.11	0.41
Number of Banks	353	353	352	353	163	163

Table 8: Regression result: The role of capitalization

This table shows regression results obtained from estimating equation (1) for the full sample of banks (panel a) and the subsample of banks located in non-GIIPS countries (panel b). The estimation period spans 2009-2014. The dependent variable is given in the column header. Columns (1)-(3) contain results for the subsample of bank observations, for which the capital ratio is smaller than or equal to the sample mean. Columns (4)-(6) contain results for the subsample of bank observations, for which the capital ratio is larger than the sample mean. Unreported 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) **Δ Bank Reserves$_t$ /Assets$_{t-1}$**	(2) **Δ Liquid Assets$_t$ /Assets$_{t-1}$**	(3) **Δ Loans$_t$ /Assets$_{t-1}$**	(4) **Δ Bank Reserves$_t$ /Assets$_{t-1}$**	(5) **Δ Liquid Assets$_t$ /Assets$_{t-1}$**	(6) **Δ Loans$_t$ /Assets$_{t-1}$**
a) Full sample						
	capital ratio < = full sample mean			*capital ratio > full sample mean*		
Δ Deposit Facility Rate$_t$ × Net Interest Margin$_{t-1}$	0.891	-0.677	-3.249**	1.605**	0.880	-3.042***
	(0.810)	(3.164)	(1.373)	(0.784)	(1.823)	(1.025)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank and Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	900	900	900	455	455	454
R-squared	0.04	0.08	0.47	0.10	0.15	0.37
Number of Banks	297	297	297	176	176	176
b) Non-GIIPS sample						
	capital ratio < = subsample mean			*capital ratio > subsample mean*		
Δ Deposit Facility Rate$_t$ × Net Interest Margin$_{t-1}$	1.508	-0.429	-2.679	2.103*	3.526	-3.212***
	(1.078)	(3.334)	(1.621)	(1.073)	(2.314)	(1.110)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank and Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	610	610	610	338	338	337
R-squared	0.05	0.08	0.46	0.14	0.20	0.41
Number of Banks	185	185	185	129	129	129

Table 9: Regression result: Alternative proxies for interest sensitivity of business model

This table shows regression results obtained from estimating a modified equation (1) for a sample of euro area banks. The dependent variable is given in the column header. The policy rates are interacted with a) the net interest margin, b) the loan share, c) the net interest income share in total assets, and d) the net fees and commissions share. The estimation period is 2009-2014. Control variables at the bank and country level are included in the estimation but not reported. 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.

	(1)	(2)	(3)	(4)
Explan. Var.\ Dep. Var.	**Δ Bank Reserves$_t$ /Assets$_{t-1}$**	**Δ Liquid Assets$_t$ /Assets$_{t-1}$**	**Δ Loans$_t$ /Assets$_{t-1}$**	**Δ Assets$_t$ /Assets$_{t-1}$**
a) Net Interest Margin				
Δ Deposit Facility Rate$_t$ × Net Interest Margin$_{t-1}$	0.828**	0.933	-2.314***	1.323
	(0.418)	(1.407)	(0.785)	(1.788)
Controls	Yes	Yes	Yes	Yes
Bank and Time Fixed Effects	Yes	Yes	Yes	Yes
Number of Observations	1,978	1,978	1,976	1,978
R-squared	0.04	0.12	0.39	0.40
Number of Banks	516	516	515	516
b) Loans to Total Assets				
Δ Deposit Facility Rate$_t$ × Loans to Total Assets$_{t-1}$	0.127***	0.236**	-0.501***	-0.128
	(0.041)	(0.108)	(0.054)	(0.161)
Controls	Yes	Yes	Yes	Yes
Bank and Time Fixed Effects	Yes	Yes	Yes	Yes
Number of Observations	1,977	1,977	1,976	1,977
R-squared	0.05	0.14	0.47	0.40
Number of Banks	515	515	515	515
c) Net Interest Income to Total Assets				
Δ Deposit Facility Rate$_t$ × Net Interest Income to Total Assets$_{t-1}$	0.853*	0.906	-3.187***	0.078
	(0.506)	(1.789)	(0.887)	(2.254)
Controls	Yes	Yes	Yes	Yes
Bank and Time Fixed Effects	Yes	Yes	Yes	Yes
Number of Observations	1,978	1,978	1,976	1,978
R-squared	0.05	0.12	0.39	0.40
Number of Banks	516	516	515	516
d) Net Fees and Commissions to Total Assets				
Δ Deposit Facility Rate$_t$ × Net Fees and Commissions to Total Assets$_{t-1}$	-1.357*	-2.058	3.571***	5.024
	(0.767)	(1.596)	(1.153)	(3.243)
Controls	Yes	Yes	Yes	Yes
Bank and Time Fixed Effects	Yes	Yes	Yes	Yes
Number of Observations	1,974	1,974	1,972	1,974
R-squared	0.04	0.12	0.39	0.41
Number of Banks	515	515	514	515

Table 10: Regression result: Simultaneous equations (3SLS)

This table shows regression results obtained from estimating the baseline specification (Tables 4-6, Column (1)) in a set-up of simultaneous equations. In Column (1), the estimates of the first stage regression with reserves as the 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. Here, 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)-(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.

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

Table 11: Regression result: Further robustness: Loans

This table shows robustness tests for the baseline specification (Column (1)). The dependent variable is the change in loans to assets in the preceding period. The estimation sample covers euro area banks and the period 2009-2014. 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 BLS are controlled for. Column (4) includes the change in MFIs' cost of borrowing for non-financial corporations. 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.

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