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ECB stepping on the brake(s)

Monetary tightening in an abundant reserve
system



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Supporting monetary policy scrutiny



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ECB stepping on the brake(s)

Monetary tightening in an abundant reserve system

Abstract

Confronted with a historic inflation surge, the ECB steps on the brake(s). While interest rate hikes are its primary tool, unconventional tools are also adjusted to strengthen the brake intensity. Quantitative tightening will reduce the stock of bonds in a slow process. The change from a scarce to an abundant reserve system will prevail. In contrast to previous monetary tightening cycles, in an abundant reserve system huge interest expenses result in central bank losses and fiscal costs for the coming years.

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LIST OF ABBREVIATIONS

APP	Asset purchase programme
DM	Deutsche Mark
ECB	European Central Bank
Fed	Federal Reserve System
OIS	Overnight index swaps
OMT	Outright monetary transactions
PEPP	Pandemic emergency purchase programme
SMP	Securities market programme
PSPP	Public sector purchase programme
TLTRO	Targeted longer-term refinancing operations
TPI	Transmission protection instrument
USD	US dollar
GBP	Great Britain pound
TARGET2	Trans-european automated real-time gross settlement express transfer system (2. generation)

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EXECUTIVE SUMMARY

- **The ECB is confronted with a historic inflation surge.** Inflation rates have started to rise to uncomfortably high values since mid-2021. While central banks around the world, including the ECB, first deemed the rising inflation to be of a transitory nature and hesitantly adjusted their monetary policy stance, the broad-based inflation surge became clearer over time, even before the energy crisis was triggered by the start of the war in Ukraine.
- **Since the first rate hike in July 2022, the ECB has increased the key interest rates in an unprecedented steep process.** The main refinancing rate will reach a level of 3.5 percent in March 2023, only nine months after the inception of the tightening cycle. Compared to the two main monetary tightening cycles since the start of the currency union, the current tightening cycle is quicker as the interest rate step size is higher. Interest rate hikes are the ECB's primary tool for stepping on the brake and the ECB communicates that further interest rate hikes are data-dependent.
- **After years of extending the monetary expansion toolbox, the ECB now steps on the brake(s) and adjusts all its tools in a holistic approach.** In October 2022, the ECB adjusted the conditions of the targeted longer-term refinancing operations (TLTROs), which reduced the accommodative effect on bank lending and led to large voluntary repayments of banks. The ECB outlined its balance sheet reduction plans in the recent February 2023 Governing Council meeting. The reduction pace will be EUR 15 billion per month from March to June 2023, possibly followed later on by an increase of up to EUR 30 billion. The ECB could further increase the brake intensity by signalling a higher terminal rate and accelerating the pace of its balance sheet reduction.
- **But the dampening effect of quantitative easing on the term premium of long-term yields cannot be quickly reversed fully.** The effect of quantitative easing on the term premium is dependent on the stock of sovereign bonds in the central bank's balance sheet in comparison to the stock of sovereign bonds in the hands of private investors. When bonds mature and are rolled-off the central bank's balance sheet, fiscal authorities roll over their debt and bonds in the hands of private investors increasingly accumulate. However, the process is slow. The higher the pace of quantitative tightening, the faster the dampening effect on the term premium is reversed.
- **The change from a scarce to an abundant reserve system will result in losses for the Eurosystem in the order of EUR 95 in 2023 and 80 billion in 2024.** As excess reserves are only slowly decreased by quantitative tightening, the interest expense of the Eurosystem will rise with the deposit facility rate in the new context of a positive interest rate environment. The interest expenses in the coming years can possibly deplete the capital and reserve position of the Eurosystem, resulting in indirect fiscal costs as no profits from the national central banks will be transferred to treasuries in the coming years.

1. INTRODUCTION

The European Central Bank (ECB) is confronted with a historic inflation surge. Inflation rates have started to rise to uncomfortably high values since mid-2021. While central banks around the world, including the ECB, first deemed the rising inflation to be of a transitory nature and hesitantly adjusted their monetary policy stance, the broad-based inflation surge became clearer over time, even before the energy crisis was triggered by the start of the war in Ukraine.

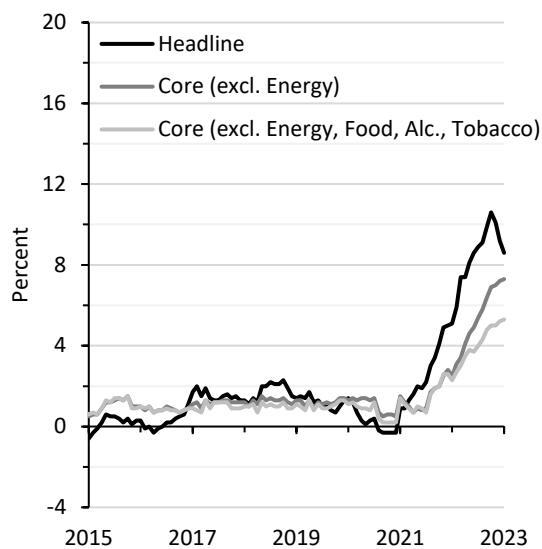
In the course of 2021, in the euro area, headline inflation rose from 1 to 5% (Figure 1 a). During the lockdowns, demand shifted from services to goods consumption. Incomes during the pandemic were stabilised by a fiscal-monetary mix in many countries worldwide, where fiscal deficits were totally absorbed by purchases of bonds by central banks. Equipped with newly created money, fiscal authorities then stabilised the incomes of households. The result of this fiscal-monetary mix was a rapid increase in the money supply in many countries worldwide (Borio et al., 2023). But these incomes were not backed by real production activity as production capabilities were heavily impaired by supply-chain disruptions and resulting material shortages¹. Hence inflationary pressures first built up in the energy and goods sector. Then, in the first phase of post-pandemic recovery, consumption reversed back to services, where production capabilities were scaled back during the pandemic years. Hence inflationary pressures spread also to services. The supply-side of the economy after the pandemic was simply not able to keep pace with demand, which was fuelled by excess savings (Kooths, 2022).

During the year 2022, with the outbreak of the war in Ukraine and the resulting energy crisis, headline inflation in the euro area rose from 5.1 to 9.2% (Figure 1 a). The inflationary pressures were already high and broad-based in historical comparison before the outbreak of the war in Ukraine, but accelerated with the surge of energy prices for fuels and gas. The surge in the price of gas quickly spread to electricity prices, as gas power plants were now the price-setting producers (merit order). The increased energy costs spread through the production structure and pushed producer prices to historic levels. Also, food prices rose heavily because of skyrocketing fertiliser prices and increased production and transportation costs due to the energy price surge (Gern et al., 2022a). Apart from the classical aggregates of inflation (Figure 1 a), one can observe a clear shift in the distribution of sub-group inflation rates starting in 2021, i.e. the inflationary pressures affected more and more items and became more broad-based (Figure 1 b).

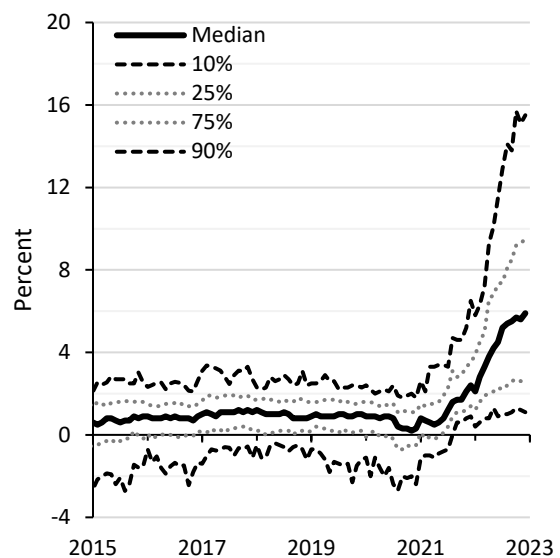
¹ Kooths (2022) calls the incomes resulting from the fiscal-monetary mix applied during the pandemic “phantom”-incomes.

Figure 1: Inflation rates and distribution of sub-group inflation rates in the euro area

a) Inflation rates



b) Distribution of sub-group inflation rates



Source: Refinitiv, Eurostat, author's calculations.

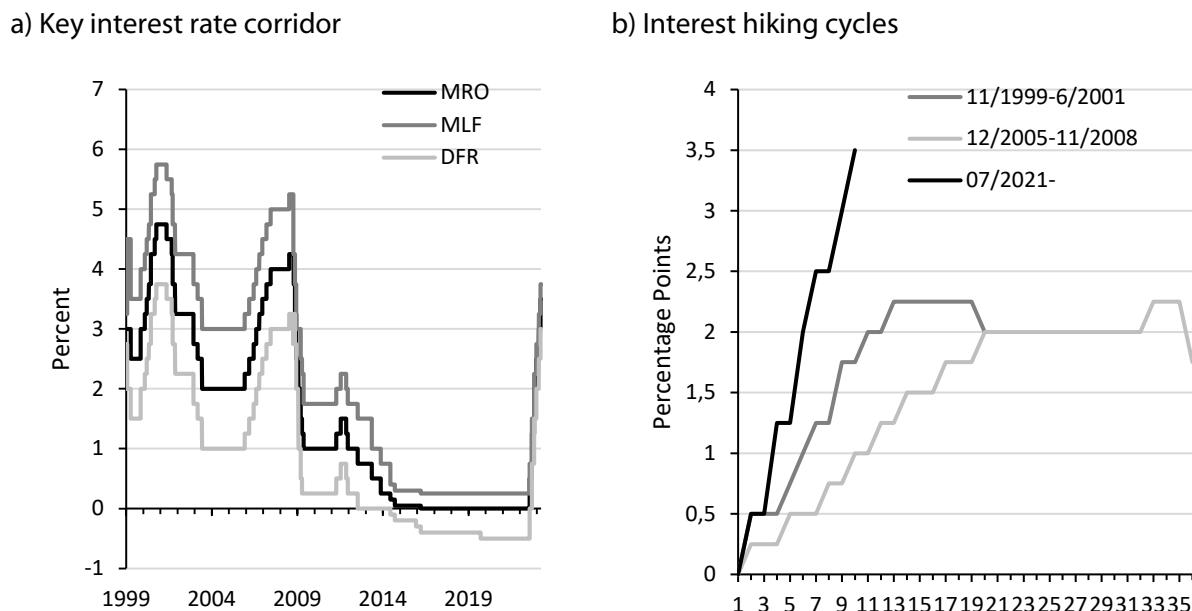
Notes: Panel b shows the distribution of the sub-group inflation rates at the 4-digit level. In total 101 different indices were considered. The 101 inflation rates can be ordered by their respective value. The median shows the inflation rate, which parts the 101 categories in two halves of equal size. Also, the 10%, 25%, 75% and 90% quantiles are calculated. The 90% quantile is the rate where 90%, hence approximately 90 categories, have a lower rate.

The ECB started to adjust its monetary policy stance at the end of 2021. While the first interest rate hike by the ECB occurred in July 2022, the forward guidance was adjusted at the end of 2021 by signalling an earlier end of the pandemic emergency purchase programme (PEPP), which led to an increase in the expected path of short-term interest rates. In line with the shift in the expected path of short-term interest rates medium- to long-term yields adjusted. With the rise in the yields also financial conditions for the private sector tightened already in early 2022 (Lane, 2023).

Since the first rate hike in July 2022, the ECB has increased its key interest rates in an unprecedented steep process. Compared to the two main monetary tightening cycles since the start of the currency union, the current tightening cycle is quicker as the interest rate step size is higher (Figure 2 a, b). The ECB first hiked by 0.5 percentage points (p.p.) in July 2022, followed by two 0.75 p.p. hikes in September 2022 and October 2022. Then the pace switched back to the 0.5 p.p. size in December 2022. Recently the ECB hiked by another 0.5 p.p. in its February 2023 Governing Council meeting and already committed to another 0.5 p.p. hike in March 2023. The main refinancing rate will thus reach a level of 3.5% in March 2023 only nine months after the inception of the tightening cycle (Figure 2 b).

The ECB communicates that further interest rate hikes are data-dependent. From recent speeches of Governing Council members, one can gauge that interest rate hikes might continue after the March 2023 meeting. But it is probable that the ECB might switch to a 0.25 p.p. interest rate hike size in the near future. One can gauge from recent speeches that Governing Council members are not comfortable about the market pricing rate cuts in late 2023, hence Governing Council members adjusted their communication. The pricing accordingly not only shifted upwards in recent weeks, but also interest rate cuts are more and more priced out.

Figure 2: Key interest rate corridor and interest hiking cycles



Source: Refinitiv, ECB, Own calculations.

Notes: The announced rate hike of 0.5 p.p. in the coming March Governing Council meeting (16 March 2022) was already manually incorporated in the data. The interest rate corridor consists of the marginal lending facility (MLF), main refinancing operations (MRO) and deposit facility rate (DFR). Panel b portrays the three major tightening cycles since the start of the currency area. The cycle length is defined in months since the start of the hiking cycle until the first rate cut.

In the recent February Governing Council meeting, the ECB also outlined its balance sheet reduction plans. The balance sheet reduction process will be of a passive nature as a part of all maturing bonds will not be reinvested. The reduction pace will be EUR 15 billion per month from March to June 2023 and only concerns roughly half of all monthly maturing bonds of the asset purchase program (APP). The maturing bonds from the PEPP will be fully reinvested. While the Federal Reserve System (Fed) also announced a passive balance sheet reduction plan though with a higher pace of USD 95 billion per month, the Bank of England set a yearly target reduction of GBP 80 billion, which includes GBP 45 billion in active bond sales. In contrast to the Fed, the ECB has no experience yet with quantitative tightening. The Fed reduced its balance sheet from 2017 until 2019 by an amount of roughly USD 700 billion (Figure 5).

After years of extending its monetary expansion toolbox, the ECB now steps on the brake(s) and adjusts all its tools in a holistic approach. The ECB started to change its forward guidance in December 2021, which increased the market-implied short-term interest rate path and led to adjustments in the medium- to long-term yields. Then actual interest rate hikes occurred since July 2022, when also the period of its negative remuneration of excess reserves ended. In October 2022, the ECB adjusted the conditions of the targeted long-term refinancing operations (TLTROs), which led to large voluntary repayments by banks. In December 2022, the ECB signalled its balance sheet reduction plan and published the pace in its February 2023 Governing Council meeting (European Central Bank, 2023). Hence the ECB adjusted its conventional and unconventional monetary toolbox. The ECB could now increase the brake intensity by signalling a higher terminal rate through its communication and accelerating the pace of the balance sheet reduction (quantitative tightening).

The paper is structured as follows: Section 2 presents the monetary toolbox of the ECB. First, the rationale for the introduction of un-conventional tools in terms of monetary easing will be discussed,

followed by a description of the recent adjustments to the tools. Section 3 discusses the consequences of the institutional change from a scarce to an abundant reserve system and provides an estimate of the costs of the current abundant reserve operating system in a positive interest environment. Due to the large quantities of excess reserves the interest expenses of central banks will increase sharply and lead to losses for the national central banks. This will also have some fiscal repercussions for the coming years. Section 4 concludes.

2. ADJUSTING THE MONETARY TOOLBOX: FROM EASING TO TIGHTENING – STEPPING ON THE BRAKE(S)

Over the years of the currency union, the monetary toolbox of the ECB changed drastically. While originally the ECB was equipped with two refinancing operations, which allowed the ECB to steer the short-term interest rate on interbank markets, first the great financial crisis and second the euro crisis led to the introduction of new instruments. The new instruments had the task of making sure that the ECB did not lose control of its targeted monetary policy stance. First, the ECB increased its portfolio of refinancing operations. Then the ECB engaged in asset purchases to control the funding conditions of banks. In the euro crisis, the ECB engaged in purchases of sovereign bonds of struggling euro area member countries in the securities market program (SMP) and finally, at the peak of the euro crisis, the ECB introduced the outright monetary transactions (OMT) programme, which is connected to Mario Draghi's famous sentence: "Within our mandate, the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough." (Draghi, 2012).

Until this point, the tools had a crisis-fighting character (Schnabl and Sonnenberg, 2020). As the acute phase of the crisis was over, the ECB expanded its toolbox with a large-scale asset purchase programme, because, at that time, the ECB's primary tool of setting the short-term interest rate was restricted by the zero-lower bound² and its use of forward guidance, i.e. solely signalling a time path for the evolution of the short-term interest rate (lower-for-longer) proved not powerful enough. This time the aim of the asset purchases was to stimulate economic activity and the inflation outlook by lowering yields along the term structure of interest rates. The asset purchases lead to the creation of a huge amount of excess reserves. To further enhance its expansionary stance the ECB started to remunerate these excess reserves from 2014 onwards negatively.

Finally, the ECB introduced three series of targeted longer-term refinancing operations, which not only provided banks with reserves for a long period, but also should incentivise banks to engage in handing out new credits to the private sector. Similarly to the first asset purchases, the aim of the refinancing operations changed from a crisis character to a tool for the stimulation of economic activity. After the outbreak of the pandemic in March 2020, the playbook was repeated by the introduction of a large-scale asset purchase program called PEPP and a new series of targeted longer-term refinancing operations (Bridge LTRO, TLTRO-III). First, these monetary policy instruments addressed the uncertainty in financial markets, which led to a tightening of financial conditions, then the introduced policies had the aim of stimulating economic activity and the inflation outlook (Schnabel, 2021). Since December 2021, the ECB is now adjusting all policy tools in a holistic approach in order to address the historic inflation surge.

In the following section the mentioned tools are portrayed in greater detail. First by outlining the monetary easing character of the tools and then explaining how the tools have been adjusted recently to enhance the overall brake intensity of monetary tightening.

2.1. Interest rates and refinancing operations

From the start of the currency union, the ECB was equipped with one policy instrument to steer the short-term interest rate. The ECB could change the short-term interest rate on the interbank market by adjusting its refinancing operations. The original refinancing operations consisted of one-

² Nominal interest rates can be lowered up to zero percent, but usually not lower. This defines the zero-lower bound.

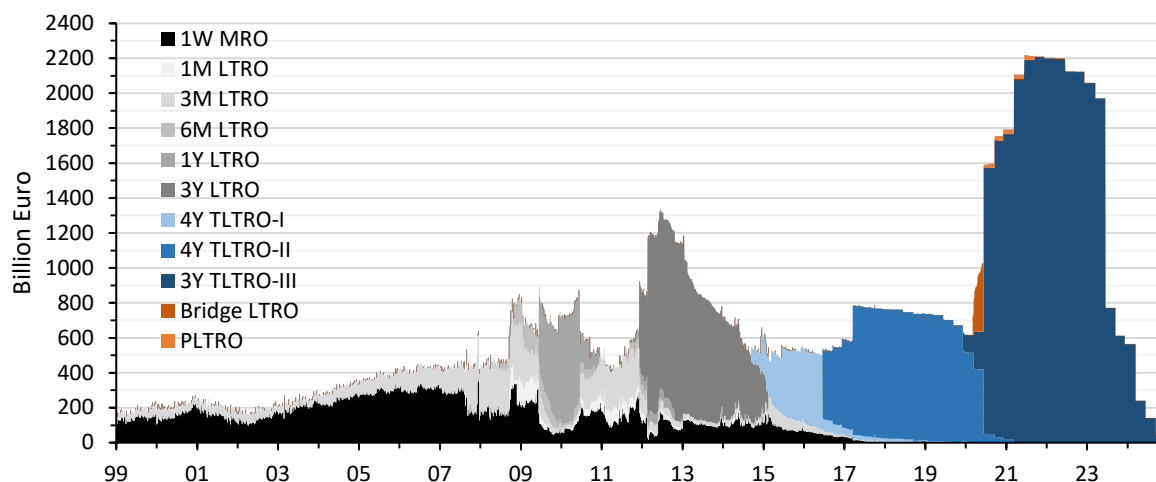
week main refinancing operations and 3-month longer-term refinancing operations³. Banks need to hold a certain amount of reserves to fulfil the minimum reserve requirement. The amount of minimum reserves a bank needs to hold depends on the maturity of its liability structure, mostly deposits. If banks issue new credits at the same time new deposits are created, which ultimately increase the banks' demand for minimum reserves (Deutsche Bundesbank, 2017; McLeay et al., 2014). The minimum reserve requirement hence leads to a constant demand for reserves and an increasing demand if banks engage in credit creation. Banks that hold excess reserves engage in lending operations on the interbank market and lend to banks with a reserve shortage.

Apart from the interbank market the ECB also offered reserves in its main refinancing operations and longer-term refinancing operations. The ECB made sure that the market for reserves was in a structural liquidity deficit, i.e. some banks always had to refinance with the ECB (Deutsche Bundesbank, 2015). By increasing the amount of reserves in the system, the ECB could manipulate the price of reserves, i.e. the interbank interest rate. In theory, the ECB could thereby step on the brake, i.e. increase the interest rate in interbank markets, when economic activity and inflation were running above target, and could step off the brake, i.e. lower the interest rate, when economic activity and inflation were running below target. This procedure becomes obvious in Figure 2 a. While in the first year of the currency union interest rates were hiked, with the onset of the dot-com crash in 2000 interest rates were lowered. Before the great financial crisis, the economy in the euro area was more and more operating at its capacity and interest rates were hiked correspondingly. With financial imbalances materialising during the great financial crisis, interest rates were lowered quickly to cushion the economic fallout (Borio, 2012).

While the ECB steered the short-term interest rate, long-term yields were solely determined by market forces. By setting the interest rate on interbank markets, the ECB controlled only the short-term interest rate. While with its three-month longer-term refinancing operations the ECB could directly steer interest rates up to this maturity, the importance of the three-month longer-term refinancing operations was lower than the one-week main refinancing operations (Figure 3). Interest rates of longer maturities were determined by market forces and the influence of the ECB was limited⁴.

³ A refinancing operation has two balance sheet consequences for a central bank: 1. The amount of reserves increases, which is a liability for the central bank. 2. The asset side of the central bank lengthens as the new refinancing operation is booked. Vice versa, the reserves are an asset for commercial banks and they book the refinancing operation as a liability (Cecchetti et al., 2012; Pool, 2021).

⁴ At the beginning of the currency union, there was no explicit communication regarding the future path of interest rates (forward guidance), hence the influence on medium- to longer-term yields was limited. This changes with the introduction of forward guidance, when the interest rate hit the zero-lower bound.

Figure 3: Refinancing operations of the Eurosystem

Source: ECB: "History of all open market operations" and "Summary of ad hoc communication", author's calculations.

Notes: The figure shows the total amount of outstanding refinancing operations of the Eurosystem and its distribution into the different refinancing operations by maturity horizon from 1999 to 2024. For the TLTRO-III the maturity profile is shown on the basis of the original maturity of the single tenders. Voluntary repayments are not considered.

In the face of the two big crises, the great financial crisis and the euro crisis, the character of the refinancing operations changed. During the great financial crisis, interbank markets froze and the lending operations between banks came to a standstill. Banks which are either in need of reserves to fulfil their minimum reserve requirements or unable to roll-over existing interbank loans could refinance with their respective national central bank. On 8 October 2008, the Eurosystem also changed from a competitive auction scheme of its refinancing operations to a fixed rate full-allotment policy (European Central Bank, 2008). Fixed-rate full allotment means that every demand for reserves of banks would be fulfilled by a corresponding supply operation at a fixed-rate by the Eurosystem, as long as the collateral requirements are fulfilled. Additionally, the ECB in the great financial crisis step by step introduced new maturities (1M, 6M, 1Y) of longer-term refinancing operations to mimic all the different maturities of the interbank money market (Figure 3). In the euro crisis, the ECB introduced a three-year longer-term refinancing operation⁵ in order to provide long-term liquidity to the banking system of struggling euro area Member States. By analysing the national banking statistics, it becomes apparent that the reserves were mostly created by national central banks of "crisis countries", while the reserves ultimately ended up in Germany and the Netherlands (Cecchetti et al., 2012). The reserve flow had its origins in cross-country interbank loans not being renewed (no roll-over) and private capital flight (deposits flowing out of crisis countries). This is one explanation why the TARGET2 balances increased sharply during the euro crisis (Cecchetti et al., 2012).

In 2014, the ECB introduced TLTROs, which are explicitly connected to banks' credit issuance. One problem for the ECB, which occurred during the great financial crisis and the euro crisis, is that banks reduced their credit issuance (credit crunch), when the economy was struggling and the ECB wanted to increase its expansionary stance. While the ECB could provide unlimited⁶ amounts of reserves through its refinancing operations, it could not directly control the effect on bank lending. The introduction of TLTROs augmented its classical longer-term refinancing operations through incentives for banks to engage in credit creation or at least not to shrink their credit portfolio. Andreeva and

⁵ This operation is also known under the abbreviation VLTRO, which stands for very long-term refinancing operation, because of its 3-year maturity, which was longer than all previous operations.

⁶ The amount is principally only limited by the available collateral of banks.

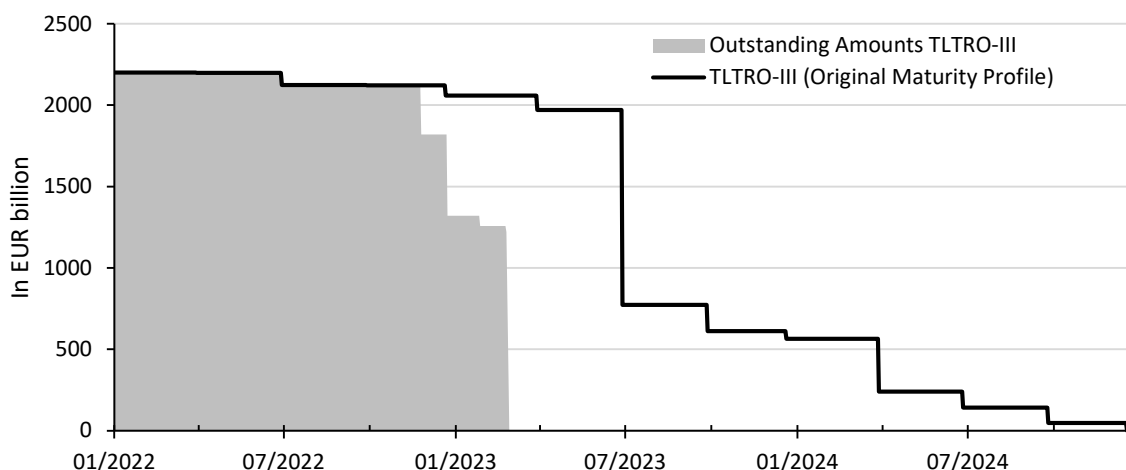
García-Posada (2020) found that the first series of TLTROs had positive effects on the loan supply, because of lower marginal costs due to the attractive conditions of the refinancing operations. Lane (2020) shows that the TLTROs had a different effect in vulnerable and non-vulnerable countries. The lending rates for participants in the TLTROs are lower than for non-participants in vulnerable countries, while this effect is not that pronounced in non-vulnerable countries.

After the outbreak of the COVID-19 pandemic in March 2020, the ECB launched a new series of targeted longer-term refinancing operations (TLTRO-III) with especially attractive conditions. If the lending criteria set by the ECB were met, the targeted longer-term refinancing operations had an interest rate of -1%, i.e. banks earned interest income by taking up targeted longer-term refinancing operations (liability for banks). But ultimately the gross amount of interest income for banks hinged on the amount taken-up and the fulfilment of the lending criteria. The final net interest income also depended on the bank's cost of holding reserves at the central bank. As bank reserves increase by the amount of refinancing operations, the interest rate on the deposit facility (-0.5%) decreases the gross interest income from the refinancing operations. Hence in the normal case, banks could earn a net 0.5% on the refinancing operations. Especially banks that held low amounts of reserves before the take-up of refinancing operations could profit from the scheme. This is because of the tiering scheme introduced by the ECB in 2019. In the tiering scheme, an amount of six-times the minimum reserve for each bank was exempted from the application of the negative deposit facility rate (European Central Bank, 2019). Thus, banks with idle exemption allowance space could take up refinancing operations at -1% and place the reserves at the central bank for 0%. While for these banks the new series of refinancing operations was particularly attractive, the incentive for lending also existed for banks with no exemption allowance left.

Banks participating in TLTRO-III increased their lending volume. Barbiero et al. (2021) show the different behaviour of the lending volume of participants of the new series of TLTROs and of non-participants. While participants and non-participants shared a similar behaviour of their lending volumes before the introduction of TLTRO-III, the lending volume for participants increased in the period from March 2020 until June 2021 (i.e. after the introduction of TLTRO-III), while for non-participants the lending volume even decreased. The TLTROs hence led to an increase in the availability of credit to the private sector and worked against a broader deleveraging process of banks cutting their loan portfolio. As in the euro area private sector funding is bank-centred in contrast to the United States, where private sector funding relies more on capital markets, funding-for-lending schemes like the TLTROs play a bigger role in safeguarding favourable financing conditions, which ultimately are connected to the targeted monetary policy stance (Bernanke, 2020).

In order to align the TLTROs with its monetary tightening stance, the ECB adjusted the conditions of TLTRO-III in its October 2022 Governing Council meeting. The incentive scheme based on interest income through the refinancing operations was constrained by the Governing Council in October 2022 (European Central Bank, 2022). This led to voluntary repayments of the banks. Figure 4 plots the outstanding amount in March 2023 against the original maturity profile of the TLTRO-III tenders. The difference is equal to the amount of voluntary repayments, which lie in the order of EUR 800 billion. In line with the outstanding amounts of TLTROs, the excess reserves decreased. Going forward, there is no extra incentive for credit creation for banks other than internal considerations. The effect of the TLTROs on bank lending conditions and volumes, hence, will vanish. This is an adjustment in line with the targeted monetary stance of the ECB and part of the holistic approach of adjusting all monetary policy tools.

Figure 4: Outstanding amounts of TLTRO-III and original maturity profile



Source: ECB, author's calculations.

Notes: The figure shows the total outstanding of TLTRO-III and its original maturity profile. The difference is equal to voluntary repayments triggered after the October 2022 meeting of the Governing Council of the ECB.

2.2. Forward guidance and asset purchases

Forward guidance and large-scale asset purchases are the main unconventional tools for increasing the expansionary monetary policy stance at the zero-lower bound. When central banks worldwide lowered interest rates in the aftermath of the great financial crisis, they quickly hit the zero-lower bound. At the zero-lower bound the conventional policy tool, i.e. the steering of the short-term interest rate, loses its traction and central banks revert to unconventional tools in order to influence financial conditions.

Forward guidance and large-scale asset purchases aim to decrease medium- to long-term yields along the term structure of interest rates. Theoretically, long-term yields can be split into expectations of the path of short-term interest rates and a term premium, i.e. a long-term asset should at least return the cumulative interest income from a short-term asset plus a term premium. The term premium is related to the risk related to increasing uncertainty about events occurring in the future. Therefore, usually the yield curve is positively sloped, with longer maturities returning higher yields and hence compensation for the higher risk.

Forward guidance influences the expectations on the path of short-term interest rates. By a communication strategy of “lower-for-longer”, the central bank can signal that it envisages to keep interest rates at the zero-lower bound for some time. The first attempts of forward guidance were based on such indeterminate communication. Then the communication in terms of forward guidance became more determinate in the sense that an explicit date was mentioned. Finally, the communication strategy in terms of forwards guidance was based on specific economic conditions, which have to be met in order to lift interest rates (Bernanke, 2020). Bernanke (2020) describes forward guidance at the zero-lower bound as being equal to committing to “lower-for-longer” like “when Odysseus bound himself to the mast to avoid the temptations of the Sirens”. Bernanke (2020) also reports that the forward guidance approach evolved over time, becoming more sophisticated and effective. This is partly due to better communication on the side of the central bank, but also a better understanding on the side of financial markets. By credibly committing to keep rates at the zero-lower bound, the central bank can influence yields along the whole term structure of interest rates, while the effects are most pronounced for the short- to medium-term maturities. To enhance sole

communication, an important commitment device is an asset purchase programme. Through the combination with asset purchases, the effectiveness of forward guidance increases (Bernanke, 2020; Lane 2020). The rationale is that as long as asset purchases are conducted, the central bank will not hike interest rates (Schnabel, 2021). That means in a monetary tightening cycle first the conditions for an end of net asset purchases have to be met and afterwards a possible lift-off of interest rates occurs.

Recently in their monetary tightening cycles, it can be observed that the ECB and the Fed are addressing market pricing of the path of short-term interest rates. Also, above the zero-lower bound, central bank communication recently reacted to the market pricing of short-term interest rates. This mostly concerns the terminal rate, i.e. the interest rate at which central banks stop increasing interest rates. Over the last weeks, it can be observed that the terminal rates are pushed higher and that the path of expected interest rates becomes flatter, i.e. possible rate cuts are priced out for the year 2023 (Cherry and Hirai, 2023).

Quantitative easing by large-scale asset purchases was the main unconventional monetary policy tool at the zero-lower bound. In the midst of the great financial crisis, the Fed and the Bank of England introduced large-scale asset purchases quickly. The Fed bought not only sovereign bonds, but also mortgage-backed securities. In the first phase from November 2008 onwards, these purchases had a market stabilisation aim and in total USD 1725 billion of assets were bought (Schnabl and Sonnenberg, 2020; Bernanke, 2020). But the Fed after so-called “QE1” launched two more rounds (November 2010: USD 600 billion and September 2012: open-ended programme) of large-scale asset purchases, which had the aim of stimulating economic activity and the inflation outlook (Bernanke, 2020). When purchases ended in October 2014, a total of USD 3,800 billion were bought (Bernanke, 2020). In contrast, during the great financial crisis the ECB first stabilised interbank money markets by its refinancing operations (Figure 3) and asset purchases of covered bonds⁷. In the euro crisis the ECB launched a new longer-term refinancing operation (Figure 3) and engaged in a second covered bond purchase programme to stabilise banks. From 2010 onwards, the ECB also started to buy sovereign bonds of struggling crisis countries in the SMP⁸, but the purchases were sterilised in order not to have an influence on the overall monetary policy stance (Bernanke 2020; Lane 2020). Because of the sterilisation, the purchases under the SMP are not considered as quantitative easing. Hence the first introduction of quantitative easing by the ECB occurred with the launch of the asset purchase programme (APP) in mid-2014. This is more or less the time when the Fed terminated its asset purchases (Schnabl and Sonnenberg, 2020).

From 2015 onwards, in the APP, the ECB bought sovereign bonds on a large scale as well as corporate bonds, asset-backed securities and covered bonds. These purchases had the aim to provide ample policy accommodation in order to stimulate economic activity and the inflation outlook. The ECB with the introduction of the APP changed from crisis management to policy accommodation and bought assets in the amount of EUR 2,600 billion until the end of 2018, a major part of which represented purchases of sovereign bonds⁹.

The large-scale asset purchases had the aim of lowering long-term yields by reducing the term premium. Whereas forward guidance was explicitly targeted to lower long-term yields by reducing the expectations on the short-term policy path, quantitative easing explicitly targeted the term premium, i.e. the compensation of risk investors demand for investing in long-term assets. The effects of

⁷ For details on the covered bond purchase programme see: <https://www.ecb.europa.eu/mopo/implement/app/html/index.en.html>.

⁸ For details on the SMP see: <https://www.ecb.europa.eu/mopo/implement/app/html/index.en.html>.

⁹ For details on the APP see: <https://www.ecb.europa.eu/mopo/implement/app/html/index.en.html>.

quantitative easing on long-term yields were analysed in various empirical studies (for a compilation of results see Bernanke, 2020).

In line with the implementation of large-scale asset purchases, the literature studying the effects of quantitative easing evolved over time. While the first empirical studies were based on analysing the announcement effects of quantitative easing in event studies, there were problems to control for expectations. This is especially true after the first quantitative easing round of the Fed in 2008 (Bernanke, 2020), as financial markets form expectations on the launch of quantitative easing programmes and yields could thus react beforehand. The literature to study the effects of quantitative easing evolved by the publication of a theoretical model by Vayanos and Vila (2009) and an empirical application of Li and Wei (2013) for the United States. For the euro area, Eser et al. (2019) provided estimates for the APP building on the model of Vayanos and Vila (2009). The model suggests that the policy accommodation effect of quantitative easing mostly works through the portfolio re-balancing channel¹⁰. As the central bank increases its market footprint by asset purchases on the sovereign bond market, price-sensitive investors are re-balancing their portfolios, i.e. reallocating funds in other asset classes to obtain a certain risk-reward relation. Through the increasing market presence of the central bank, the term premium is pushed down as more and more duration risk¹¹ is shifted from private investors to the central bank¹². The effect in the model is dependent on the relative supply of sovereign bonds in the hands of price-sensitive private investors and the central bank as well as expectations on the future supply of newly issued sovereign bonds.

In an empirical application, the effect of the APP on the term premium of a 10-year bond is estimated to be approximately 100 basis points. Eser et al. (2019) implement the Vayanos and Vila (2009) model for the euro area and estimate the effect of the APP on the term premium. They report an estimate of approximately 100 basis points (bps) on a synthetic euro area bond consisting of the four biggest euro area countries. The announcement effect is equal to 50 bps and then the effect increased with the extension of the APP over time. In June 2018, the effect reached 95 bps. The effect depends on the stock of bonds in the portfolio of the Eurosystem, i.e. the effect only slowly vanishes with maturing bonds being rolled off the central bank's balance sheet and new bond issuance by the fiscal authorities being held by private investors. Eser et al. (2019) report a half-life of the effect of five years. For the United States, Ihrig et al. (2018) report similar findings. They estimate a cumulative effect after the three rounds of quantitative easing (QE1, QE2, QE3) in the range of 120 bps. In line with Eser et al. (2019), the effect is persistent.

After the outbreak of the pandemic in March 2020, central banks worldwide engaged in renewed rounds of quantitative easing to ultimately backstop huge fiscal deficits. In March 2020, the ECB launched the PEPP with a total envelope ending up at EUR 1,850 billion. Additionally, the pace of net purchases of the APP was increased from March 2020 onwards¹³. In the euro area the net purchases did not only absorb the new issuance of sovereign bonds, but also the stock of bonds held by other investors decreased (Gern et al., 2022b). The balance sheet of the Eurosystem increased from EUR 4,700 billion to EUR 8,800 billion (Figure 5). The Fed and the Bank of England likewise started new large-scale purchase programs in the face of the pandemic. The Fed's balance sheet increased by the renewed round of asset purchases from roughly USD 4,000 billion to USD 8,900 billion (Figure 5). While the

¹⁰ In times of increased financial market stress, the character of quantitative easing is different as mostly the market stabilisation channel is at work (Schnabel, 2021).

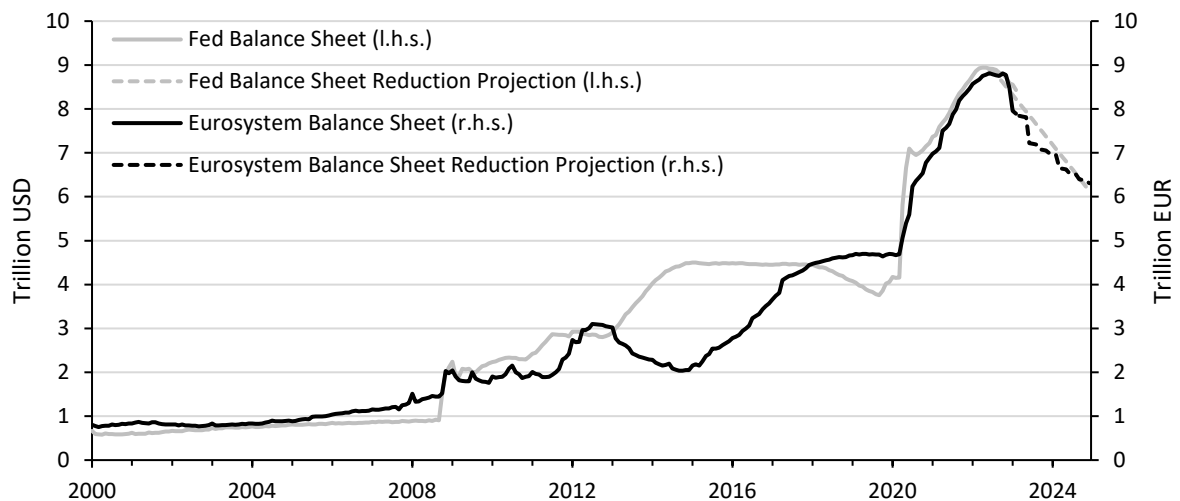
¹¹ Duration risk is closely related to the risk stemming from a change in the interest rate. With rising interest rates, bond prices fall. The intensity of the price correction depends on the maturity. The longer the maturity, the higher the price effect.

¹² In the literature the portfolio re-balancing channel is sometimes also called the duration extraction channel (Schnabel, 2021).

¹³ The APP was restarted even before the pandemic. No net asset purchases occurred between January and October 2019. In November 2019 it was restarted.

increase in the case of the Fed was caused mostly by asset purchases of treasury securities and mortgage-backed securities, the balance sheet of the Eurosystem expanded by asset purchases in the APP and PEPP, but also by the increase in the TLTRO-III (Figures 3, 5).

Figure 5: Balance Sheet of Fed and Eurosystem



Source: Refinitiv, ECB, Fed, author's calculations.

Notes: The figure shows the size of the balance sheet of the Eurosystem and the Fed in trillion EUR and USD respectively. The balance sheet projections include the announced pace of quantitative tightening. For the Eurosystem also the repayments of the TLTRO-III are considered.

The asset purchases of the Eurosystem during the pandemic further decreased the term premium of 10-year bonds with an estimated effect reaching 180 basis points (bps). In a recalibrated version of the Eser et al. (2019) empirical application, the effect on the synthetic 10-year bond of the four biggest euro area countries is estimated to be around 180 bps. The effect on lower maturities is also sizable with 120 bps for five-year bonds and 60 bps for two-year bonds (Schnabel, 2021). The additional effect of the pandemic-related purchases in excess of the effect caused by the APP is around 100 bps for yields with a maturity of 10 years (Schnabel, 2021). Estimations based on overnight index swaps (OIS) are in line with the findings, but the level effects are smaller (Deutsche Bundesbank, 2023b). OIS in contrast to sovereign bonds do not contain e.g. credit risk of the specific country, but the duration extraction channel of asset purchases decreasing the term premium also applies for these financial products. The estimations suggest that the term premium of an OIS with ten-year maturity was decreased by 100 bps by the end of 2020 (Deutsche Bundesbank, 2023b).

The effects of quantitative easing on economic activity and inflation depend on the transmission of financial conditions to the real economy. While studies on the effects of quantitative easing on asset prices like long-term yields are uncertain as they depend on modelling assumptions and empirical strategies, Bernanke (2020) argues that the persistent effect on the term premium of asset purchases and the easing of financial conditions is a feature that can be found in many studies in the literature. It is often argued that the easing of financial conditions has positive effects on economic activity and the inflation outlook. While this is true at the margin, it remains a very active field of research and the size of the effects is hard to determine as the transmission channel is very complex (Crawley, 2022). One note of caution is that monetary policy cannot solve structural problems, which impair growth dynamics. Hence even favourable financial conditions have different state-dependent effects.

In December 2022, the ECB announced plans for the reduction of its asset portfolio. While the TLTROs will be repaid either at maturity or at the date foreseen for voluntary repayments (Figure 4), the reduction in the asset portfolio can be configured by the ECB. At its February 2023 Governing Council meeting, the ECB announced that EUR 15 billion of maturing bonds of the APP portfolio will be run down from March 2023 until June 2023 (European Central Bank, 2023). Then the pace could be adjusted upwards. The total redemptions of the APP portfolio are equal to roughly EUR 30 billion¹⁴ per month, while the redemptions regarding sovereign bonds are equal to approximately EUR 20 billion. As the weighted average maturity in the PEPP portfolio is roughly equal to the one in the public sector purchase programme (PSPP) portfolio regarding sovereign bonds, one can derive an additional EUR 12 billion of possible redemptions from the PEPP portfolio. But the reinvestments of the PEPP portfolio can be applied flexibly across countries. In light of fragmentation risk, the PEPP reinvestments are seen as the “first line of defence” (Gern et al., 2022b)¹⁵. Therefore, it is hard to imagine that the quantitative tightening process will also concern the PEPP portfolio. The maximum monthly pace is thus equal to EUR 30 billion of redemptions in the PSPP portfolio. The current holdings in the PSPP portfolio are equal to EUR 3252 billion. Running down the portfolio would take 18 years with a pace of EUR 15 billion per month and nine years with a pace of EUR 30 billion.

The Fed announced its quantitative tightening plans in May 2022 and currently the pace is USD 95 billion per month. The Fed started with a monthly pace of USD 47.5 billion in June 2022 (Federal Reserve, 2022). The USD 47.5 billion split into redemptions of USD 17.5 billion of mortgage-backed securities and USD 30 billion of treasury securities. After the phase-in period of three months, both amounts were doubled. From its peak of USD 8,900 billion, the balance sheet already decreased to USD 8,400 billion by mid-February (Figure 5). It is expected that the balance sheet will further decrease, but the Fed announced that it would slow the balance sheet run-off at some point in the future, when a level “consistent with ample reserves” is reached (Federal Reserve, 2022). Crawly et al. (2022) consider in their simulations a balance sheet run-down to a level of USD 6,500 billion, which equals roughly 20% of GDP. This was also the level before the pandemic and when the 2019 financial stress on the repo markets occurred. At that time, the Fed was also in the process of quantitative tightening (Acharya, 2022).

The Bank of England set an annual target for the reduction of its asset holdings of GBP 80 billion. In contrast to the ECB and the Fed, the Bank of England will also engage in active sales of GBP 45 billion (Bank of England, 2022a). The institutional set-up in the United Kingdom is different from the Fed and the ECB. An ad hoc asset purchase facility was created. First, the Bank of England gave loans to this facility and then engaged in asset purchases. The facility is fully backed by the Treasury and, from 2009 to 2022, GBP 123.8 billion of interest income was distributed to the Treasury (Bank of England, 2022a). Recently, payments started to reverse. In the fourth quarter of 2022, the Treasury made an indemnification payment to the facility of GBP 828 million. The indemnification payments are targeted to “interest costs and the gains or losses made at maturity or sale” (Bank of England, 2022a). Active sales can lead to losses, when the purchase prices of the assets are lower than the current market prices. Maturing bonds can lead to losses if the par value is lower than the book value.

Central banks increased interest rates in a steep process and quantitative tightening supports the monetary tightening cycle. Short-term interest rates were quickly adjusted to face the historic inflation surge. Through the adjustments in expectations on the path of short-term interest rates also

¹⁴ The estimated amounts of redemptions are summarised here: <https://www.ecb.europa.eu/mopo/implement/app/html/index.en.html>.

¹⁵ The new transmission protection programme (TPI) introduced in July 2022 is considered the “second line of defence”, which primarily achieved a prophylactic stabilising effect on government bond yields of some member countries and ensured that the steep interest rate hike cycle could be executed to this extent without risking financial market turbulences.

long-term yields adjusted, though the dampening effect of quantitative easing on the term premium of long-term yields cannot be quickly reversed. The effect of quantitative easing on the term premium is dependent on the stock of sovereign bonds in the central bank's balance sheet in comparison to the stock of sovereign bonds in the hands of private investors. When bonds mature and are rolled-off the central bank's balance sheet, fiscal authorities roll-over their debt and bonds in the hands of private investors increasingly accumulate, but the process is slow. The dampening effect on the term premium can be reduced when central banks adjust their pace of quantitative tightening upwards as the shift from holdings of bonds from the central bank to the private sector occurs faster¹⁶. Also a higher-than-expected future debt issuance would push the term premium upwards.

Reversing the dampening effect of quantitative easing on the term premium of 10-year bonds will take time. Wei (2022) provides an estimate on the effects of quantitative tightening on ten-year yields for the United States, where a passive balance sheet roll-off of USD 2,200 billion over three years is equal to the effects of an increase in 29 bps of the federal funds rate. If quantitative tightening is conducted for five years, the equivalent hike in the fed funds rate would be 35 bps. Crawley et al. (2022) report similar results. In their simulation, a balance sheet reduction of USD 2,500 billion over the next years is equal to the effect of a 50 bps increase in the federal funds rate with respect to the effects on ten-year yields. Thus, in order to remove policy accommodation with respect to the ten-year yields and to tighten financing conditions, interest rate hikes currently play a bigger role.

Nevertheless, the reversing of unconventional policy instruments is contributing to the monetary tightening cycle. One way to gauge the effect of adjustments in forward guidance and quantitative tightening is to derive proxy rates. Proxy rates relate the changes in financial conditions to hikes in the federal funds rate. However, also an adjustment in forward guidance and the balance sheet policies influences the financial conditions. Choi et al. (2022) report that judging from the adjustment in financial conditions, they would expect a higher federal funds rate than is actually prevailing. Hence, the proxy rate gives an insight into the additional easing of financial conditions at the zero-lower bound by unconventional instruments but now also indicates a tightening of financial conditions, which goes beyond the actual interest rate hikes. But it is probable that the effect on financial conditions through the adjustment of ten-year yields runs mostly via the adjustment of the expectations on the future path of interest rates and not through the balance sheet policies.

Quantitative tightening for the ECB is uncharted territory and therefore a step-by-step adjustment of the process can be expected. In line with the Fed, the ECB uses its balance sheet run-off as a passive accompanying process to interest rate hikes. In contrast to the Fed, the ECB considers the risks of a heterogeneous sovereign bond market. In the past, the ECB was eager to constrain a possible fragmentation in sovereign bond markets (Gern et al., 2022b). Therefore, the ECB introduced the transmission protection instrument (TPI) to contain potential fragmentation in the process of monetary tightening by an explicit ex-ante communication. Quantitative tightening can trigger financial stability risks. Recent examples are the strains in the repo market in late 2019 in the United States and the financial dislocations faced by pension funds in the United Kingdom in September 2022 (Acharya, 2022, Bank of England, 2022b). The Fed made explicit that it intends to keep ample reserves, which means that the balance sheet reduction will end at a specific level of reserves (Fed, 2022). For the ECB a similar procedure can be expected.

¹⁶ The slow process is related to the findings of Eser et al. (2019), which report a half-life of five years of the dampening effect on the term premium of the APP. The half-life can be decreased if the expected path of balance sheet run-off is surprised to the upside.

3. FISCAL COSTS OF AN ABUNDANT RESERVE SYSTEM

The Eurosystem changed from a scarce to an abundant reserve operating system. Equipped with two refinancing operations, the ECB originally controlled the amount of reserves in the banking system. As there was a structural liquidity deficit, some banks always had to refinance with the ECB. Hence, the ECB could influence the price of reserves, i.e. the interest rate on the interbank market. During the great financial crisis, the ECB was the lender of last resort with respect to reserves as interbank markets froze, because banks lost faith in the solvency of one another. National central banks took over the role of the interbank market and fulfilled the reserve demand of the banks via refinancing operations (Figure 3). The amount of reserves in the system during this time surpassed the minimum reserve requirements to a large extent. The operations led to an increase in the balance sheet of the Eurosystem¹⁷. During the euro crisis, refinancing operations increased sharply again (Figure 3), but also receded rather quickly after the famous “whatever it takes” speech of Mario Draghi in July 2012 (Draghi, 2012).

The inception of the asset purchase program was the biggest driver of reserve creation from 2015 onward. When national central banks buy bonds from banks, they basically swap newly created reserves for bonds. The bonds shift from the bank’s asset side to the central bank’s asset side. The bank receives newly created reserves from the central bank, which are a liability for the central bank. The purchase of assets from the banking sector hence increases the amount of reserves in the banking system. Even when national central banks buy bonds from the non-financial private sector, reserves are created as the purchase is intermediated by the banks of the non-financial private sector agents. In contrast from buying directly from banks, in this case the asset purchase is also connected to an increase in broader monetary aggregates¹⁸ (Deutsche Bundesbank, 2016).

The large-scale asset purchases increased the amount of reserves in the banking system and led to an abundance of reserves. While originally the ECB could control short-term interest rates by adjusting the amount of refinancing operations, this was only possible because overall reserves were scarce (structural liquidity deficit). As the amount of reserves in the system grew in line with the large-scale asset purchases, this scarcity vanished and reserves became abundant, i.e. greatly surpassed the minimum reserve requirements. When interest rates hit the zero-lower bound, the ECB practically switched from a corridor to a floor operating system and the deposit facility rate became the key interest rate of the interest rate corridor, because it determined the short-term interest rate on money markets from which all other medium- to longer-term interest rates are derived¹⁹. This caused no significant issues as long as interest rates were at the zero-lower bound.

The ECB hiked interest rates into the positive rate environment after years of negative interest rates in order to push against the historic inflation surge. Since 2014, the ECB set the deposit facility rate into negative territory, i.e. that banks needed to pay interest for holding reserves on their accounts at the national central bank. With its first interest rate hike in July 2022, the ECB ended the negative interest rate period. After several interest rate hikes the deposit facility rate will reach 3% in March 2022 (Figure 1). The remuneration of reserves increases the interest expenses of the national central banks, but more so than in previous monetary tightening cycles, because the starting point was an abundant reserve system and not a scarce reserve system. If the ECB decides not to remunerate reserves, the ECB

¹⁷ Refinancing operations increased the asset side of the Eurosystem, while the newly created reserves increased the liability side of the Eurosystem.

¹⁸ Reserves and currency in circulation make up the monetary aggregate base money (M0). The broader monetary aggregates include currency in circulation and other forms of money holding of the non-financial private sector e.g. deposits, time deposits, and money market holdings.

¹⁹ For details on floor operating systems see e.g. Bindseil (2016) or Selgin (2018).

would lose control of its targeted monetary policy stance as the deposit facility rate serves as the benchmark (floor) for short-term interest rates.

As reserves are not scarce anymore, the ECB does not influence the interest rate by refinancing operations, but simply sets the interest rate on reserves via the deposit facility rate. In contrast to a scarce operating system, the control of the short-term interest rate seems to be more stable as in the past the ECB had to forecast anonymous liquidity factors²⁰, which might influence the scarcity of reserves and hence the short-term interest rate. Now, in an abundant reserve system, the ECB simply sets the interest rate on reserves (deposit facility rate), which acts as a floor to all other interest rates.

In contrast to a scarce operating system, abundant reserves lead to higher costs for the central banks. The ECB has to remunerate reserves in order to control the interest rate. This was also the case in a scarce reserve system as minimum reserves were remunerated by the main refinancing rate. But through asset purchases, the amounts of reserves in the system are today way higher and hence trigger interest rate flows, which are also higher and rise in line with the deposit facility rate. The bonds purchased during the asset purchase programmes determine the interest income of central banks. The yield was locked-in at the purchase date of the particular bonds, while the interest expenses rise in line with the deposit facility rate. As the assets were mostly bought in a low interest rate environment, the interest income is lower than the current level of short-term interest rates, and hence resulting in losses for the Eurosystem as a whole. However, the losses are not distributed equally and depend on various aspects. For example, yields along the term structure of national sovereign bond markets of euro area members had different interest rate levels, when the purchases were conducted. While German sovereign bonds are the “safe haven” benchmark and have a particularly low yield, the yields of other euro area member countries are higher. A second determinant is connected to the TARGET2 balances of euro area Member States.

The asset purchase programmes increased TARGET2 balances in the euro area. The national central banks are responsible for the implementation of asset purchases. If national central banks buy bonds from domestic banks, no TARGET2 balances arise as the reserve creation and purchase is implemented in the same jurisdiction. But if the purchase is occurring across jurisdictions, TARGET2 balances, i.e. liabilities and claims, arise. For example, if the Banca d’Italia (Italian central bank) wants to buy an Italian bond from an investor, who has an account at a bank in Germany, the purchase is executed in the following way. The Deutsche Bundesbank (German central bank) buys the bond from the investor by creating new reserves. Then the Bundesbank transfers the bond to the Banca d’Italia. As the Bundesbank has a new liability, but no asset anymore, a TARGET2 claim fills the gap. Vice versa, the Banca d’Italia holds an additional asset, but no liability, hence a TARGET2 liability fills the gap. Auer and Bogdanova (2017) report that many investors hold accounts at German banks, which are ultimately connected with the Bundesbank, and that roughly 60% of all asset purchases of the Eurosystem were channelled through the Bundesbank, although direct purchases of German bonds by the Bundesbank represented just 26% of all purchases in accordance with the capital key.

German, Dutch and Luxembourg TARGET2 claims increased strongly during the asset purchase programmes²¹. The claims are remunerated by the main refinancing rate, but as the main refinancing rate since 2014 was stuck at 0% (Figure 1), the TARGET2 claims did not provide any interest income for

²⁰ One typical example of a seasonal scarcity pattern of reserves is the increased cash holding of households during December because of the Christmas season. As an increase in cash holding decreases the reserves of banks, reserves in the system as a whole become scarcer and this puts upward pressure on the short-term interest rate. If the central bank wants to counter this upward pressure, because it is not in line with its targeted monetary stance, it has to provide more reserves via refinancing operations.

²¹ See TARGET2 balances at the statistical data warehouse of the ECB: <https://sdw.ecb.europa.eu/browse.do?node=9691112>.

the respective national central banks. In contrast, Italy and Spain accumulated the biggest TARGET2 liabilities during the purchase programmes. For these national central banks, no interest expenses arose as the main refinancing rate was equal to 0%. The positive interest rate environment will now result in huge interest payment flows between the national central banks²². Hence, for the countries with TARGET2 claims the interest expenses resulting from excess reserves will be partly offset by the interest income from their TARGET2 balances. Actually, any interest expenses from reserves, which were created for the purchase of non-domestic bonds will be totally offset by interest income from the TARGET2 claims. For countries with TARGET2 liabilities, the interest expense resulting from reserves will be increased by the amount of TARGET2 liabilities.

National central banks receive interest income from their bond holdings. The monthly purchases of sovereign bonds by the national central banks in the asset purchase programmes (APP and PEPP) can be observed in two statistics published on the ECB website²³. There is also information on the weighted average maturity for the total bond holdings for each national central bank. While the exact information on the purchases regarding price and yield is not available, from the aggregate information one can obtain a rough estimate of the interest income from the bond holdings. For this rough estimation the price and yield data from a seven- and eight-year sovereign bond are used as it is approximately equal to the weighted average maturity of the aggregate bond portfolio. In combination with the information on the amount of monthly purchases, a hypothetical average yield of the aggregate bond holdings of each national central bank can be constructed. This can only be a rough estimate as national central banks not only bought nominal sovereign bonds, but for example also inflation-indexed bonds, which currently generate especially high interest income. The interest income of the national central banks is additionally determined by the non-sovereign bond portfolio, which consists of corporate bonds, covered bonds, commercial paper and asset-backed securities. The interest income resulting from these private sector assets is hard to estimate, as there are no benchmarks from which one could derive price and yield information. However, in the asset purchase programmes the private sector assets play a minor role in comparison to sovereign bonds (PEPP: 97%, PSPP: 80%).

By combining the interest expenses from excess reserves and TARGET2 liabilities and the interest income from the sovereign bond holdings and TARGET2 claims, one can construct an approximation of the costs of an abundant reserve system. In the following parts, the estimations for each position are presented for the Eurosystem as a whole and the five biggest national central banks for the years 2023 and 2024.

3.1. Estimation of interest expenses related to reserves

The amount of reserves will decrease with the pace of quantitative tightening and the maturing TLTRO-III tenders²⁴. For the estimation of the interest expense on reserves it is assumed that the pace of quantitative tightening equals EUR 15 billion from March 2023 until December 2024. Furthermore,

²² The ECB will act as a clearing house.

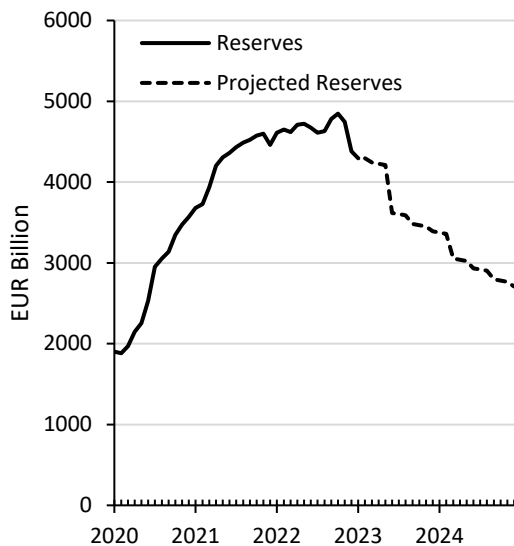
²³ History of cumulative purchase breakdowns under the PSPP: <https://www.ecb.europa.eu/mopo/implement/app/html/index.en.html>; History of public sector securities cumulative purchase breakdowns under the PEPP: <https://www.ecb.europa.eu/mopo/implement/pepp/html/index.en.html>.

²⁴ The ECB currently envisages a passive balance sheet run-off, i.e. maturing bonds are not reinvested. Active sales of the bonds to banks would result in a one-to-one reduction in the outstanding reserves. Anyhow it can be assumed that even the passive reduction can result in a one-to-one reduction of reserves under certain constellations. As governments roll-over maturing bonds, it can be assumed that banks buy part of the newly issued bonds. The payment for the bonds is probably settled between the accounts the banks and the state hold at the central bank. When the government uses the funds, this should result in a reduction of total reserves.

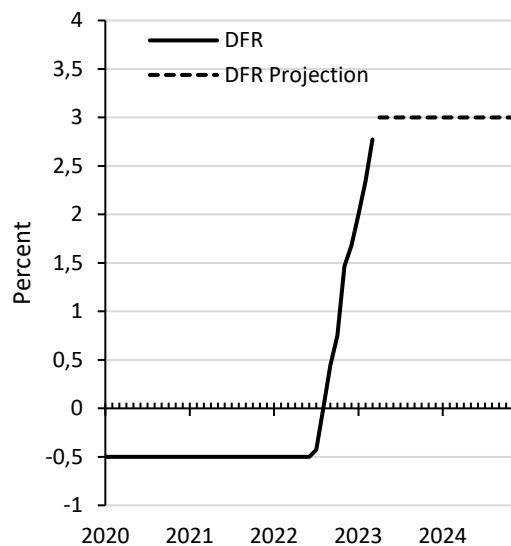
it is assumed that the remaining TLTRO-III tenders will be fully repaid at their respective maturity date²⁵. The combined effect is plotted in Figure 6 a. The remuneration of reserves is based on the deposit facility rate²⁶. The projection of the deposit facility rate is based on a simple estimate. The announced interest rate hike of 0.5 p.p. in the coming March meeting is considered, but no interest rate hikes after the 16 March meeting are assumed (Figure 6 b). Neither are any future interest rate cuts considered.

Figure 6: Projection of reserves and deposit facility rate

a) Reserves projection



b) Deposit Facility Rate projection



Source: ECB, author’s calculations.

Notes: The figure shows the monthly averages for reserves and the deposit facility rate. Reserves are equal to the balance sheet item “Liabilities to euro area credit institutions related to MPOs denominated in euro”. From March 2022 onwards EUR 15 billion are deducted in line with the quantitative tightening pace announced. Maturing TLTRO-III tenders are also deducted on their original maturity dates. However, the repayments could also occur earlier in terms of voluntary repayments.

In line with the reserves of the Eurosystem as a whole, the reserves of national central banks decrease over time. For the five biggest euro area countries, it is assumed that reserves decrease by EUR 15 billion times their respective capital key. The reserve amounts and the TLTRO-III tenders for national central banks can be obtained from the statistics on national central banks contributions to the Eurosystem consolidated financial statement. It is assumed that the repayments of TLTRO-III tenders to national central banks occur in line with the repayments for the Eurosystem as a whole, i.e. 60% in 2023 and 40% in 2024.

The estimates suggest an aggregate interest expense on reserves for the Eurosystem of EUR 107 billion in 2023 and EUR 90 billion in 2024 (Table 1). The estimates of the interest expenses for national central banks are especially high for Germany (EUR 33 billion) and France (EUR 25 billion) in line with the high reserve positions (Table 1). The estimates are based on a yearly average deposit rate of 2.8% in 2023 and 3% in 2024 (Figure 6). The average reserves for national central banks decrease in

²⁵ It is probable that there will occur voluntary repayments on earlier dates, which could influence the outstanding amounts of reserves in 2023 and 2024. Information on the outstanding amounts and the maturity date of TLTRO-III tenders can be found here: <https://www.ecb.europa.eu/mopo/implementation/omo/html/index.en.html>.

²⁶ Even the remuneration of minimum reserves is currently based on the deposit facility rate and not anymore on the main refinancing rate, which was used since the start of the currency union. This change occurred in the October 2022 meeting of the ECB Governing Council: <https://www.ecb.europa.eu/press/pr/date/2022/html/ecb.pr221027~25d335259c.en.html>.

line with the amount of quantitative tightening and TLTRO-III repayments. For Italy, full TLTRO-III repayments would lead to a negative reserve position in 2024, which is unrealistic. Either the ECB will launch new longer-term refinancing operations or the Italian banks will borrow via regular open market operations. It is also possible that a revival of the private interbank market occurs and reserves start to flow again between the banks and countries.

Table 1: Estimation of reserves per year (AVG) and yearly interest expenses, in EUR billion

	Year	Eurosystem	Germany	Spain	France	Italy	Netherlands
Reserves (AVG)	2023	3,822.8	1,137.5	211.9	886.4	71.3	321.4
	2024	2,971.9	995.9	136.9	719.2	-101.5	286.1
Interest expenses	2023	106.7	33.9	6.8	25.6	2.5	10.0
	2024	89.2	31.3	4.9	21.8	-2.6	9.4

Source: Refinitiv, ECB, author's calculations.

Notes: The table shows the projected yearly averages for reserves. Reserves are equal to the balance sheet item "Liabilities to euro area credit institutions related to MPOs denominated in euro". From March 2022 onwards EUR 15 billion are deducted in line with the quantitative tightening pace announced. The EUR 15 billion are distributed among the five biggest national central banks in line with their respective capital key. Maturing TLTRO-III tenders are also deducted on their original maturity dates. It is assumed that the repayment (60% in 2023 and 40% in 2024), which occurs for the Eurosystem as a whole, has the same relative share profile across all national central banks.

3.2. Estimation of interest income/expense of TARGET2 balances

In the positive interest environment, TARGET2 claims will be again remunerated by the main refinancing rate. Since 2014, TARGET2 balances did not lead to any interest expense/income as the main refinancing rate was stuck at 0% (Figure 1). But during this phase of zero interest rates, TARGET2 balances further accumulated. While for the Eurosystem as a whole the TARGET2 balances net out, they will lead to interest payments between the national central banks. As TARGET2 balances increased in the phase of quantitative easing, it is possible that quantitative tightening partly reverses the accumulated TARGET2 balances (see the introduction of section 3 for details). These dynamics however are difficult to estimate ex-ante, as they depend on the cross-border execution of quantitative tightening. As the quantitative tightening process is passive, i.e. a part of the maturing bonds are not reinvested, the influence on TARGET2 balances could be limited. In consideration of these uncertainties, the best guess for the evolution of TARGET2 balances is that they will hardly diminish. For the estimation of the interest expenses/income on TARGET2 balances it is thus assumed that the TARGET2 balances stay at their current levels for the years 2023 and 2024. In accordance with the projection of the deposit facility rate for 2023 and 2024 in section 3.1, the average yearly main refinancing rate equals 3.3% in 2023 and 3.5% in 2024.

Table 2: Estimation of TARGET2 balances and yearly interest expenses/income, in EUR billion

	Year	Germany	Spain	France	Italy	Netherlands
TARGET2 balances (stocks)	2023	1,248.8	-470.9	-97.0	-668.6	144.3
	2024	1,248.8	-470.9	-97.0	-668.6	144.3

	Year	Germany	Spain	France	Italy	Netherlands
TARGET2 interest income/expenses (flows)	2023	42.0	-15.8	-3.3	-22.5	4.8
	2024	43.7	-16.5	-3.4	-23.4	5.0

Source: Refinitiv, ECB, author's calculations.

Notes: The table shows the projected yearly average stocks of TARGET2 balances and the resulting yearly interest income/expense for the five biggest euro area countries.

Germany and the Netherlands will record high interest income on their TARGET2 claims in the order of EUR 40 and 5 billion respectively (Table 2). Vice versa, this interest income means interest expenses for countries with TARGET2 liabilities. Especially for Spain and Italy, the increase in interest expenses for the years 2023 and 2024 will be significant (Spain: approx. EUR 16 billion; Italy: approx. EUR 23 billion), while also France will see a small increase (EUR 3 billion). The flows for the five biggest national central banks do not net out exactly because claims and liabilities are also distributed among the remaining euro area Member States.

3.3. Estimation of interest income of bond portfolio

The yield determining the interest income on their respective sovereign bond portfolio is largely locked-in for the national central banks for the years 2023 and 2024. The only loose joint is represented by the amount of inflation-indexed bonds in the total sovereign bond portfolio, as these bonds are currently experiencing high pay-outs. Since the biggest share of the sovereign bond portfolio is represented by nominal bonds, an estimation of the aggregate average yield on these bonds should give a rough insight into the expected interest income. The weighted average maturity of the monthly purchases varies between seven and eight years. In order to approximate the average yield on the aggregate bond portfolio, one can combine the total amount of purchases with the monthly net purchases and the yield and price data of a seven- or eight-year sovereign bond for the respective months. Then the resulting average yield can be combined with the total holdings of sovereign bonds in order to get a rough insight into the interest income of national central banks.

Table 3: Estimation of the average yield of the bond portfolio, in percentage

PSPP AVG yield	Germany	Spain	France	Italy	Netherlands
8Y	-0.01	1.02	0.28	1.42	0.19
7Y	-0.11	0.77	0.14	1.21	0.05
PEPP AVG yield					
8Y	-0.49	0.23	-0.18	0.86	-0.40
7Y	-0.52	0.11	-0.27	0.68	-0.46

Source: Refinitiv, ECB, author's calculations.

Notes: From the annual reports of the central banks a direct calculation of the average yield is possible by taking into account the stock of bonds of the respective purchase program and the interest income recorded. For the five countries the approximation points into the right direction. In the annual reports of the year 2021 the average yield was equal to: Germany: 0.1% (PSPP), -0.37% (PEPP); Spain: 1.3-1.4% (PSPP), 0.2% (PEPP); Italy: 1.4-1.6% (PSPP), 0.43% (PEPP); Netherlands 0.2% (PSPP), -0.4% (PEPP).

Table 4: Estimation of interest income 2023, in EUR billion

PSPP interest income	Germany	Spain	France	Italy	Netherlands
8Y	-0.05	3.19	1.48	6.28	0.25
7Y	-0.75	2.40	0.74	5.34	0.07
PEPP interest income					
8Y	-1.94	0.45	-0.55	2.48	-0.33
7Y	-2.05	0.21	-0.81	1.97	-0.39
Sum					
8Y	-1.99	3.64	0.93	8.76	-0.08
7Y	-2.80	2.61	-0.08	7.31	-0.32

Source: Refinitiv, ECB, author's calculations.

Notes: The average yield data from Table 3 is combined with the projection of the amount of bond holdings for 2023.

Table 5: Estimation of interest income 2024, in EUR billion

PSPP interest income	Germany	Spain	France	Italy	Netherlands
8Y	-0.05	2.98	1.38	5.84	0.23
7Y	-0.69	2.24	0.68	4.97	0.07
PEPP interest income					
8Y	-1.94	0.45	-0.55	2.48	-0.33
7Y	-2.05	0.21	-0.81	1.97	-0.39
Sum					
8Y	-1.98	3.42	0.83	8.32	-0.10
7Y	-2.75	2.45	-0.13	6.94	-0.32

Source: Refinitiv, ECB, author's calculations.

Notes: The average yield data from Table 3 is combined with the projection of the amount of bond holdings for 2024.

The yearly interest income resulting from the sovereign bond holdings is highest in Italy and Spain, and in the order of roughly EUR 8 billion and EUR 3 billion, respectively (Tables 4, 5). For Germany and the Netherlands the interest income from their respective sovereign bond holdings is expected to be negative (Table 4, 5). This is especially driven by the PEPP portfolio, where the yields of purchased bonds were deeply negative (Table 3). The interest income for France is expected to be roughly zero, as positive income from the PSPP portfolio is equalised by negative income from the PEPP portfolio (Table 4, 5).

For all countries, these estimates should be analysed with caution and under the assumptions made. Especially the yields of inflation-indexed bonds could push the estimates up. Also, only half of the redemptions in the regular purchase programme is not reinvested (quantitative tightening). The other half will be reinvested. Currently yields are higher than in the past period of net purchases, thus this could also contribute to the upside, although the effect materialises only slowly. The maturing bonds from the PEPP will be reinvested fully. This could also slowly push the average yield upwards. But the overall reinvestments are small in comparison to the stock, so the upward effect should be limited.

For the Eurosystem as a whole the yearly interest income from its sovereign bond portfolio is estimated to be in the order of EUR 8-13 billion for the years 2023 and 2024. This estimate is obtained by considering the weighted average yield of the five biggest euro area countries (Table 3)

and applying the resulting yield on the total amount of bond purchases. It is hence assumed that the average yield on the bond portfolio of the remaining euro area Member States is roughly equal to the weighted average of the five biggest euro area countries.

3.4. Resulting net profits/losses from the estimations

From the above estimations, losses in the order of EUR 95 billion and 80 billion for the Eurosystem as a whole in the year 2023 and 2024 can be derived²⁷. For the Eurosystem as a whole, the capital and reserve position in the consolidated balance sheet at the end of 2022 was equal to EUR 114.5 billion²⁸. This means the combined estimated losses would be higher than the capital and reserves of the Eurosystem. The losses are distributed unevenly among national central banks. The highest losses are estimated for the French, Spanish and Italian national central banks (Table 6). For the German national central bank, the estimation does not result in a loss. This is mainly driven by the interest income on the TARGET2 claims, which in this assumption-based estimation exercise offsets the interest expenses on reserves and the negative interest income from its bond portfolio.

Table 6: Resulting net profits/losses of estimations, in EUR billion

	Germany	Spain	France	Italy	Netherlands
2023	5.7	-19.5	-28.4	-16.9	-5.4
2024	10.1	-18.5	-24.9	-13.2	-4.6

Source: Refinitiv, ECB, author's calculations.

Notes: The net effects give an insight into the estimated profit/loss from the interest expense derived from excess reserves (section 3.1.), the interest income/expense from TARGET2 claims/liabilities (section 3.2.) and the interest income from the bond portfolio (section 3.3.). The net effects hinge on the assumptions made in the sections to derive the single estimates. For example, in 2023 for Germany EUR 33.9 billion of interest expenses from reserves (section 3.1., Table 1) and EUR 42 billion of interest income from TARGET2 claims (section 3.2., Table 2) are estimated. Combined with the interest income from the bond portfolio in the order of EUR – 2.4 billion (avg. between seven- and eight-year yield in section 3.3., Table 4) a net effect of roughly EUR 5.7 billion results.

3.5. Discussion of the fiscal costs of an abundant reserve system

While the exact size of the losses for the national central banks is uncertain, the estimation exercise above provides insights into the costs of an abundant reserve system, which the Fed has already presented in a transparent way. In fact, this is a feature which was stressed by many central bankers years ago and many central banks were preparing for this possibility by building up provisions (Berentsen et al., 2014; Selgin, 2018; Deutsche Bundesbank 2023 a). But the historic inflation surge and the steep monetary tightening cycle put the system under stress, which is symbolised by the sheer size of the projected losses. Similarly, losses occurred in the first quantitative tightening cycle of the Fed. Also, this time the Fed already announced that the accumulating losses would be parked in a deferred asset, i.e. that the equity position of the central bank will actually become negative (Andersen et al., 2022). The Fed also announced that this position will be reduced over time by future profits. Until the deferred asset position is reduced to zero, the Fed will not distribute any profits to the Treasury. While the estimation exercise above only provides one possible scenario, the Fed provides a thorough scenario analysis for the evolution of the deferred asset size under different assumptions for the pace

²⁷ For the Eurosystem as a whole the net effect is equal to the interest income of the bond portfolio (see section 3.3.). This is estimated in the order of EUR 8-13 billion. The interest expenses from the remuneration of reserves is estimated in section 3.1. This is estimated in the order of EUR 107 billion in 2023 and EUR 90 billion in 2024. The net effect ranges between EUR 94-99 billion for 2023 and EUR 77-82 billion for 2024, hence EUR 95 billion for 2023 and EUR 80 billion for 2024 seem to be reasonable rounded estimates. The net effects for the national central banks additionally include the interest income/expense due to TARGET2 claims/liabilities.

²⁸ See position 12 capital and reserves:

<https://www.ecb.europa.eu/pub/annual/balance/html/ecb.eurosystembalancesheet2022~4a2e481250.en.html>.

of quantitative tightening and the level of short- and long-term interest rates (Andersen et al., 2022). In the baseline case the deferred asset will return to a zero by 2026, while in the worst-case scenario it could take until 2030. That would also mean that remittances to the treasury would be zero until 2030.

National central banks of the Eurosystem already reacted to the upcoming losses deriving from the interest expenses on reserves. De Nederlandsche Bank (the Dutch central bank) has already sent a letter to the Dutch Finance Ministry warning of considerable losses for the years 2023 and 2024 (De Nederlandsche Bank, 2022). De Nederlandsche Bank (2022) also warns that in an extreme case a capital injection by the state would be necessary. Against the expected losses, De Nederlandsche Bank (2022) reports benefits through lower financing costs for the government of EUR 28 billion between 2015 and 2021. In reaction to the letter from De Nederlandsche Bank, also the National Bank of Belgium (Belgian central bank) has issued two press releases concerning the issue of expected losses (National Bank of Belgium, 2022a, b). Recently, also the Deutsche Bundesbank (2023a) has published a warning in its press release of the 2022 annual accounts, where it referred to “burdens on the Bundesbank’s profit and loss account are likely to increase considerably in the years to come”.

The Fed also gives explicit guidance on unrealised gains/losses on its bond portfolio. Losses occur for example when the market price of the bonds is lower than the purchase price of the bonds. Private banks have to mark-to-market part of their asset positions, i.e. the difference between the purchase price and market price would result in a loss. The valuation guidelines for the Eurosystem, in line with the Fed, do not foresee mark-to-market pricing as the bonds are assumed to be held until maturity (Deutsche Bundesbank, 2021, p. 52). Other assets, e.g. gold and foreign currency instruments, are priced at the market values on the balance sheet date²⁹. In contrast, securities held until maturity, including the securities held for monetary policy purposes are valued at amortised cost, hence the current market price is not fully determining the valuation. However, if the par value of maturing bonds is below the book value a loss would materialise. The unrealised losses are sizable as in the case of the Fed (Andersen, 2022). The Bank of England has received an indemnification payment by the Treasury of GBP 828 million in October 2022 for the losses arising from interest expenses and “losses made at maturity or sale” (Bank of England, 2022a). From the derivation of the average yield of the bond portfolios (section 3.3., Table 3), also an estimate of the unrealised losses can be derived. If one compares current prices of seven- or eight- year sovereign bonds to the estimate of the average price of the bond portfolio, the current losses are equal to: 23% for Germany, 29% for Spain, 17.4% for France, 26% for Italy and 26% for the Netherlands. These relative losses are equal to: EUR 150 billion for Germany, EUR 90 billion for Spain, EUR 94 billion for France, EUR 117 billion for Italy and EUR 34 billion for the Netherlands. However, these unrealised losses are dependent on the current interest rate level and would decrease in a lower interest rate environment.

Currently in the Eurosystem, it is expected that no capital injections occur by national treasuries. The fiscal costs would thus be limited to the fact that no profits are distributed to national treasuries until the capital positions are sufficiently rebuilt (indirect costs). In the face of the sheer size of the projected losses, this could take several years. There exist different debates, which also become clear by the letter to the Dutch Ministry of Finance from De Nederlandsche Bank (De Nederlandsche Bank, 2022). In principle, losses are not a problem. Central banks remain operational, even if solvency per se is impaired. But, the letter also states that “should our buffers become too depleted or expected profits remain too low, additional measures may be necessary to restore our balance sheet to solidity.” (De Nederlandsche Bank, 2022). Hence a capital injection for the future is not excluded, which would result

²⁹ Through the revaluation of e.g. gold reserves the Eurosystem has built a sizeable revaluation account of EUR 586 billion. See position 11 revaluation account: <https://www.ecb.europa.eu/pub/annual/balance/html/ecb.eurosystembalancesheet2022~4a2e481250.en.html>.

in direct fiscal costs in comparison to the indirect costs. This capital injection would be based on the “solidity” argument. Bolt et al. (2023) argue that in history there were many cases when central banks with negative equity operated without any problems, while they also report that there are limits and that trust in the value of money can be disrupted in certain cases.

The Bundesbank experienced negative equity in 1973, when the Bretton Woods System broke down and USD reserves were devalued. In line with the deferred asset procedure of the Fed, the 1973 annual report of the Bundesbank shows a similar procedure. The losses on the USD reserves had to be re-valued after the Bretton Wood System collapsed and the Deutsche Mark (DM) appreciated (Deutsche Bundesbank, 2013). The gross losses on the USD reserves were equal to DM 10 billion (Deutsche Bundesbank, 1973, p. 106)³⁰. It is reported that the board of the Bundesbank at that time was also discussing to ask the Treasury for re-capitalisation, because of the negative equity position (Braunberger, 2017). But as the Bundesbank was fully operational, they proceeded in the way of booking a deferred asset. Hence there was no direct cost for the taxpayer, but indirect costs as in the following years no profits were distributed to the treasury (Braunberger, 2017). In retrospect the losses on the USD reserves occurred out of a position of strength as the domestic currency (DM) was highly demanded and appreciated consequently.

The institutional change to an abundant reserve system is not easily and quickly revertible and the interest expenses of central banks could be interpreted as a feature instead of a bug. The historic inflation surge (Figure 1) and the consequently steep interest increase (Figure 2) can trigger financial stability risks. The unprecedented period of low interest rates led to an increase in private sector debt in many countries around the world. Even when compared to the aggregate income development, private indebtedness increased in several countries, also in the euro area³¹. The financial cycle, which consists of the house price development and indebtedness of the private non-financial sector, was also turning up in many countries (Borio, 2012). The financial cycle is often related to the build-up of financial imbalances. When these financial imbalances materialise, often banking crises occur and recoveries from the bust take a long time, because of subdued growth rates (Borio, 2012, Boysen-Hogrefe, 2016). Recent data on housing prices suggest a first adjustment of prices³². The new business credit statistics show a marked drop in the face of the higher interest rate level. Over time this higher interest level will also influence the debt service of the private sector, which is currently still mostly shielded by long-term credit contracts. This mix of potential financial risks can put the banking sector under strain. From this perspective, central bank losses, because of high interest rate expenses on reserves, come along with the feature that commercial banks generate high interest income by holding reserves. It could be advisable that banks retain large parts of this windfall profit in order to shield against potential risks in their asset portfolio and funding conditions. The interest income, which banks earn on reserves, also increases the possibility of interest payments on private sector accounts. While the conditions also hinge on the degree of competition for deposit funding, this could also be interpreted as a feature of an abundant reserve system. The higher the probability of deposits of the private sector being remunerated, the higher is the brake intensity of interest rate hikes. This would help to align aggregate demand with aggregate supply and decrease inflationary pressures.

³⁰ The deferred asset position was called “Adjustment item due to revaluation of currency reserves and other foreign currency items - Balance sheet loss - Depreciation in 1973”.

³¹ For an overview of the indebtedness of the private sector see: <https://stats.bis.org/statx/srs/table/j?m=A>.

³² See e.g. a monthly house price index for Germany: <https://report.europace.de/epx-hedonic/>.

4. CONCLUSION

This paper provides an overview of the current context where monetary policy faces a historic inflation surge after years of monetary expansion. An analysis of the rationale for the introduction of unconventional monetary policy tools is provided and the evolution of the new instruments is portrayed over time. The unconventional monetary policy instruments introduced by the ECB are now adjusted to align the policy toolbox with the ECB's targeted monetary policy stance. The adjustment occurs rather quickly concerning TLTROs launched during the pandemic. Yet, the stock of bond holdings resulting from the large-scale asset purchase programmes accumulated over a long time period and reached a sizeable level. This sizable stock of bonds cannot be quickly reduced by quantitative tightening. Similarly, the dampening effect on the term premium of long-term yields cannot be reversed fully in a quick process.

Currently it becomes apparent that an institutional change from a scarce to an abundant reserve system occurred. The consequences were until now hardly visible, because the side effects of asset purchases, namely the creation of huge amounts of excess reserves, had no flow effects. This is different in a positive interest rate environment as the interest expenses of central banks rise with the level of interest rates, while their bond portfolios are not generating interest income of similar size. The paper intends to give an insight into the flow effects by an assumption-based estimation. It is shown that central banks could end up accumulating losses resulting in negative equity positions. From a historical perspective this is per se nothing new, but the sheer size of the losses could result in being historic.

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Confronted with a historic inflation surge, the ECB steps on the brake(s). While interest rate hikes are its primary tool, unconventional tools are also adjusted to strengthen the brake intensity. Quantitative tightening will reduce the stock of bonds in a slow process. The change from a scarce to an abundant reserve system will prevail. In contrast to previous monetary tightening cycles, in an abundant reserve system huge interest expenses result in central bank losses and fiscal costs for the coming years.

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