DISCUSSION PAPER

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The Impact of Quantitative Easing on Bank Loan Supply and Monetary Policy Implementation in the Euro Area

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Abstract

In March 2015, the Eurosystem launched its QE-programme. The asset purchases induced a rapid and strong increase in excess reserves, implying a structural liquidity surplus in the euro area banking sector. Against this background, the first part of this paper analyses the Eurosystem's liquidity management during *normal times*, *crisis times* and *times of too low inflation*. With a focus on the latter, the second part of this paper develops a relatively simple theoretical model in which banks operate under a structural liquidity surplus. The model shows that increasing excess reserves have no or even a contractionary impact on bank loan supply. As the newly created excess reserves are heterogeneously distributed across euro area countries, the impact of QE on bank loan supply may differ across countries. Moreover, we derive implications for monetary policy implementation. Increases in the central bank's main refinancing rate as well as in the minimum reserve ratio and decreases in the central bank's deposit rate develop expansionary effects on loan supply – contrary to the case in which banks face a structural liquidity deficit.

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1 Introduction

In March 2015, the Eurosystem[1] started implementing its large-scale asset purchase pro-
gramme – commonly referred to as Quantitative Easing (QE) – to address the risks of a
too prolonged period of low, temporarily even negative, inflation rates since the begin-
ning of 2013. The aim of this programme is to directly lower long-term interest rates
at times when (short-term) monetary policy interest rates are approaching the effective
lower bound, so that it is no longer possible to reach expansionary monetary policy stimuli
through conventional interest rate cuts.[2] By directly lowering long-term interest rates, the
Eurosystem wants to improve financing conditions for households and firms so that they
consume and invest more. Hereby, aggregate demand and thus also the price level are
intended to increase until the target inflation rate of less than, but close to, 2% is finally
reached again (European Central Bank, 2015).

There are various channels by which QE may be transmitted to the real economy.[3] In
this paper, we focus on the bank lending channel. The focus of early papers dealing with
this channel is on the relationship between bank deposits affected by a monetary policy
shock and bank loan supply (see e.g. Bernanke and Gertler, 1995; Kashyap and Stein,
1995; Mishkin, 1996). However, recent papers also explicitly consider the banking sectors'
excess reserve holdings in this context (see e.g. Rodnyansky and Darmouni, 2017; D'Avino,
2018; Lojschova, 2017). Bank reserves consist of deposits on banks' current accounts with
the central bank and currency physically held by banks. Excess reserves are defined as the
amount of commercial banks' current account balances (CAB) at their national central
bank in excess of the minimum reserve requirements (MRR). Excess liquidity is a concept
different from excess reserves and can be significantly larger, since banks' recourse to the
deposit facility is additionally taken into account in the calculation of excess liquidity.
However, to simplify matters, for our analysis we use the terms *excess liquidity* and *excess
reserves* interchangeably. We refer to them as all central bank overnight deposits beyond

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[1]The term "Eurosystem" stands for the institutions responsible for monetary policy in the euro area,
i.e. the European Central Bank (ECB) and the national central banks in the euro area. To simplify
matters, the terms ECB and Eurosystem are used synonymously in this paper.

[2]In January 2015, the interest rate on the ECB's main refinancing operations (MROs) was already
located at 0.05%, the interest rate on its deposit facility was already negative at -0.2%, and the interest
rate on the marginal lending facility amounted to 0.3% (data source: ECB).

[3]For a general description of different possible transmission channels in the context of the Eurosystem's
large-scale asset purchase programme, see e.g. Deutsche Bundesbank (2016a).

the MRR and hence do not make a distinction between whether they are held on a current account or in the deposit facility.

Due to the Eurosystem's asset purchases on a large scale, the amount of aggregate excess liquidity in the euro area increased from 200 billion euros in March 2015 to 1.9 trillion euros in December 2018 (corresponding to 17% of the annual euro area GDP). This excess liquidity is not homogeneously distributed across euro area countries. About 30% of total excess liquidity in the euro area are held solely in Germany, for example (data source: ECB). Holding excess liquidity is costly. In particular, the kind of "penalty interest rate" banks have to pay on excess liquidity[4] has caused a debate as to whether commercial banks may have an incentive to expand lending to reduce their costly excess liquidity holdings (see e.g. Keister and McAndrews, 2019). This is in line with the question of how far a QE-induced increase in bank deposits, and thus also in costly excess reserve holdings, leads to higher bank loan supply, i.e. whether there is a bank lending channel of QE.

The contribution of our paper to this debate is twofold. First, it analyses and compares the Eurosystem's liquidity management during *normal times*, *crisis times* and *times of too low inflation*. Focussing on the latter and considering the specific institutional characteristics of the QE-implementation in the euro area, we describe and analyse in detail the QE-induced creation of bank reserves and deposits and the causes of their heterogeneous distribution across euro area countries. Second, focussing on the *times of too low inflation*, the paper develops a theoretical model of a banking sector consisting of commercial banks offering loans to the non-banking sector and a central bank purchasing assets on a large scale from the non-banking sector. The model allows us to discuss three closely related issues: first, the impact of QE-induced increases in bank reserves and deposits on bank loan supply; second, the effect of a QE-induced heterogeneous distribution of excess reserves across banks on bank loan supply; and third, the consequences of a QE-induced structural liquidity surplus in the banking sector for the implementation of other monetary policy instruments.

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[4]Since June 2014 excess liquidity has been remunerated at a negative rate, currently (September 2019) at -0.5%. This interest rate has to be paid independently of whether this liquidity is held in the Eurosystem's deposit facility or on current accounts with the Eurosystem.

With respect to the first issue, we cannot document evidence of the presence of a bank lending channel in the sense that a QE-induced increase in bank deposits and reserves implies a positive impact on bank loan supply. We find that increasing excess reserves and deposits in the euro area banking sector have no or even a contractionary impact on bank loan supply. The impact will be contractionary if banks face increasing marginal costs of holding deposits due to, for example, agency or regulatory costs. Following the literature, we refer to these costs as balance sheet costs (see e.g. Martin et al., 2016). The strength of the contractionary effect increases in the banks' holdings of excess reserves. This leads us to the second issue. The banking sectors' QE-induced excess reserve holdings differ significantly across euro area countries. Consequently, increasing marginal balance sheet costs imply that the negative impact of QE on bank loan supply differs across euro area member states. Concerning the third issue, our model shows that conventional monetary policy measures will work in the opposite direction if the banking sector faces – for example, a QE-induced – structural liquidity surplus instead of a structural liquidity deficit.[5] Since October 2015 the reserves created through the Eurosystem's large-scale asset purchases have exceeded the banking sector's structural liquidity needs. Consequently, banks started to operate in an environment characterised by structural liquidity surplus. Our model reveals that in such an environment commercial banks' incentive to expand their loan supply will be strengthened if the central bank (i) increases the rate on its MROs, (ii) implements higher MRR for banks, and (iii) decreases the rate on its deposit facility.

The paper is organised as follows. Section 2 presents related literature. Section 3 proceeds with an overview of commercial banks' liquidity needs and liquidity provision by the Eurosystem in *normal times*, *crisis times* and in *times of too low inflation* and, with a focus on the latter, provides some stylised facts with regard to the effects of the implementation of the Eurosystem's QE-programme. Section 4 describes the model framework and derives banks' optimal loan supply to the non-banking sector. Implications for monetary policy implementation are discussed in Section 5. Section 6 concludes.

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[5]A banking sector facing a structural liquidity deficit has to rely on an ongoing liquidity provision by the central bank to cover its structural liquidity needs resulting from MRR and autonomous factors. In the euro area, banks faced such a structural liquidity deficit until October 2015. The Eurosystem provided the respective liquidity mainly through credit transactions, as its MROs.

2　Related Literature

Our paper contributes to two strands of literature. The first strand is primarily related to the literature on the bank lending channel of monetary policy transmission which is a subchannel within the credit channel. The credit channel theory states that credit market frictions, especially in the form of asymmetric information between lenders and borrowers, amplify conventional interest rate effects. The frictions drive a wedge between the cost of funds generated internally and the cost of funds raised externally, i.e. there is an external finance premium.[6] According to the credit channel theory, the direct effects of monetary policy on interest rates are amplified by changes in the external finance premium. The credit channel theory offers two explanation for this amplification: the balance sheet channel and the bank lending channel. While the former focusses on the impact of monetary policy on the borrowers' balance sheets,[7] the latter focusses on bank loan supply. The bank lending channel stresses that, for example, a contractionary monetary policy leads to a loss of deposits, forcing banks to rely on other, more costly liabilities. The bank loan supply curve shifts to the left, raising the external finance premium.[8]

More recent work attempts to assess the effects of central banks' large-scale asset purchase programmes (QE) in this context. There are various empirical studies that investigate the impact of QE on bank lending in general. Examples include Bowman et al. (2015) for Japan, Garcia-Posada and Marchetti (2016) for Spain, and Rodnyansky and Darmouni (2017) for the US showing different results. However, only limited attention

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[6]The external finance premium reflects deadweight costs linked with the principal-agent problem that typically exists between borrowers and lenders, such as the lender's expected costs of evaluation and monitoring, or the "lemons" premium that results from the fact that the borrower has better information than the lender with regard to its own prospects (Bernanke and Gertler, 1995).

[7]The main idea is that, e.g. a contractionary monetary policy deteriorates the borrower's financial position (lower cash flow due to higher interest payments, lower collateral value due to declining asset prices). The deterioration of the financial position increases agency costs, and thus the external finance premium.

[8]For a detailed description and discussion of the credit channel of monetary policy, see e.g. Bernanke and Blinder (1988) and Bernanke and Gertler (1995). Kashyap and Stein (1995) show that monetary tightening reduces lending by relatively small banks which have a very simple capital structure and are financed almost exclusively with deposits and common equity. Analogously, Campello (2002) provides evidence that contractionary monetary policy reduces the amount of loans made by banks that are unrelated to a large banking group. Kashyap and Stein (2000) and Kashyap et al. (2002) explain the same mechanisms for banks that hold fewer liquid assets, showing that such banks cannot protect their loan portfolio against monetary tightening simply by drawing down cash and securities. Kishan and Opiela (2000) and Gambacorta and Mistrulli (2004) carry out the analysis for banks with higher leverage ratios. They provide evidence that small, undercapitalised banks may not be able to offset a drain in demand deposits. Consequently, their loan supply will be more responsive to monetary policy shocks than that of larger, well-capitalised banks.

has been paid to assessing whether QE has worked its way through the economy via the bank lending channel, i.e. whether QE-induced increased levels of bank reserves and deposits imply an expansion of bank loan suply. For instance, Butt et al. (2014), looking at the UK experience, do not find significant effects of QE-induced increasing deposits in banks' balance sheets on bank lending. They argue that the deposits created through QE had a rather flighty nature. Giansante et al. (2019) employ a difference-in-differences estimation to assess the impact of QE-induced increases of bank reserves and deposits on bank lending. By comparing UK banks that received deposit injections due to the Bank of England's asset purchases, with those that did not, they find that "QE-banks" show no increase in bank lending compared to the "non-QE-banks". They even find a reduction of about 50% of customer/retail loans for "QE-banks" compared to "non-QE-banks".

The second strand of related literature deals with monetary policy implementation.[9] There is a long tradition of developing models to analyse monetary policy implementation in an environment with *scarce reserves*. The seminal contribution by Poole (1968) posits a downward-sloping demand curve for reserves and analyses how the Federal Reserve could target the desired Federal Funds Rate by manipulating the supply of reserves. Poole's idea of using a late payment shock, to which banks are exposed to, to introduce uncertainty into his stochastic bank reserve management model, has been used in various papers.[10] However, to date, only very few papers have attempted to study the effects of monetary policy in an environment with *excess reserves*, induced, for instance, by the central bank's large-scale asset purchases. Examples include Martin et al. (2013, 2016), Ennis (2018), and Williamson (2019). These papers consider so-called balance sheet costs of commercial banks. These costs, e.g. in the form of agency or regulatory costs, may occur and increase if a commercial bank's balance sheet increases, e.g. as a consequence of the central bank's large-scale asset purchases. Developing a general equilibrium macroeconomic model Ennis (2018) shows that due to these costs sufficiently large asset purchases imply that the tight link between bank reserves and the price level in the economy reemerges. Williamson (2019) uses a general equilibrium model with two banking sectors in which one banking

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[9]For a survey, see e.g. Friedman and Kuttner (2011). By describing and discussing different parts of a central bank's operational framework, Bindseil (2014) gives a broad survey of monetary policy implementation in times of non-crisis and crisis.

[10]See e.g. Furfine (2000), Bindseil et al. (2006), Whitesell (2006), Bech and Monnet (2016), and Bucher et al. (2019).

sector is exposed to balance sheet costs due to capital requirements. He shows, inter alia, that then the large-scale asset purchases can have redistributive effects and reduce welfare. The work by Martin et al. (2016), which is a very close reference to our paper, finds that due to bank balance sheet costs, large-scale asset purchases by the central bank may reduce bank lending. In their model, the government issues a fixed amount of bonds which are bought by the central bank and by households. The central bank funds its government bond purchases by issuing an equal amount of reserves. Households are endowed with a fixed amount of wealth which they invest in deposits, government bonds and/or storage. Households buy all the bonds not being purchased by the central bank. As long as commercial banks face no additional costs related to their deposit holdings and thus to the size of their balance sheet (balance sheet costs), the households' return on deposits is higher than their return on storage. Consequently, households invest the difference between their total wealth and their government bond holdings only in deposits, they hold no storage. An increase in the central bank's purchases of government bonds thus implies an increase in reserves, a decrease in the households' bond purchases and thus an increase in deposits. The increase in the households' deposits is equal to the increase in reserves issued by the central bank. The quantity of bank loans remains constant. However, if banks face balance sheet costs, they pass on these costs to the households by paying a lower return on deposits. For sufficiently large bond purchases by the central bank and thus sufficiently large reserves and deposit holdings, the balance sheet costs become so high and the return on deposits so low that households prefer to hold storage instead of deposits. In this case, bank reserves increase more than deposits and, considering the bank balance sheet constraint, hence partially crowd out bank lending. In contrast to the paper by Martin et al. (2016), we consider that the central bank as well as commercial banks create money in the form of deposits. Commercial banks create deposits by granting loans to the non-banking sector, the central creates deposits by purchasing bonds from the non-banking sector (QE). The induced increases in bank deposits imply higher balance sheet costs for banks. As a result, banks will reduce their loan supply to avoid additional increases in costly deposits.

Our paper combines these two described strands of literature. The novelty of our paper is that it provides a detailed description of the consequences of the specific QE implementation in the euro area for the commercial banks' liquidity situation which constitutes the base of a theoretical model that we develop. Considering main elements of the Eurosystem's operational framework, the model allows us to analyse the impact of QE-induced increasing excess liquidity on bank loan supply, as well as the implications for the implementation of conventional monetary policy instruments in an environment characterised by a structural liquidity surplus in the banking sector. We show that QE-induced increases in excess liquidity have no or a contractionary effect on bank loan supply and that, for instance, increases in the minimum reserve ratio and the MRO-rate as well as decreases in the deposit rate incentivise banks to expand their loan supply – contrary to the situation in which banks face a structural liquidity deficit.

3 Liquidity Needs of the Euro Area Banking Sector and Liquidity Provision by the Eurosystem

The Eurosystem's large-scale asset purchases (QE) led to the creation of bank reserves and bank deposits. This implied that since October 2015 the euro area banking sector has faced a structural liquidity surplus. The newly created reserves and deposits are heterogeneously distributed across euro area countries. Both the structural surplus and the heterogeneous distribution has important implications for bank loan supply and for the effects of conventional monetary policy as revealed by our model analysis in Section 4. To get a better understanding of the institutional environment thus used in Section 4, Section 3.4 describes and analyses in detail how bank reserves and deposits are created in the context of the Eurosystem's QE-programme and why they are heterogeneously distributed across euro area countries. To emphasise the importance of the QE-induced change in the institutional environment for the euro area banks' liquidity management and thus for their loan supply as well as for the effects of conventional monetary policy, Section 3.1 gives a brief overview of the euro area banking sector's liquidity needs in

general, whereas Section 3.2 and Section 3.3 briefly describe the banks' specific liquidity needs and the liquidity provision by the Eurosystem before QE was introduced.

3.1 Liquidity Needs of the Euro Area Banking Sector

In the euro area, the banking sectors' needs for reserves primarily result from the MRR imposed by the ECB and so-called autonomous factors. Note that MRR are remunerated at the ECB's main refinancing rate. Autonomous liquidity factors can be divided into liquidity providing factors, such as net foreign assets, and absorbing factors, such as banknotes in circulation or government deposits. They are called autonomous factors since they are beyond the control of the ECB. Instead, they are determined by the behaviour of the public or by institutional arrangements. In the euro area, net autonomous factors are positive, i.e. the sum of liquidity absorbing factors is larger than the sum of liquidity providing factors. MRR and positive net autonomous factors imply a structural need for reserves of the euro area banking sector. Interbank transactions due to, for example, deposit transfers between customers of different banks, are settled to a large part via the banks' reserve accounts at the central bank. Consequently, a bank may end up with a reserve deficit, another bank with a surplus. If there is a functioning interbank market for reserves, banks will be able to balance their different individual liquidity needs, i.e. there will be no need for reserves going beyond the structural need of the banking sector. However, if the interbank market does not function properly, banks with a liquidity deficit have to take recourse to the central bank's lending facility. The Eurosystem offers two standing facilities, a lending facility and a deposit facility, which allow banks to balance their overnight liquidity needs with the rate on the deposit facility being lower than the rate on the lending facility. To avoid the relatively costly use of the lending facility, banks may want to hold precautionary liquidity. This means that there may be a demand for reserves beyond the structural need due to MRR and autonomous factors.[11]

The reasons why banks want to hold reserves (MRR, cash withdrawals, precautionary liquidity) reveal that bank deposits are a crucial determinant of bank demand for reserves: bank deposits determine the reserve requirements; they determine the cash withdrawals,

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[11]Developing a theoretical model, Bucher et al. (2019) show that interbank market frictions may imply that banks will start to hold precautionary liquidity.

as people usually want to hold cash and deposits in a certain ratio; and they determine the demand for precautionary liquidity, as usually banks' demand for precautionary liquidity increases in their deposits (see Bucher et al. (2019)). When granting loans, commercial banks create deposits. This means that granting loans goes along with an increase in demand for reserves. This creates a link between monetary policy and bank loan supply, as the central bank, being the monopoly producer of reserves, determines the costs of reserves and the quantity of reserves available to the banking sector.

3.2 Normal Times

Until the collapse of the investment bank Lehman Brothers in September 2008, a period to which we refer to as "normal times", the interbank market functioned properly and thus allowed for an efficient distribution of reserves across banks, in principle. The liquidity needs of the euro area banking sector thus corresponded to its structural liquidity deficit resulting from MRR and autonomous factors. There was no need for additional reserves, e.g. for precautionary holdings of liquidity due to a malfunctioning interbank market (Eser et al., 2012). Until September 2008, the Eurosystem provided the banking sector in principle with reserves in amounts equal to the banking sector's structural liquidity deficit. It provided this liquidity mainly through its MROs. MROs are regular liquidity-providing credit transactions with a frequency and maturity of typically one week. These credit transactions have to be based on adequate collateral. The interest rate on these credit operations is the MRO-rate. The interest rates on the two central bank's standing facilities form a corridor around the MRO-rate, see Figure 1.[12]

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[12]For a general documentation on the implementation of standard monetary policy by the Eurosystem, see European Central Bank (2012a).
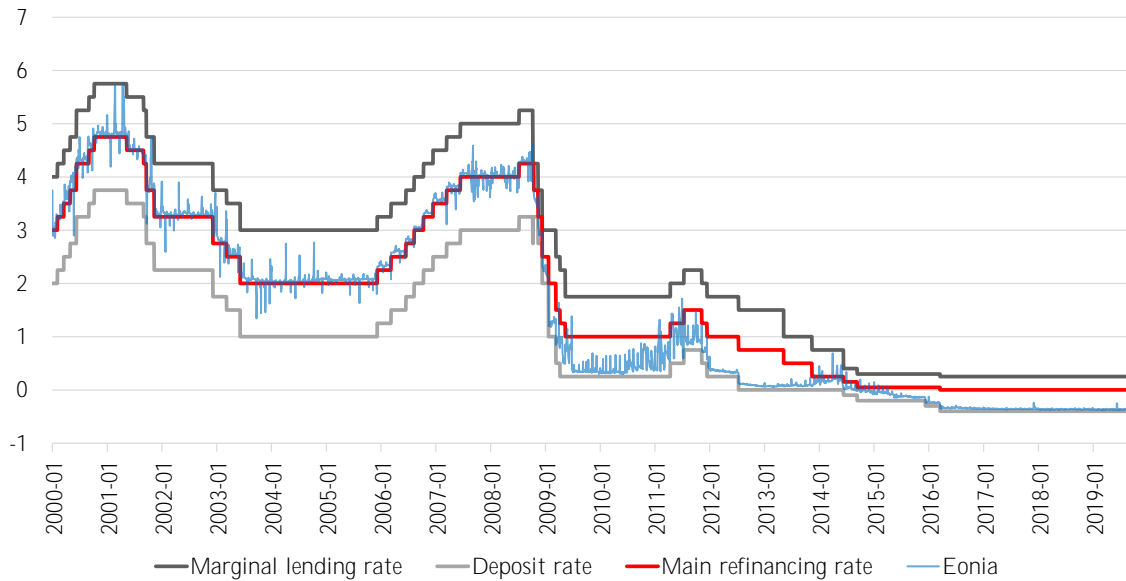
Figure 1: ECB key interest rates and the euro overnight unsecured interbank rate (on a daily basis, in %). Data Source: ECB.

Figure 2 illustrates the development of the Eurosystem's balance sheet since 2008. Components providing liquidity to the banking sector are indicated in the upper area, whereas liquidity absorbing components are mapped in the lower area. Prior to September 2008, the banking sector's structural liquidity deficit (pink line) was quite perfectly covered by the ECB's open market operations (blue line) so that liquidity conditions in the euro area were balanced.

The facts that, first, the Eurosystem almost exactly satisfied the banking sector's aggregate liquidity needs and that, second, a functioning interbank market smoothly redistributed reserves between banks with an individual surplus and those with an individual deficit, implied that prior to September 2008 neither the lending nor the deposit facility were used systematically and that the interbank rate (EONIA)[13] fluctuated closely around the MRO-rate (see Figure 1). Consequently, there were two main monetary policy instruments influencing bank loan supply in the euro area: the MROs, as the MRO-rate determined the costs of borrowing the necessary reserves, and the MRR, as the reserve ratio determined the necessary quantity of reserves. In such a "normal-times scenario", an increase in the MRO-rate and/or the reserve ratio makes granting bank loans more

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[13]The EONIA (Euro OverNight Index Average) is the effective overnight reference rate for the euro area. It is computed as a weighted average of overnight unsecured lending transactions between banks in the euro area interbank market.

costly, i.e. it is a contractionary monetary policy impulse. The rates on the central bank's facilities serve to stabilise the interbank rate but they have no systematic effect on bank loan supply.
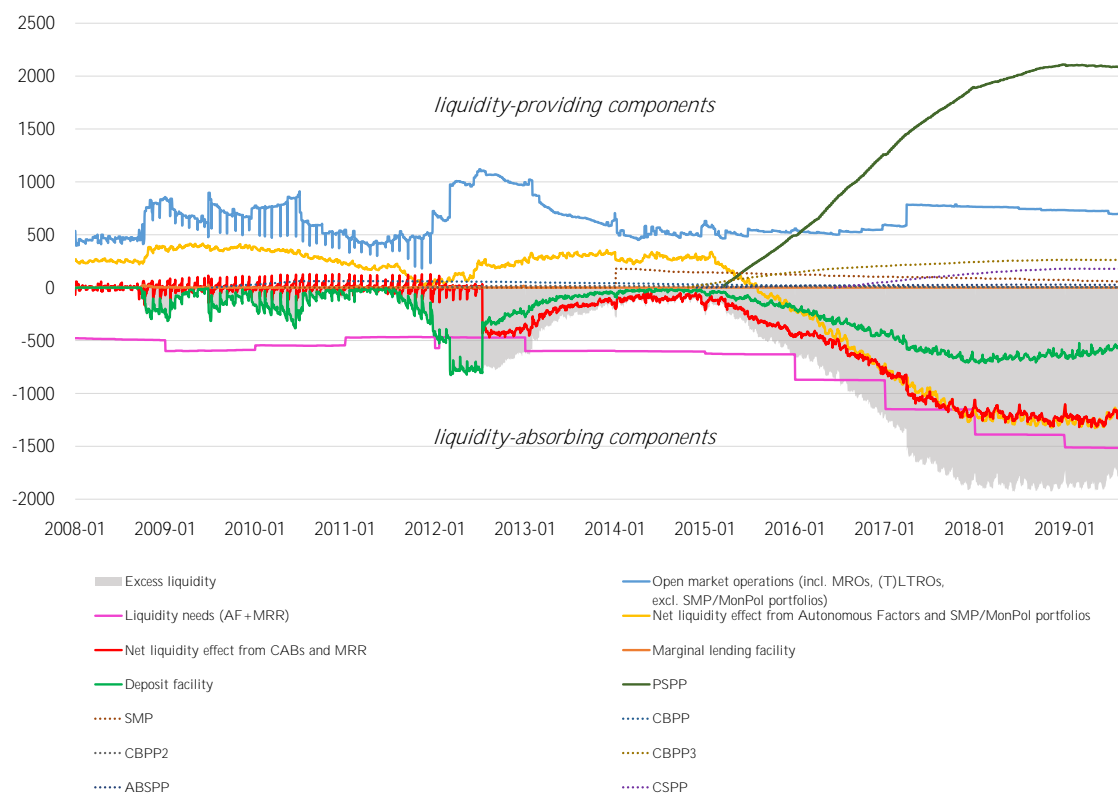

Figure 2: Liquidity provision and absorption through the Eurosystem – The central bank's balance sheet including volumes of non-standard monetary policy measures (on a daily basis, in billion euros). Data Source: ECB.

3.3 Crisis Times

During the financial crisis, which peaked in September 2008 with the collapse of Lehman Brothers, and during the subsequent sovereign debt crisis, the banks' aggregate demand for reserves significantly exceeded their structural need for reserves. One reason was that increased levels of distrust and risk perception plus increased informational asymmetries led to funding stress in the banking sector. Especially during the sovereign debt crisis, capital flight from banks in lower-rated countries to banks in higher-rated countries ("safe-haven-flows" and "flight-to-quality-phenomena") led to funding stress in the banking sectors of lower-rated countries. To substitute for the loss in market-based funding,

banks in lower-rated countries participated more significantly in the Eurosystem's refinancing operations. Another reason for the banks' aggregate demand for reserves going beyond their structural need for reserves was that the overnight interbank market was no longer functioning properly.[14] Also, due to increased levels of distrust and risk perception as well as increased informational asymmetries, banks with a surplus of liquidity refused to lend in the interbank market to banks with a liquidity deficit. The use of the central bank's deposit facility was instead the more attractive alternative for potential interbank lenders. Moreover, as the interbank market was no longer able to smoothly redistribute liquidity, banks generally built up liquidity buffers. They wanted to hold more reserves than necessary to fulfill the MRR and to cope with autonomous factors, i.e. they started to hold liquidity for precautionary reasons. The Eurosystem fully satisfied the increased demand for reserves (subject to collateral availability) by implementing a set of non-standard monetary policy measures such as fixed rate tender procedures with full allotment in its refinancing operations from October 2008 onwards as well as by launching two three-year longer-term refinancing operations (LTROs) in the years 2011 and 2012.[15] As a result, aggregate excess liquidity started to emerge.

The costs and benefits of holding precautionary liquidity are determined by the rates on the central bank's facilities. As banks create deposits by granting loans and since the demand for precautionary liquidity increases in bank deposits, the rates on the central bank's facilities have an influence on bank loan supply. With its facilities the Eurosystem thus had, besides the MROs and the MRR, a further instrument at hand to influence bank loan supply during that crisis time. In such a "crisis-time scenario", narrowing the corridor that the rates on the facilities form around the MRO-rate decreases the costs of holding precautionary liquidity, so that an increase in the rate on the deposit facility has a positive impact on bank loan supply.[16]

Figure 2 illustrates the strong increases in the recourse to the deposit facility (green line), in the liquidity provided through open market operations (blue line) and the in-

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[14]For a recent documentation on stress in the overnight interbank market in the euro area over the course of the financial and sovereign debt crisis in Europe, see e.g. Frutos et al. (2016).

[15]For a description of the implementation of monetary policy by the Eurosystem in response to the financial and sovereign debt crisis, see e.g. European Central Bank (2009, 2010, 2011, 2012b, 2014).

[16]For a theoretical analysis of the consequences of interbank market friction-induced holdings of precautionary liquidity on bank loan supply and monetary policy implementation, see Bucher et al. (2019).

creased levels of excess liquidity (grey shadowed area). Excess liquidity is the sum of commercial banks' current account balances at their national central bank in excess of the MRR (red line) plus their recourse to the deposit facility of the ECB (green line). It should be noted that the creation of excess liquidity during the financial crisis and the sovereign debt crisis was entirely demand-driven (Baldo et al., 2017): the ECB satisfied the increased liquidity demand of the banking sector. Until the beginning of 2015 most banks made use of the LTROs premature repayment option which is represented in Figure 2 by a decrease in banks' current account holdings. As a consequence, reserves in excess of the structural liquidity deficit of the banking sector decreased significantly.
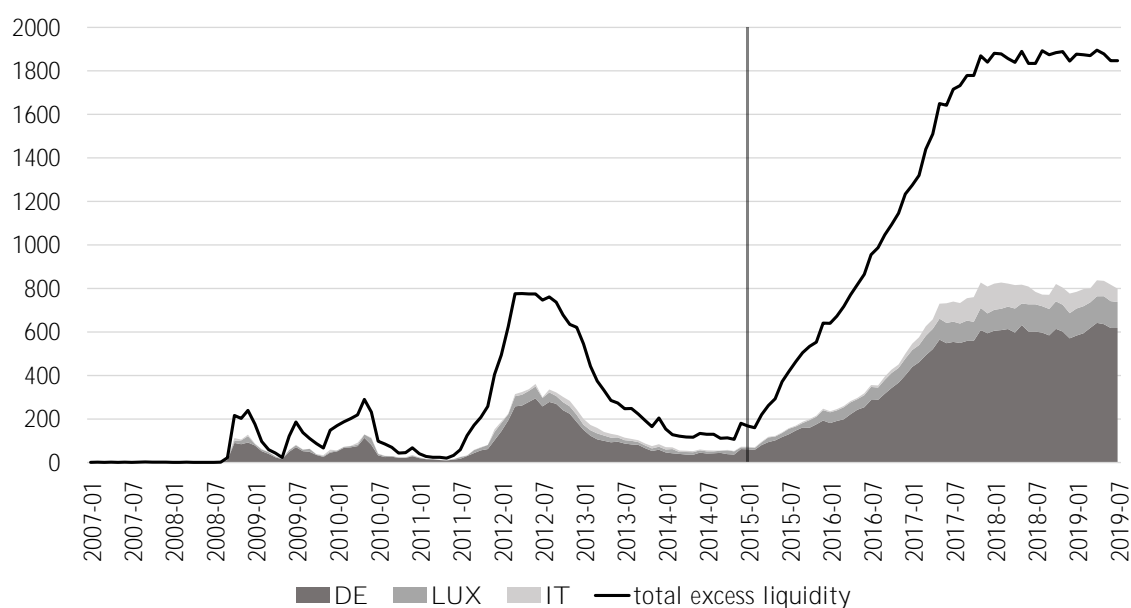

Figure 3: Accumulation of excess liquidity at specific national central banks in billion euros (maintenance period averages, vertical line indicates the APP start).
Data Source: Eurosystem.

Figure 3 reveals that during crisis times excess liquidity was heterogeneously distributed across euro area countries. The main driver for the heterogeneous distribution of excess liquidity was capital flight (so-called "flight-to-quality" phenomena or "safe-haven-flows") from lower-rated euro area countries towards higher-rated euro area countries such as in particular Germany, the Netherlands and France. Domestic households and firms, financial and non-financial, in lower-rated countries preferred to hold their deposits abroad and at the same time foreign households and firms, financial and non-financial, refused to provide (further) liquidity due to increased levels of risk and distrust. As a result, banks

in lower-rated countries were concerned by difficulties in financing themselves. Funding-stressed banks in these countries participated more significantly in the Eurosystem's refinancing operations to close emerging funding gaps and to build up liquidity buffers. The total amount of excess liquidity increased. However, the provided liquidity accumulated via cross-border flows of this liquidity from lower-rated countries towards higher-rated countries in countries that were least concerned by the crisis, thereby inducing a heterogeneous distribution of this excess liquidity.[17]

3.4 Times of "Too Low" Inflation

3.4.1 Implementation of QE

Due to a persistently low inflation rate in the euro area and monetary policy rates approaching their effective lower bound,[18] the ECB's Governing Council announced the implementation of the so-called Expanded Asset Purchase Programme (APP) in January 2015. The aim of this non-standard monetary policy measure is to safeguard the Eurosystem's primary objective of price stability and to ensure an appropriate monetary policy transmission mechanism (European Central Bank, 2015). The APP includes all programmes under which both private and public sector securities are purchased. It consists of the Corporate Sector Purchase Programme (CSPP), the Public Sector Purchase Programme (PSPP), the Asset-Backed Securities Purchase Programme (ABSPP) and the Third Covered Bond Purchase Programme (CBPP3). The PSPP represents by far the largest component of the APP covering a share of approximately 83% of all bought securities under the APP (European Central Bank, 2019a). The ECB's Governing Council stressed that it intends to carry out securities purchases until a sustained adjustment in the path of inflation is reached that is consistent with its aim to achieve inflation rates below, but close to, 2% over the medium term (European Central Bank, 2017).[19]

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[17]For a more detailed description of the heterogeneous distribution of excess liquidity across euro area countries during the financial and sovereign debt crisis, see Baldo et al. (2017).

[18]In January 2015 the MRO-rate was already at 0.05% and the rate on the deposit facility at -0.02% (see Figure 1).

[19]Initially, between March 2015 and March 2016 the monthly volume of net purchases of public and private securities amounted to 60 billion euros. It then increased to 80 billion euros between April 2016 and March 2017. From April 2017 until December 2017 it declined again to 60 billion euros. Between January and September 2018 monthly net purchases to the value of 30 billion euros were conducted. After September 2018 the monthly pace of net asset purchases was reduced to 15 billion euros until the end of December 2018, when net asset purchases were stopped for the time being. In September 2019 the ECB's

3.4.2 QE-Induced Creation of Excess Liquidity

When paying for the acquired APP securities, the Eurosystem creates reserves, meaning that the amount of central bank liquidity in the financial system, and therefore already existing excess liquidity, mechanically increase. From the launch of the APP in March 2015 until December 2018, aggregate excess liquidity increased from 200 billion euros to 1.9 trillion euros (see grey area in Figure 2). The dark green line in Figure 2 demonstrates that since July 2016 the liquidity exclusively created through the asset purchases within the PSPP has already overcompensated the structural liquidity needs of the banking sector and has hence continuously pushed up the level of aggregate excess liquidity (grey area).[20] This implied that since October/November 2015 the euro area banking sector has been operating in an environment characterised by a structural liquidity surplus. This means that from this date onwards, banks have not had to rely on the central bank's refinancing operations anymore to cover their structural liquidity deficit resulting from MRR and autonomous factors.[21] The banking sector has no longer been able to entirely eliminate excess liquidity by decreasing its borrowing from the ECB. Even if no bank borrowed from the ECB, there would still be excess liquidity despite banks' increased liquidity needs resulting from net autonomous factors.[22] In contrast to the surge of excess liquidity during the financial and sovereign debt crisis, the surge of excess liquidity within the APP period cannot be interpreted primarily as an indicator of financial market stress but is a result of the APP. Compared with the period of the financial and sovereign debt crisis, the

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Governing Council decided to relaunch the APP by purchasing again private and public sector securities at a monthly net volume of 20 billion euros. For further technical information concerning the implementation of the APP, see e.g. European Central Bank (2019c).

[20]The three dotted lines represent the other components of the APP. They obviously play a subordinate role compared with the PSPP volume.

[21]We determine the date on which the euro area banking sector was exposed to a structural liquidity surplus for the first time by calculating the net liquidity effect from MRR, autonomous factors and the ECB's monetary policy portfolio (consisting of the SMP, CBPP1, CBPP2, CBPP3, ABSPP, PSPP, CSPP). A negative value indicates that the scope of the monetary policy portfolio already exceeds banks' structural liquidity needs so that banks, in general, would not need to demand additional liquidity in open market operations to cover their liquidity needs. This was the case, for the first time, in October 2015.

[22]The reasons for the persistent increase in net autonomous factors since January 2016 are numerous. First, shrinking net currency reserves and the temporal appreciation of the euro against the dollar decreased the value of net foreign assets which reduced the liquidity providing component of autonomous factors. Second, banknotes in circulation and government deposits increased which enlarged the liquidity absorbing component of autonomous factors so that, in sum, net autonomous factors increased (Deutsche Bundesbank, 2018; European Central Bank, 2018).

creation of excess liquidity under the APP is a supply-driven phenomenon (Baldo et al., 2017).

3.4.3 Heterogeneous Distribution of Excess Liquidity

Figure 3 demonstrates that also during the APP period, i.e. since 2015, excess liquidity has been heterogeneously distributed across euro area countries. About 30% of total excess liquidity is held exclusively in Germany. Alvarez et al. (2017) and Baldo et al. (2017) show that excess liquidity predominantly accumulates in Germany, the Netherlands, France, Finland and Luxembourg with about 80-90% of total excess liquidity being held in these countries, whereas holdings of excess liquidity in Italy, Portugal or Spain, for example, are much less pronounced. The reason for this heterogeneous distribution of excess liquidity across euro area countries is threefold.

First, within the PSPP, national central banks purchase domestic government bonds in accordance with their share in the ECB's capital key.[23] Since Germany and France are most concerned by the ECB's capital key with 26% and 20% respectively, excess liquidity accumulates especially in these two countries (European Central Bank, 2019b). The second reason for excess liquidity accumulating mostly in Germany is that the ECB itself (with a share of 10% of the total PSPP purchase volume) purchases securities under the PSPP and that, as a technical particularity, the ECB's transactions are carried out through the Deutsche Bundesbank. The third reason is that the APP transactions are predominantly settled via only a few financial centres or financial gateways, in which the APP-induced creation of reserves consequently takes place. Thus, most of the excess liquidity created through the APP purchases accumulates in only a few countries (Baldo et al., 2017).

With respect to the latter, on which we focus in this paper, consider the following example for illustrative purposes (see Figure 4): the Banca d'Italia purchases Italian government bonds from a counterparty[24] resident outside the euro area. In order to participate in this cross-border transaction, the counterparty needs access to the TARGET2 payment

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[23]Bonds issued by recognised agencies, regional and local governments, international organisations and multilateral development banks located in the euro area are also allowed to be purchased under the PSPP but play a far less significant role in this context (European Central Bank, 2019a).

[24]APP counterparties are defined as the set of financial institutions from which central banks directly purchase securities. Very often, counterparties act as intermediaries for initial, underlying security owners (Eisenschmidt et al., 2017).

system.[25] As an example, we consider a UK-based counterparty that uses a correspondent German bank as an access point for TARGET2.[26] In this case, the securities purchase of the Banca d'Italia implies that both the Banca d'Italia and the Bundesbank are involved in a cross-border payment transaction leading to an increase in reserves in the German banking sector. This process can be described in detail as follows. The Banca d'Italia obtains the respective amount of government bonds and the UK-APP counterparty's deposits increase at the expense of its government bond holdings. As the UK-APP counterparty has its deposit account with a German commercial bank, the reserves of the German commercial bank, and thus the respective liability item of the Bundesbank's balance sheet, increase. The offsetting asset item of the Bundesbank's balance sheet is a TARGET2 claim on the ECB. The Banca d'Italia, on the other hand, has a TARGET2 liability towards the ECB. The increase in the Bundesbank's positive TARGET2 balances and the increase in the excess reserves of the German banking sector are thus a consequence of the bond purchases by the Banca d'Italia from non-domestic counterparties which have their deposit account with a German commercial bank. The consolidated balance sheet of the Eurosystem demonstrates that the Eurosystem's government bond holdings and reserves in the euro area have increased.

This example thus illustrates that the location of the TARGET2 account of banks selling securities to the Eurosystem is most indicative of the likely point of origin of QE-induced reserves and thus excess liquidity. Due to the fact that most of the non-euro area APP counterparties access TARGET2 via the Bundesbank, Germany absorbs a large share of the liquidity created through the asset purchases within the Eurosystem's PSPP.

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[25]TARGET (Trans-European Automated Real-time Gross Settlement Express Transfer System) balances are intra-Eurosystem assets and liabilities on the central banks' balance sheets. They typically result from net cross-border payments in the form of central bank reserves via the TARGET2 payment system. TARGET2 is the real-time gross settlement system owned and operated by the Eurosystem. It settles euro-denominated payments continuously on an individual transaction-by-transaction basis without netting (Eisenschmidt et al., 2017).

[26]Around 50% of the overall purchase volume is conducted with UK-based banks that access TARGET2 via the Deutsche Bundesbank (Alvarez et al., 2017).

Bundesbank

A	L
TARGET2 ↑	Reserves ↑

Banca d'Italia

A	L
Government bonds ↑	TARGET2 ↑

ECB

A	L
TARGET2 Italy ↑	TARGET2 Germany ↑

Eurosystem

A	L
Government bonds ↑	Reserves ↑

Commercial bank (Germany)

A	L
Reserves ↑	Deposits^{UK} ↑

APP-Counterparty (UK)

A	L
Government bonds ↓	
Deposits^{UK} ↑	

MFI sector consolidated (incl. Eurosystem)

A	L
Government bonds ↑	Deposits^{UK} ↑

Figure 4: APP implementation – Stylised balance sheets of key financial market participants.

Note in this context that around 80% of APP purchases by volume were purchased from counterparties that are not resident in the same country as the purchasing national central bank, and about 50% of APP purchases by volume occurred with counterparties belonging to banking groups whose head institution was located outside the euro area, most of them being resident in the UK (Baldo et al., 2017). Note that this third reason for the heterogeneous distribution of excess liquidity is closely connected to the development of the TARGET balances that rose with the strong increase in excess liquidity during the APP period.[27]

3.4.4 Creation of Bank Deposits

Figure 4 also shows that the increase in excess reserves of the commercial bank that has the TARGET2 access (in our example the German commercial bank), is in line with an increase in deposits of that bank. If the Italian central bank buys Italian government bonds from a UK counterparty, and if this counterparty has its TARGET2 access via a German commercial bank, the German bank will receive the respective payment in the form of reserves from the Italian central bank via the German central bank and will credit the amount on the counterparty's deposit account. Consequently, the asset purchase of the Italian central bank implies the creation of deposits in the German banking sector.

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[27]For details see e.g. (Eisenschmidt et al., 2017).

If a national central bank purchases assets from the domestic money-holding sector – principally private households and private corporations – domestic bank deposits are created. If, for example, the Italian central bank buys government bonds from the Italian non-banking private sector, the commercial bank of the respective household/firm is involved. The commercial bank will receive the respective payment in the form of reserves from the Italian central bank and will credit the respective amount to the household's/firm's current account, i.e. the deposits of the Italian banking sector will increase (see also Deutsche Bundesbank, 2016b).

Consequently, if the Eurosystem buys government bonds from the non-banking sector, the deposits and reserves of the euro area banking sector will increase. If the assets are bought by a national central bank from the domestic non-banking sector, reserves and deposits in the domestic banking sector will increase. If they are bought outside the respective country, reserves and bank deposits will increase in the banking sector of that country in which the respective counterparty (or its bank) has access to the TARGET2 system. Note that in the ECB statistics, here, the MFI balance sheet statistics including the Eurosystem, QE purchases of government bonds from the non-banking sector lead to an increase in the item "securities-based lending to euro area general government" on the asset side of the consolidated balance sheet of the MFI sector. We argued above that on the liability side the purchases imply an increase in bank deposits. However, the MFI statistics distinguish between bank deposits of euro area and non-euro area residents. If the seller is a resident of the euro area, the liability item "deposits of euro area residents held at euro area commercial banks" will be affected. If the seller is a non-euro area resident, the liability item "liabilities of euro area MFIs (excluding the Eurosystem) towards non-euro area residents" will be concerned (see also Avdjiev et al., 2019; Deutsche Bundesbank, 2016b). Both items have increased since 2015 which indicates the positive relationship between QE-asset purchases and the increase in deposits of euro area and non-euro area residents at euro area commercial banks. Note that the "liabilities of euro area MFIs (excluding the Eurosystem) towards non-euro area residents" have especially

shown a pronounced increase since 2015.[28]

4 Model

The aim of our model analysis is to shed some light on how QE-induced increases in bank reserves and deposits affect bank loan supply and to discuss the implications of these increases for the implementation of monetary policy instruments other than QE. The model reveals that the QE-induced increases in reserves and deposits have no, or a contractionary effect, on bank loan supply. The effect will be contractionary if banks are facing increasing marginal balance sheet costs. Furthermore, the model shows that these costs in combination with a specific implementation of QE imply that the impact of this monetary policy measure on loan supply differs across banks. Moreover, the model reveals that conventional monetary policy measures, such as changes in key central bank interest rates and in the required reserve ratio, will have the exact opposite effect on bank loan supply if banks operate under a structural liquidity surplus instead of a respective deficit.

4.1 Institutional Environment

Our model considers main institutional aspects described in the previous sections relevant for euro area banks: banks are required to hold minimum reserves and have to cope with cash withdrawals, i.e. the banking sector faces a structural need for reserves. However, there are excess reserves in the banking sector which imply that banks do not have to borrow additional liquidity from the central bank. The structural need for reserves can be more than satisfied by the already existing reserves in the banking sector, i.e. banks operate in an environment characterised by a structural liquidity surplus. The QE-induced large amounts of excess reserves in the euro area banking sector imply that neither the interbank market for reserves nor the Eurosystem's MROs play a significant role for the banks' liquidity management anymore.[29] Therefore, we refrain from modelling an inter-

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[28]For the respective time series see Deutsche Bundesbank statistics at: `https://www.bundesbank.de/dynamic/action/en/statistics/time-series-databases/time-series-databases/745564/745564?listId=outstanding_amounts_30` and `https://www.bundesbank.de/dynamic/action/en/statistics/time-series-databases/time-series-databases/745564/745564?listId=outstanding_amounts_49`.

[29]The aggregate trading volume in the overnight interbank market currently (September 2019) amounts to 2 billion euros while it fluctuated around 30 billion euros in January 2015. The volume of the ECB's main

bank market or refinancing operations with the central bank. In our model, the central bank buys assets from the non-banking sector on a large scale (QE). These asset purchases imply the creation of bank reserves and deposits. The structural liquidity surplus in the banking sector increases. In an extension of our model, we also consider the case in which two national central banks (within a currency union) buy government bonds from institutions outside the union, whereas the settlement of both purchases takes place in only one country. Consequently, in our model analysis, we also capture the case of a QE-induced heterogeneous distribution of bank reserves and deposits across euro area countries described in Sections 3.4.3 and 3.4.4.

4.2   Setup

In our economy there is a central bank, a continuum of measure one of risk-neutral commercial banks and a large number of bank customers. In a first step, we assume that all commercial banks are identical, which allows us to consider one representative commercial bank. Bank customers can be divided into households, firms and foreign investors. For the sake of simplicity, we subsume them under the term non-banking sector.

Our model is a one-period model. At the beginning of this period, the non-banking sector is endowed with an amount of government bonds B. Within the period, the central bank buys the government bonds from the non-banking sector (QE). These asset purchases imply an increase in the bank's reserve holdings R as well as in its deposits D^{QE}, i.e. they imply the creation of money (see also Section 3.4.4).[30] Note that this creation of money in the form of deposits by the central bank does not take place when conventional monetary policy instruments are employed. Then, only commercial banks create money in the form of deposits by granting loans to the non-banking sector. One part of the newly created

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refinancing operations decreased from about 300 billion euros at the peaks of the financial and sovereign debt crisis to 120 billion euros in January 2015 and to currently (September 2019) below 5.5 billion euros (data source: ECB).

[30]Euro area statistics distinguish between bank deposits of euro area and non-euro area residents (see Section 3.4.4). However, in our model we do not make this distinction – D^{QE} are QE-created bank deposits independently of their owner.

money remains as deposits D^{QE} in the banking sector, the other part is withdrawn as cash C^{QE}, so that

$$B = C^{QE} + D^{QE}. \tag{1}$$

The non-banking sector wants to hold cash and deposits in a certain ratio. This currency ratio is given by $b = C^{QE}/D^{QE}$, i.e.

$$C^{QE} = bD^{QE}. \tag{2}$$

Considering (1) and (2), we get

$$D^{QE} = \frac{B}{1+b}. \tag{3}$$

The bank makes loans L to the non-banking sector by crediting the respective amount to the deposit account, i.e. the commercial banks also create money. Consequently, the non-banking sector's deposits increase. One part of these deposits remains as deposits D^L in the banking sector, the other part is withdrawn as cash C^L, so that

$$L = C^L + D^L. \tag{4}$$

Again, the non-banking sector wants to hold cash and deposits in a certain ratio. This currency ratio is given by $b = C^L/D^L$, i.e.,[31]

$$C^L = bD^L. \tag{5}$$

Considering (4) and (5), we get

$$D^L = \frac{L}{1+b}. \tag{6}$$

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[31]Note that $b = \frac{C}{D} = \frac{C^L}{D^L} = \frac{C^{QE}}{D^{QE}}$.

For the bank's total deposits D we thus have

$$D = D^L + D^{QE}. \tag{7}$$

Figure 5 illustrates the change in the balance sheets during the period under consideration:

The central bank implements QE:

A	NBS	L		A	Comm. Bank	L		A	Central Bank	L
D^{QE}				$R\{$ ER		D^{QE}		B		R
C				RR						C
(-B)										

The commercial bank grants loans to the non-banking sector (NBS):

A	NBS	L		A	Comm. Bank	L		A	Central Bank	L
D^L		L		L		D^L		B		R
D^{QE}				R		D^{QE}				C
C										

Figure 5: Change in balance sheet positions of financial market participants.

At the beginning of the period, the non-banking sector (NBS) is endowed with bonds B. In a next step, by implementing QE the central bank buys these bonds, which leads to an increase in bank deposits D^{QE} and bank reserve holdings R. Furthermore, there is an increase in the currency in circulation C. Next, the bank makes loans L to the non-banking sector. As the bank credits the respective amount to its customers' deposit accounts, bank deposits (D^L) increase again. This induces higher MRR for the bank so that the bank's excess reserves decrease. Currency in circulation increases as well, since a certain proportion of the created deposits is withdrawn as cash by the bank's customers.

Managing deposits is costly for the bank. These costs are assumed to increase in D at an incremental rate:

$$G = \frac{1}{2}\gamma D^2. \tag{8}$$

This captures the idea of existing agency and/or regulatory costs, e.g. requirements for capital or leverage ratios.[32] As these costs increase in D and thus in the size of the bank's balance sheet, we follow Martin et al. (2016) and refer to them as balance sheet costs.

Managing loans generates costs

$$F = \frac{1}{2}qL^2 \tag{9}$$

for a bank. The quadratic form of this cost function captures the idea that loans differ in their complexity so that the bank adds the least complex loans to its portfolio first.

The bank is required to hold compulsory deposits on its account with the central bank. These required reserves depend on the bank's deposits D and the required reserve ratio r which is set by the central bank:

$$RR = rD. \tag{10}$$

The bank's total reserve holdings R consist of required reserves RR and excess reserves ER, i.e.

$$R = RR + ER. \tag{11}$$

The asset side of the bank's balance sheet thus consists of loans and reserves, the liability side of deposits:

$$L + R = D \tag{12}$$

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[32]Using a theoretical model, Martin et al. (2013) already showed that marginal bank balance sheet costs increase due to costly equity requirements.

Considering this balance sheet constraint and (3), (6), (7), (10) and (11), we get

$$ER = \frac{1-r}{1+b}B - \frac{b+r}{1+b}L \ ,\tag{13}$$

i.e. excess reserves increase in the asset purchases B by the central bank and decrease in the commercial bank's lending to the non-banking sector L. The strength of these effects are determined by the currency and reserve ratio.

We denote the interest rate on loans L by $i^L > 0$, the interest rate that the central bank pays on required reserves RR by i^{RO}, and the deposit rate at which the central bank remunerates excess reserves ER by i^{DF}, where $i^L > i^{RO} > i^{DF}$.[33]

4.3 Optimal Bank Loan Supply

The bank seeks to maximise its profit Π by deciding on its loan supply. The bank's objective function thus becomes

$$\max_{L} \Pi = \quad i^L L - F + i^{RO} RR + i^{DF} ER - i^D D - G$$

$$= \quad i^L L - \frac{1}{2}qL^2 + i^{RO} r\left(\frac{B+L}{1+b}\right) + i^{DF}\left(\frac{1-r}{1+b}B - \frac{b+r}{1+b}L\right)$$

$$-i^D\left(\frac{B+L}{1+b}\right) - \frac{1}{2}\gamma\left(\frac{B+L}{1+b}\right)^2 \ .\tag{14}$$

The first term of the objective function shows the bank's interest revenues from making loans to the non-banking sector. The second term describes its management costs. The third and fourth terms reflect the bank's interest revenues/costs from holding reserves. The fifth term represents the bank's interest costs from paying a return on deposits to its customers. The last term describes the bank's balance sheet costs. Solving the optimisation problem, the first-order condition (FOC) for the optimal loan supply is given by

$$\frac{\partial \Pi}{\partial L} = i^L - qL^* + i^{RO}\frac{r}{1+b} - i^{DF}\frac{b+r}{1+b} - i^D\frac{1}{1+b} - \gamma\frac{B+L^*}{(1+b)^2} \overset{!}{=} 0 \ .\tag{15}$$

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[33]To allow for $i^L \leq 0$ would not change our model results, but for the sake of simplicity we assume that $i^L > 0$, as it allows us to speak only of interest revenues and avoids talking about revenues/costs in this context.

The first term of the FOC reflects the direct marginal interest revenues from granting loans, the second term the marginal costs in the form of management costs. Granting loans, the bank credits the respective amount to its customers' deposit accounts, i.e. it creates money. For those newly created deposits which are not withdrawn as cash, the bank has to hold required reserves which are remunerated at i^{RO}. The third term thus represents indirect marginal interest revenues (or marginal interest costs if $i^{RO} < 0$) of granting loans in the form of interest revenues (costs) from holding required reserves. These marginal interest revenues (costs) increase in the reserve ratio r and decrease in the currency ratio b: If a bank grants one additional unit of loan, it creates in a first step one additional unit of deposits. However, as a part of these deposits is withdrawn, required reserve holdings only increase by $r/(1+b)$ per unit of loan. The fourth term of equation (15) represents either marginal costs of granting loans in the form of opportunity costs or marginal revenues of granting loans in the form of avoided interest payments: As the additional required reserve holdings and the cash withdrawals are met by reducing the bank's excess reserves, there will be some kind of opportunity costs of granting loans in the form of a loss in interest revenues on holding excess reserves if $i^{DF} > 0$. However, if $i^{DF} < 0$, granting loans allows the bank to reduce interest costs combined with holding excess reserves. These costs/revenues also increase in b and r as increasing currency and/or reserve ratios imply a decrease in excess reserve holdings. The fifth term comprises the bank's marginal interest costs of granting loans in the form of interest payments to its depositors. Again, by granting one more unit of loans, the bank creates in a first step one more unit of deposits. For the proportion of this newly created unit of deposits that is not withdrawn as cash, the bank has to pay interest at the rate i^{D} to the non-banking sector. Obviously, these interest costs decrease in b. Moreover, for the proportion of the created unit of deposits that is not withdrawn, the bank is exposed to balance sheet costs. The respective marginal costs of granting loans are captured by the last term.

Solving (15) for L^* we obtain the bank's optimal loan supply:

$$L^* = \frac{i^L(1+b)^2}{q(1+b)^2 + \gamma} + \frac{r\, i^{RO}(1+b)}{q(1+b)^2 + \gamma} - \frac{i^{DF}(b+r)(1+b)}{q(1+b)^2 + \gamma}$$
$$- \frac{i^D(1+b)}{q(1+b)^2 + \gamma} - \frac{\gamma B}{q(1+b)^2 + \gamma} \, . \tag{16}$$

4.4 Monetary Policy and Bank Loan Supply

In the following, we analyze how monetary policy affects bank loan supply. Our model captures four main elements of the ECB's monetary policy toolkit: the large-scale asset purchases (QE), the minimum reserve ratio, the MRO-rate, and the deposit rate. By using comparative statics, we examine how the bank's optimal loan supply is affected by changes in these variables. Starting with QE, its impact on bank loan supply is captured by the first derivative of $L^*(\cdot)$ with respect to B:

$$\frac{\partial L^*}{\partial B} = - \frac{\gamma}{q(1+b)^2 + \gamma} < 0 \; . \tag{17}$$

Implementing QE, the central bank purchases government bonds from the non-banking sector which leads to an increase in B on the asset side of the central bank's balance sheet and in R on the liabilities side (see Figure 5). The negative impact of QE on bank loan supply results from the bank's balance sheet costs. If we abstain from such costs ($\gamma = 0$), QE will not have any effect on bank loan supply. However, the existence of balance sheet costs implies that the commercial bank's marginal costs of granting loans will increase if the central bank purchases government bonds as these purchases imply the creation of costly deposits. Hence, the bank reduces its loan supply.

For the impact of a change in the minimum reserve ratio on bank loan supply, we get

$$\frac{\partial L^*}{\partial r} = \frac{(i^{RO} - i^{DF})(1+b)}{q(1+b)^2 + \gamma} > 0 \; . \tag{18}$$

The effect of an increase in the reserve ratio on the bank's optimal loan supply is positive. This means that an increase in this ratio is an expansionary monetary policy impulse, i.e. changes in the reserve ratio will have the exact opposite effect on bank loan supply if the banking sector faces a structural liquidity surplus instead of a respective deficit. The explanation is as follows. An increase in bank lending implies the creation of bank deposits for which the bank is required to hold reserves. Since $ER = R - RR$, the bank's excess reserves decrease when required reserves increase. Consequently, an increase in loans implies a reserve shifting from excess reserves to required reserves. As the latter are remunerated at a strictly higher rate ($i^{RO} > i^{DF}$), this reserve shifting, that goes hand in

hand with granting more loans, is beneficial. An increase in r means a higher, beneficial reserve shifting and thus implies an increase in marginal revenues of granting loans in the form of higher interest revenues (or lower interest costs)[34] of holding reserves. Obviously, the strength of this beneficial reserve shifting effect on bank loan supply increases with the spread between i^{RO} and i^{DF}, so that we get that

$$\frac{\partial L^*}{\partial i^{DF}} = -\frac{(1+b)(b+r)}{q(1+b)^2+\gamma} < 0 \tag{19}$$

and

$$\frac{\partial L^*}{\partial i^{RO}} = \frac{r(1+b)}{q(1+b)^2+\gamma} > 0 \; . \tag{20}$$

Note that the effect of a change in i^{DF} on L^* is stronger the higher r is, as then granting one more unit of loans results in a more pronounced decline in excess reserves. In the same vein the effect also increases in b. If there were neither cash withdrawals nor MRR ($b = r = 0$), there would not be any impact of increases in i^{DF} on L^*, since granting more loans would then not affect excess reserve holdings. The positive impact of an increase in i^{RO} on L^* decreases in b, since increasing cash withdrawals provoke decreasing deposits and hence also decreasing required reserve holdings and thus declining interest revenues.

4.5 Consideration of Heterogeneity

So far we have assumed identical commercial banks. This means that all banks were affected in the same way by the central bank's large-scale asset purchases, i.e. all banks faced the same increase in deposits D and excess reserves ER due to the central bank's asset purchases B. This allowed us to model the commercial banking sector as a representative entity. However, in Section 3.4.3, we showed that in the euro area, banks were affected differently by the Eurosystem's large-scale asset purchases and, in particular, there were country-specific differences.

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[34]This reserve shifting implies marginal revenues of granting loans in the form of lower interest *costs* if $i^{DF} < 0$ and if $|i^{DF}| > |i^{RO}|$.

In a next step we account for this heterogeneity. As argued in Section 3.4.3, the Eurosystem's asset purchases from non-domestic (predominantly even non-euro area) counterparties result in liquidity creation in only a few financial centres, implying a heterogeneous distribution of excess liquidity across euro area countries. For example, with respect to the German banking sector, the creation of excess liquidity, and hence also the creation of deposits, exceeds the level one would expect according to the asset purchases conducted by the Deutsche Bundesbank. By contrast, with regard to the Italian banking sector, the creation of reserves and deposits is below the level corresponding to asset purchases conducted by the Banca d'Italia. To capture this phenomenon in our model, we consider two banking sectors. One banking sector represents the banking sector of euro area countries that are home to financial centres. The banking sector of these countries is characterised by an increase in the amounts of excess reserves and deposits going beyond the corresponding level of asset purchases conducted by their respective national central banks. We refer to these countries as high-liquidity countries. The other banking sector belongs to countries that are not home to financial centres, which implies that banks in these countries are not selected as TARGET2 access point by counterparties that are resident in non-euro area countries. The banking sector of these countries is characterised by an increase in the amounts of excess reserves and deposits that is below the according level of asset purchases by their national central banks. We refer to these countries as low-liquidity countries. For simplification reasons, we consider one representative high-liquidity country and one representative low-liquidity country each endowed with a central bank and a commercial bank representing the country's commercial banking sector. We denote the QE-created amount of deposits in the high-liquidity country by $\overline{D}^{QE}$, and those created in the banking sector of the low-liquidity country by $\underline{D}^{QE}$ respectively. Both national central banks buy assets equal to an amount B from the non-banking sector, and both national central banks buy a share $0 \leq \beta < 1$ of these assets from counterparties not residing in one of the two countries. For the deposits created in both countries we then obtain

$$\overline{D^{QE}} \; = \; \frac{B}{1+b} + \frac{\beta B}{1+b} \; = \; \frac{B}{1+b}(1+\beta) \; , \tag{21}$$

29

and

$$\underline{D^{QE}} \;=\; \frac{B}{1+b} - \frac{\beta B}{1+b} \;=\; \frac{B}{1+b}(1-\beta) \,. \tag{22}$$

The first term of equation (21) represents the deposits created in the high-liquidity country due to the asset purchases by its central bank. Note that it plays no role that a share β of these assets is purchased from residents outside one of the two countries, as these residents hold their deposit account in the high-liquidity country. The second term of (21) represents those deposits created in the high-liquidity country because of the asset purchases of the central bank of the low-liquidity country as a number of the respective counterparties have their account with the bank in the high-liquidity country. The first term of (22) represents all the deposits created through the asset purchases by the central bank of the low-liquidity country. However, a part of these deposits is created in the high-liquidity country as the share β of total asset purchases is bought from counterparties having their deposit account in the other country. This part of the newly created deposits is represented by the second term of (22).

Again, each commercial bank maximises its profit Π by deciding on its loan supply. Hence, the bank's adjusted objective function in the respective banking sector now becomes

$$\max_{L} \overline{\Pi} = \quad i^{L} L - \frac{1}{2}qL^{2} + i^{RO} r\left(\frac{B(1+\beta)+L}{1+b}\right) + i^{DF}\left(\frac{(1-r)(1+\beta)}{1+b}B - \frac{b+r}{1+b}L\right)$$

$$- i^{D}\left(\frac{B(1+\beta)+L}{1+b}\right) - \frac{1}{2}\gamma\left(\frac{B(1+\beta)+L}{1+b}\right)^{2}, \tag{23}$$

and

$$\max_{L} \underline{\Pi} = \quad i^{L} L - \frac{1}{2}qL^{2} + i^{RO} r\left(\frac{B(1-\beta)+L}{1+b}\right) + i^{DF}\left(\frac{(1-r)(1-\beta)}{1+b}B - \frac{b+r}{1+b}L\right)$$

$$- i^{D}\left(\frac{B(1-\beta)+L}{1+b}\right) - \frac{1}{2}\gamma\left(\frac{B(1-\beta)+L}{1+b}\right)^{2} \tag{24}$$

respectively. Accordingly, for the optimal loan supply of the representative bank of the high-liquidity country we obtain

$$\overline{L^*} = \frac{i^L(1+b)^2 + r\, i^{RO}(1+b) - i^{DF}(b+r)(1+b) - i^D(1+b) - \gamma B(1+\beta)}{q(1+b)^2 + \gamma}, \qquad (25)$$

and for the representative bank of the low-liquidity country

$$\underline{L^*} = \frac{i^L(1+b)^2 + r\, i^{RO}(1+b) - i^{DF}(b+r)(1+b) - i^D(1+b) - \gamma B(1-\beta)}{q(1+b)^2 + \gamma} \qquad (26)$$

respectively. We are now able to compare the impact of QE on the loan supply of the two banks. Building the partial derivative of $L^*(\cdot)$ w.r.t. B, we obtain

$$\frac{\partial \overline{L^*}}{\partial B} = -\frac{\gamma(1+\beta)}{q(1+b)^2 + \gamma} < 0, \qquad (27)$$

and

$$\frac{\partial \underline{L^*}}{\partial B} = -\frac{\gamma(1-\beta)}{q(1+b)^2 + \gamma} < 0. \qquad (28)$$

The effect of QE on the loan supply of both banks is still negative. If the central bank purchases one more unit of government bonds, the amount of deposits in the banking sector will increase. Consequently, the marginal costs of granting loans in the form of balance sheet costs increase in both banking sectors, so that the bank in both the high-liquidity and the low-liquidity country will reduce its loan supply. However, the extent of this effect differs between both countries. As the increase in deposits is higher in the high-liquidity country than in the low-liquidity country, the negative effect is stronger in the former country, as revealed by equations (27) and (28). Obviously, the greater β, which means the greater the share of government bonds purchased from residents outside the considered countries, the larger the decrease in loan supply in the high-liquidity country and the smaller the decrease in the low-liquidity country:

$$\frac{\partial^2 \overline{L^*}}{\partial B\, \partial \beta} = -\frac{\gamma}{q(1+b)^2 + \gamma} < 0, \qquad (29)$$

$$\frac{\partial^2 \underline{L}^*}{\partial B\ \partial \beta} = \frac{\gamma}{q(1+b)^2 + \gamma} > 0\ .\tag{30}$$

5   Implications for Monetary Policy in the Euro Area

Based on the previous findings, we discuss two issues with respect to monetary policy in the euro area. First, we discuss the existence of a possible bank lending channel of the Eurosystem's large-scale asset purchases. Second, we analyse consequences of the QE-induced structural liquidity surplus in the euro area banking sector for the implementation of monetary policy instruments other than QE.

Existence of a Bank Lending Channel

In Sections 3 and 4 we show that if central banks purchase assets, e.g. government bonds, from commercial banks or from the non-banking sector, excess reserves and bank deposits will increase. The literature survey in Section 2 reveals that traditional approaches to the bank lending channel investigate how bank loan supply responds to monetary shocks that affect the quantity of deposits and thus the liability side of banks' balance sheet. However, recent papers also explicitly consider the asset side of banks' balance sheets when investigating how bank loan supply responds to QE-induced increases in excess reserves. For instance, as already pointed out in the literature survey, Lojschova (2017) argues that in the euro area excess reserves are remunerated at a relatively low rate and that banks may therefore benefit from an expansion of lending to reduce their costly excess reserve holdings. This is what she refers to as a bank lending channel.

However, referring to our model results, such a bank lending channel does not exist for the euro area. The Eurosystem's large-scale asset purchases actually increase excess reserves and deposits, but this has no or even a negative effect on bank loan supply. For the negative effect, the banks' increasing marginal costs of holding deposits (balance sheet costs), due to, for example, regulatory issues or agency costs, play a crucial role. Granting loans implies the creation of deposits. Consequently, the balance sheet costs are

one component of the increasing marginal costs of granting loans. The central bank's asset purchases imply increasing deposits and hence also increasing marginal costs of granting loans and therefore a reduction in loan supply.

If marginal costs of holding deposits are constant, asset purchases will have no impact on bank loan supply as they do not influence the bank's marginal costs or revenues of granting loans (see equation (15)). Note that even a negative interest rate on excess reserve holdings will not incentivise banks to grant more loans if they face a QE-induced increase in costly excess reserves as, in the absence of increasing marginal balance sheet costs, larger quantities of excess reserves and deposits do not affect marginal costs or revenues of granting loans.

Furthermore, the APP-induced increased excess reserves are heterogeneously distributed across euro area countries (see Section 3.4.3). Concerning our model results, the extent of the negative effect on bank loan supply therefore varies across euro area countries. Countries exposed to larger amounts of excess reserves and bank deposits consequently face larger balance sheet costs and are therefore more concerned by the negative impact on loan supply (see Section 4.5).

Consequences for Monetary Policy Implementation: MRO-Rate

With respect to the implementation of monetary policy instruments other than QE in the euro area, we can infer from our model results that main elements of the ECB's monetary policy toolkit affect bank loan supply differently in times when the banking sector is exposed to a structural liquidity surplus instead of a structural liquidity deficit. If the banking sector faces a structural liquidity deficit, banks have to rely on an ongoing liquidity provision by the central bank to cover cash withdrawals and MRR.[35] This means that an increase in the MRO-rate – the rate which is applied on the ECB's refinancing operations as well as on required reserve holdings – has a strictly negative impact on bank loan supply as banks' funding costs in the ECB's refinancing operations increase. However, when banks face a structural liquidity surplus, they no longer need to take part in refinancing operations so that a higher MRO-rate just positively affects their returns

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[35]Note that when discussing the tools of monetary policy, traditional textbooks usually consider a structural liquidity deficit (see e.g. Mishkin (2018, Section 15)).

from fulfilling their MRR. Since this implies increasing marginal revenues of granting loans (see Section 4), banks will expand their loan supply. Consequently, according to our model results, the ECB must increase rather than decrease the MRO-rate to boost bank loan supply in times when the banking sector is exposed to a structural liquidity surplus.

Consequences for Monetary Policy Implementation: Minimum Reserve Ratio

MRR imply a structural demand for reserves (see Section 3). If the euro area banking sector operates under a structural liquidity deficit, it will borrow the respective reserves from the ECB's MROs. Credit expansion leads to the creation of deposits for which banks are required to hold (costly) reserves. Although minimum reserve holdings are remunerated at the same rate at which the respective liquidity is borrowed from the Eurosystem (the MRO-rate), holding required reserves is costly as central bank credits have to be based on adequate collateral, i.e. additional costs in the form of collateral costs accrue. Consequently, increasing the minimum reserve ratio will have a contractionary impact on bank loan supply. Also, the simple money multiplier underscores the traditionally assumed contractionary impulse of an increase in the minimum reserve ratio. Neglecting the currency holdings of the non-banking sector ($b = 0$), the money multiplier is defined as $\frac{1}{r}$. For a given amount of reserves (R) supplied by the central bank, the whole banking sector can hold a maximum amount of deposits equal to $D = \frac{1}{r}R$. Taking into account a bank balance sheet constraint $D = L + R$, the maximum amount of loans the banking sector can provide is restricted to $L = (\frac{1-r}{r})R$. A higher reserve ratio implies that for any given amount of reserves (monetary base), banks can create fewer deposits, i.e. they make fewer loans.

However, we can infer from our model results that in the presence of a structural liquidity surplus in the banking sector, the negative relationship between the reserve ratio and bank loan supply no longer exists.[36] An increase in the minimum reserve ratio implies an increase in banks' structural liquidity needs. But as the banking sector operates under a structural liquidity surplus, there is no need for banks to take part in the ECB's refinancing operations to cover such risen liquidity needs. On the contrary,

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[36]The absence of the traditional money-multiplier effect in the case that banks face a structural liquidity surplus, is also discussed by Keister and McAndrews (2019).

the increased minimum reserve ratio implies that banks have to increase their holdings of required reserves at the expense of excess reserve holdings. This reserve shifting is beneficial as required reserves are remunerated at a higher rate than excess reserves, i.e. indirect marginal interest revenues of granting loans increase, so that banks expand their loan supply. Therefore, an increase in the minimum reserve ratio corresponds to an expansionary monetary policy impulse. Consequently, the ECB must increase rather than decrease the minimum reserve ratio to boost bank loan supply at times when banks face a structural liquidity surplus.

Consequences for Monetary Policy Implementation: Deposit Rate

Alternatively, or complementarily, the ECB can reduce its deposit rate – the rate at which excess reserve holdings are remunerated. In an environment characterised by a structural liquidity surplus, the deposit rate has a different meaning and effect than in an environment characterised by a structural liquidity deficit. If there is a structural liquidity deficit which is (exactly) covered by the central bank's MROs and if there is furthermore a functioning interbank market, the deposit rate will have no systematic effect on bank loan supply. If the interbank market does not function properly, banks will hold precautionary liquidity. The respective amount increases in their loan supply. A decrease in the deposit rate makes holding precautionary liquidity more expensive and thus has a negative impact on bank loan supply (Bucher et al., 2019). However, if the banking sector faces a structural liquidity surplus, an increase in the deposit rate will negatively affect bank loan supply. The incentive to reduce the excess reserve holdings by granting more loans decreases, since the opportunity costs of granting loans increase (if $i^{DF} > 0$) or since avoided (penalty) interest payments decrease (if $i^{DF} < 0$).[37]

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[37]However, note that an increase in loan supply will not decrease excess reserve holdings to the same extent. For example, assuming a minimum reserve ratio of 1% and cash withdrawals in the amount of 14%, Bucher and Neyer (2016) show that granting a loan in the amount of 100 euros, the bank creates an additional structural need for reserves amounting to 15 euros. Thus, to entirely eliminate excess reserve holdings, the bank must grant an amount of loans that is almost seven times greater than the amount of its excess reserve holdings.

6 Summary

In March 2015, the Eurosystem started implementing its large-scale asset purchase programme, also known as quantitative easing (QE), to address the risks of a too prolonged period of low or even negative inflation rates since the beginning of 2013. As a consequence of these asset purchases, excess liquidity and deposits held by the euro area commercial banking sector increased to unprecedented levels.

The large quantity of excess liquidity has generated a great amount of concern and debate. However, there is little analysis of whether and to what extent excess liquidity affects bank loan supply, i.e. whether there is a bank lending channel in the sense that QE-induced increases in bank reserves and deposits have a positive impact on bank loan supply. Against this background, the first part of this paper describes and analyses the Eurosystem's liquidity management in *normal times*, in *crisis times* and in *times of too low inflation*. Focussing on the latter, the QE-induced creation of bank reserves and bank deposits as well as their heterogeneous distribution across euro area countries are analysed. Building on this analysis, the paper's second part develops a theoretical model of the euro area banking sector. Using this model we show that large quantities of excess liquidity and deposits have no or even a contractionary impact on bank loan supply. The effect will be contractionary if banks face increasing marginal costs of holding deposits, for example, due to agency or regulatory costs.

As – due to the Eurosystem's large-scale asset purchases – the newly created excess reserves and deposits are heterogeneously distributed among euro area member states, the impact of QE on bank loan supply may differ across countries. Banks in countries that are exposed to larger amounts of excess liquidity and deposits consequently have larger marginal costs of holding deposits. Banks in those countries will decrease their loan supply to a greater extent than banks in countries with less pronounced amounts of excess liquidity and deposits.

Since October 2015, the reserves exclusively provided through the Eurosystem's large-scale asset purchases have exceeded the banking sector's structural liquidity needs resulting from MRR and autonomous factors. Consequently, since then banks have operated in an environment characterised by a structural liquidity surplus. This has

important implications for monetary policy implementation in the euro area. Increases in the central bank's MRO-rate as well as in the minimum reserve ratio, and/or decreases in the central bank's deposit rate, develop expansionary effects on bank loan supply – contrary to the case in which banks are exposed to a structural liquidity deficit.

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