FACULTY OF ECONOMICS AND BUSINESS ADMINISTRATION

UNWINDING THE STIMULUS: THE RATIONALE AND CHALLENGES OF THE BALANCE SHEET NORMALISATION IN THE EURO AREA

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Abstract

This master dissertation examines the justifications and challenges associated with the balance sheet normalisation in the euro area. Following years of expansive asset purchases conducted under the Eurosystem's asset purchase programme and pandemic emergency purchase programme, the ECB has initiated a gradual reduction of its securities holdings. This analysis explores the motivations behind this policy, including the need to scale back the persistent effects of asset holdings, restore monetary policy space, and reinforce institutional credibility. At the same time, this thesis examines the potential challenges that coincides with quantitative tightening, such as uncertainty surrounding the optimal size of the ECB's balance sheet, the appropriate path of this normalisation process, and the fragmentation risks within the euro area. Employing an event study methodology, this paper assesses the impact of QT announcements on a range of financial indicators and compares these effects with those observed during balance sheet expansions. The results indicate that QT announcements are associated with statistically significant increases in sovereign bond yields across various maturities, though the overall magnitude of these announcement effects remain limited. This finding challenges the symmetry hypothesis of balance sheet policies, which posits that the effects of balance sheet reductions should mirror those of expansions. Moreover, the analysis reveals that the impact on other financial indicators is generally insignificant, reinforcing the conclusion that the effects of the balance sheet normalisation are markedly weaker than those observed during asset purchases.

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Abbreviation	Definition	Section
ABSPP	Asset-backed securities purchase programme	2.1
APF	Asset Purchase Facility	2.3
APP	Asset Purchase Programme	1
BoE	Bank of England	2.2
CBPP3	Covered bond purchase programme	2.1
CESI	Citigroup Economic Surprise Index	3
CHF	Swiss franc (Confoederatio Helvetica franc)	3
CJEU	Court of Justice of the European Union	2.2
CSPP	Corporate sector purchase programme	2.1
DFR	Deposit Facility Rate	2.1
DNB	De Nederlandsche Bank	2.2
ECB	European Central Bank	1
ELB	Effective lower bound	2.1
EMH	Efficient Market Hypothesis	2.3
EONIA	Euro overnight index average	2.1
Fed	Federal Reserve	2.1
FFR	Federal Funds Rate	2.3
FRFA	Fixed-rate full allotment	2.1
GBP	British pound sterling	3
GFC	Global Financial Crisis	1
GDP	Gross Domestic Product	2.1
HICP	Harmonized Index of Consumer Prices	2.2
HQLA	High-quality liquid asset	2.2
HLW	Holston-Laubach-Williams models	2.3
IORB	Interest rate on reserve balances	2.3
LCR	Liquidity Coverage Ratio	2.3
LDI	Liability-Driven Investment	2.3
LSAP	Large Scale Asset Purchases	1
LTRO	Long-Term Refinancing Operations	2.1
MD	Money demand	2.3
MLF	Marginal Lending Facility	2.1
MRO	Main Refinancing Operations	2.1
MS	Money supply	2.3
NBB	National Bank of Belgium	2.2
NCBs	National central banks	2.1
NSFR	Net Stable Funding Ratio	2.3
OCA	Optimal Currency Area	2.3
OIS	Overnight Index Swap	2.1
OMT	Outright Monetary Transactions	2.1

continued on next page

Abbreviation	Definition	Section
ON RRP	Overnight Reverse Repo Facility	2.2
PEPP	Pandemic Emergency Purchase Programme	1
PSSP	Public Sector Purchase Programme	2.1
QE	quantitative easing	1
QT	quantitative tightening	1
SGP	Stability and Growth Pact	2.3
SMA	Survey of Monetary Analysts	2.3
SMP	Securities Markets Programme	2.1
SOFR	Secured Overnight Financing Rate	2.2
TEU	Treaty on European Union	2.2
TFEU	Treaty on the Functioning of the European Union	2.1
TPI	Transmission Protection Instrument	2.3
USD	United States dollar	3
€STR	Euro short-term rate	2.1

1. Introduction

In the aftermath of the global financial crisis (*GFC*), central banks across advanced economies adopted a range of unconventional monetary policy measures to counter deflationary pressures, support economic recovery, and stabilise financial systems. Among these, forward guidance, negative interest rates, and long-term refinancing operations became the measures of first resort. Large-scale asset purchases (*LSAP*), commonly known as quantitative easing (*QE*), emerged as a key policy instrument, particularly in an environment where policy rates had reached the effective lower bound. Through the acquisition of sovereign and private sector securities, the ECB aimed to lower long-term interest rates, compress risk premia, and inject liquidity into the financial system with its asset purchase programme (*APP*) and pandemic emergency purchase programme (*PEPP*).

As the macroeconomic environment shifted, particularly following the COVID-19 crisis and the inflationary surge triggered by supply disruptions and geopolitical tensions, central banks began tightening monetary policy. This new phase involved aggressive interest rate hikes, as well as launching policies to gradually reduce the central banks' balance sheets through the runoff of assets acquired under QE programmes. This process, known as quantitative tightening (*QT*), became a central feature of the post-pandemic normalisation strategy across developed economies. In line with the global trend, the ECB commenced its QT process in 2022, making a shift after nearly a decade of ultra-accommodative monetary policy.

The decision to reduce the size of the central bank's balance sheet requires justification, as conventional monetary tightening, via interest rate hikes, does not necessarily require a leaner balance sheet. These justifications are explored in detail in section 2.2. First, QT can help align long-term interest rates with the ECB's policy stance by mitigating the residual downward pressure on yields exerted by large asset holdings, thereby strengthening the transmission of monetary policy. Second, reducing the balance sheet may correct asset price distortions and help realign valuations with underlying economic fundamentals. Third, normalisation allows the ECB to reclaim balance sheet space, thereby preserving its ability to reuse QE in future downturns without breaching technical or legal constraints. Fourth, the large volume of securities on the ECB's balance sheet has contributed to collateral scarcity in key market segments such as the repo market. A smaller balance sheet could alleviate these shortages and improve overall market functioning. Finally, there are institutional considerations: persistently large-scale asset holdings may raise questions about the ECB's credibility and independence, especially in light of legal constraints on monetary financing.

However, these motivations must be weighed against a number of significant challenges, which are addressed in section 2.3. Compared to quantitative easing, the empirical literature on quantitative tightening remains limited because actual instances of balance sheet reductions have been relatively rare. Consequently, its macroeconomic and financial effects are far less well understood. This section investigates key areas of uncertainty, including the appropriate size and composition of the ECB's balance sheet, the optimal pace of normalisation, and the communication strategies needed to minimise market disruptions. Additionally, this section discusses how net negative asset purchases influence the natural rate of interest, which

challenges the actual transmission of monetary policy. This section ends off with a discussion on fragmentation risks in the euro area, where structural asymmetries and uneven transmission may complicate the balance sheet reduction.

The empirical component of this dissertation, presented in sections 3 and 4, employs an event study methodology to assess the financial market impact of ECB QT announcements. The analysis focuses on a broad set of indicators, including sovereign bond yields, equity prices, exchange rates, and other variables. In these sections, I will test whether the “symmetry hypothesis” of balance sheet policies holds. This hypothesis posits that QT should exert effects that are equal in magnitude but opposite in direction to those of QE. The findings indicate that, while QT announcements lead to statistically significant increases in sovereign bond yields across maturities, the overall market response is limited. Other financial indicators show little to no significant reaction, suggesting that the effects of QT are not symmetric to those of QE.

2. Literature Review

2.1. Background and context

Unlike the Federal Reserve and the Bank of Japan, the European Central Bank (*ECB*)[1] was initially reluctant to implement large-scale asset purchases in response to the economic distress caused by the financial crisis of 2008. Quantitative easing was viewed as an ultimum remedium, a measure of last resort, primarily due to its political sensitivity, fragmentation risks in the sovereign bond market and legal constraints within the euro area. A key legal barrier was Article 123 of the Treaty on the Functioning of the European Union (*TFEU*), which explicitly prohibits the ECB (and national central banks) from directly purchasing government debt instruments, aiming to prevent monetary financing of fiscal deficits (EUR-Lex, 2007).

Next to this, the ECB viewed its toolbox at the time as adequate enough to deal with the effects of the financial crisis and the euro crisis. As a result, the ECB initially relied on alternative monetary policy measures, such as long-term refinancing operations (*LTROs*) and forward guidance, rather than outright asset purchases. To maintain monetary policy control and address financial instability, the ECB also implemented other monetary policy measures, including the reform of the refinancing operations and asset purchasing programmes such as the Securities Markets Programme (*SMP*) and Outright Monetary Transactions (*OMT*). These measures were designed to restore market confidence and ensure liquidity in malfunctioning segments of the debt securities market (ECB Monthly Bulletin, 2010). In contrast, other major central banks in advanced economies adopted asset purchase programs more rapidly in response to the 2008 financial crisis, recognizing the necessity for asset purchases to stabilize financial markets.

It's important to clarify that, although the SMP is an asset purchase programme, it does not qualify as quantitative easing. This is because its design and objective differs fundamentally from those of conventional QE programmes. In particular, the SMP was intended to address dysfunctions in specific sovereign bond markets, not to inject broad-based liquidity into the financial system. Moreover, purchases under the SMP were fully sterilized, meaning that any liquidity created by asset purchases was simultaneously withdrawn from other monetary operations, thereby preventing a net increase in the central bank's balance sheet (Gros, 2012). Nevertheless, in practical terms, it is difficult to isolate sterilisation operations from other liquidity-providing measures implemented at the time, such as the fixed-rate full allotment (*FRFA*) on all refinancing operations. This overlap suggests that the liquidity absorbed through sterilisation efforts may have been offset by simultaneous liquidity injections elsewhere in the financial system. Therefore, the distinction between the SMP and QE became ambiguous, as both mechanisms contributed to the expansion of the central bank's balance sheet (Gros, 2012).

[1] Throughout this paper, the term "ECB" is used for ease of reference, even when referring more precisely to the Eurosystem or the ECB's Governing Council. The Eurosystem comprises both the ECB and the national central banks (*NCBs*) of the euro area member states.

Although the ECB did not initially resort to LSAP, deteriorating conditions forced the bank towards reconsideration. This shift became clear in a speech on 24 April 2014 in Amsterdam where Mario Draghi, president of the ECB, outlined the specific conditions under which the bank could trigger asset purchases (without sterilisation) (ECB, 2014). One of these conditions was a further decline in the already low inflation expectations.

After this announcement, market-based measures of middle term inflation expectations showed a downward trend, getting further away from the inflation target of 2% (ECB, 2021). Consequently, a few months later, on September 4 2014, The president of the ECB announced that the Governing Council had decided to begin purchasing assets without sterilisation within its asset purchase programmes (*APP*), with the objective of expanding the ECB's balance sheet, which had shrunk due to the gradual unwinding of earlier LTROs, back to its size at the beginning of 2012 (ECB, 2014). Initially these purchases were limited to private sector securities and did not include sovereign bonds. However, as economic conditions continued to deteriorate and inflation remained at a low level, the ECB decided to expand the asset purchase programmes to include euro-denominated, investment-grade securities issued by euro area governments and agencies in the secondary market, thereby launching the Public Sector Purchase Programme (*PSPP*) (ECB, 2015).

PSPP is one component of the broader APP framework, which also include three other purchase programmes. Specifically, the APP encompasses: (i) the asset-backed securities purchase programme (*ABSPP*), corporate sector purchase programme (*CSPP*), (iii) covered bond purchase programme (*CBPP3*) and (iv) public sector purchase programme (*PSPP*). Under the ABSPP, the ECB purchased securities backed by the securitisation of bank loans (Banca d'Italia, n.d.). The CSPP allows the ECB to buy investment-grade bonds issued by non-bank corporations based in the euro area (Macchiarelli et al., 2017). The CBPP3 involved the purchase of covered bonds issued by banks (DNB, n.d.).

To understand the magnitude of APP, the evolution of the asset side of the ECB's balance sheet is illustrated in figure 1. Prior to the establishment of APP, the expansion (contraction) was primarily driven by the central bank's lending operations, particularly under its fixed-rate full allotment policy (*FRFA*), and LTROs. These measures were implemented to address disruptions in the interbank market and ensure sufficient liquidity supply. However, as noted, between 2012 and 2014, the balance sheet shrank as a result of the expiration of LTROs (ECB, 2025). The introduction of APP subsequently sparked the start of persistent balance sheet growth, driven primarily by these asset purchases (ECB, 2025). This expansion continued for the following years, but significantly slowed between January and October 2019, reflecting the ECB's decision to reduce the pace of net purchases under APP as economic conditions improved and inflation projections moved closer to the 2% target (Deutsche Bundesbank, 2018). However, in light of renewed disinflationary risks, the ECB decided to resume asset purchases in November 2019. This renewed intervention was further reinforced from March 2020 onward, when an additional purchase envelope (see later) was introduced to support market functioning and ensure the continued transmission of monetary policy (ECB, 2025).

Figure 2 illustrates the relative weight of each component within the ECB's APP, expressed as a percentage of total securities holdings for monetary policy purposes. The data clearly indicate that PSPP has consistently represented the most significant share of asset purchases. Although the CBPP3 was the first to be introduced, the PSPP rapidly became the dominant programme, accounting for approximately 80% of total holdings at least until 2020. In comparison, the CSPP, which was only introduced in March 2016, has remained relatively modest in scale, peaking only at 8% of total holdings. Similarly, the ABSPP has constituted only a minor share of total purchases throughout the years.

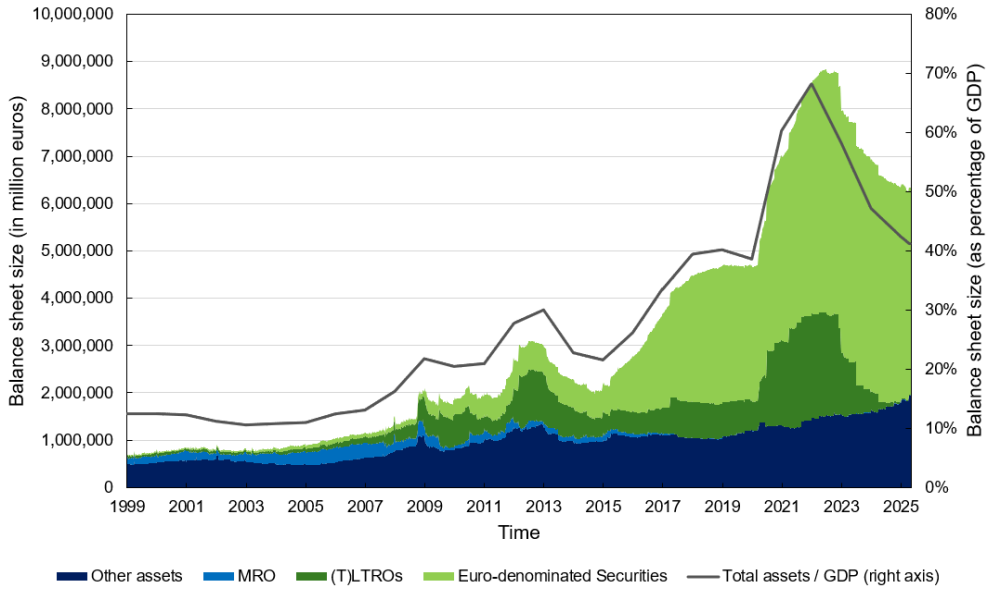

Figure 1 - Assets of the Eurosystem consolidated balance sheet (1999 - 2025), in million euros (left axis) and percentage of GDP (right axis)

Note: The first y-axis, which contains absolute numbers, are based on weekly data and are written in millions of euros.The relative data on the second y-axis is based on annual data and is written as a percentage of GDP. The latter is based on my own calculations.

Source: (1) European Central Bank Data Portal. (2025). *Longer-term refinancing operations - Eurosystem, Euro area (Dataset)*.
(2) European Central Bank Data Portal. (2025). *Main refinancing operation - Eurosystem, Euro area (Dataset)*.
(3) European Central Bank Data Portal. (2025). *Securities of euro area residents denominated in euro - Eurosystem (Dataset)*.
(4) European Central Bank Data Portal. (2025). *Total assets/liabilities - Eurosystem, Euro area (Dataset)*.
(5) European Central Bank Data Portal. (2025). *Gross domestic product at market prices, Euro area (changing composition), Annual (Dataset)*.

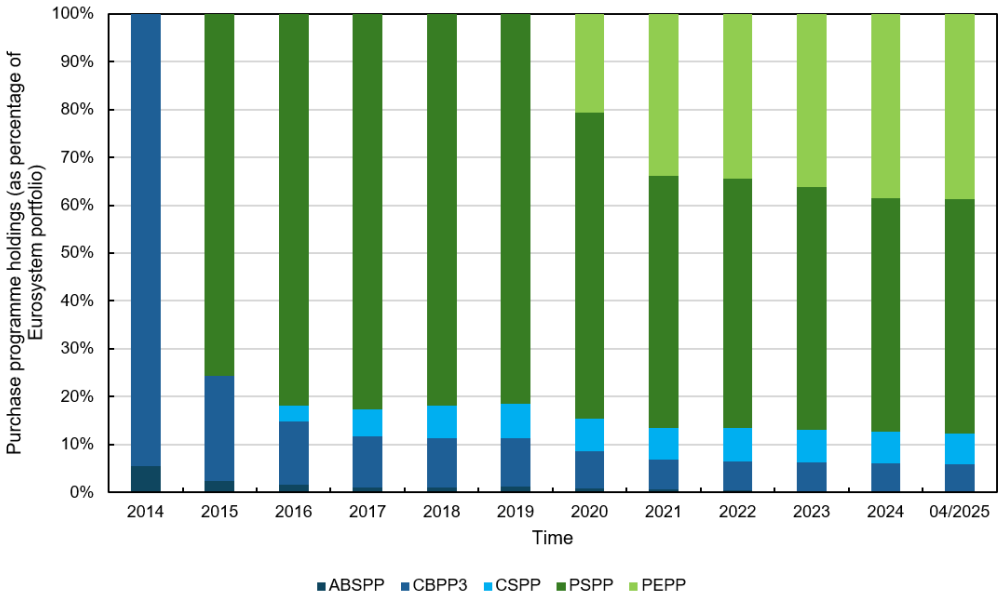

Figure 2 - Asset purchase programmes securities holdings as percentage of total holdings for monetary purposes (2014 - 2025)

Note: Each bar shows the composition of the ECB's asset purchase programmes as a percentage of total asset holdings at the end of the respective year. The only exception is the distribution for 2025, which reflects the composition of April.

Source: (1) European Central Bank. (2025). *Pandemic Emergency Purchase programme.*

(2) European Central Bank. (2025). *Asset purchase programmes.*

Under these asset purchase programmes, the ECB conducts purchases of bonds on the secondary market, typically from entities such as pension funds and commercial banks. In return, these institutions receive central bank reserves, making the APP the principal mechanism for reserve creation from 2015 onward. This is illustrated in figure 3, which depicts the liability side of the ECB's balance sheet. Since 2015, the principal contributor to balance sheet expansion has been the growth of central bank reserves, represented in dark green, amounting to over €4 trillion at its peak. Even when the national central banks (*NCBs*) acquired bonds from the non-financial private sector, reserves were still created, as these transactions were intermediated by commercial banks (Sonnenberg, 2023). These large-scale asset purchases created an abundant reserve system, generating excess liquidity[2] within the euro area banking sector[3]. This shift had important implications for short-term market rates, which can be seen in figure 4. Before the GFC, the EONIA (now the Euro short-term rate; *€STR*) fluctuated around the main refinancing operations (*MRO*) rate, moving within a corridor defined by the deposit facility rate (*DFR*) and the marginal lending facility (*MLF*) rate. Consequently, this framework was known as a corridor system. However, with the introduction of FRFA policy and QE by the ECB, the market rate began to closely track the DFR with minimal deviations. As a result, the post-GFC monetary system became known as a floor system, where the DFR replaced the MRO rate as the main policy rate.

[2] Excess liquidity is defined by the ECB as the amount of money in the banking system that remains after commercial banks have fulfilled their mandatory reserve requirements (ECB, 2023).

[3] It's important to note that the ECB's FRFA policy had already contributed to the creation of excess liquidity within the Eurosystem. The implementation of LSAP further accelerated this process.

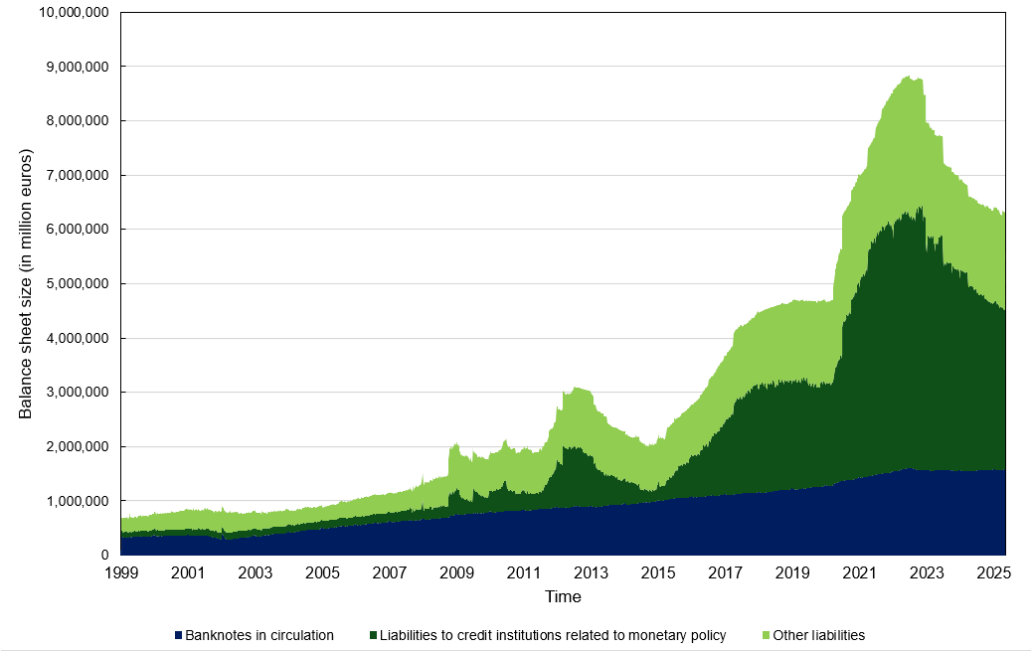

Figure 3 - Liabilities of the Eurosystem consolidated balance sheet (in million euros, 1999 - 2025)

Source: (1) European Central Bank Data Portal. (2025). *Total assets/liabilities - Eurosystem, Euro area (Dataset)*.
(2) European Central Bank Data Portal. (2025). *Banknotes in circulation - Eurosystem, Euro area (Dataset)*.
(3) European Central Bank Data Portal. (2025). *Liabilities to euro area credit institutions related to MPOs denominated in euro - Eurosystem, Euro area (changing composition), Weekly (Dataset)*.

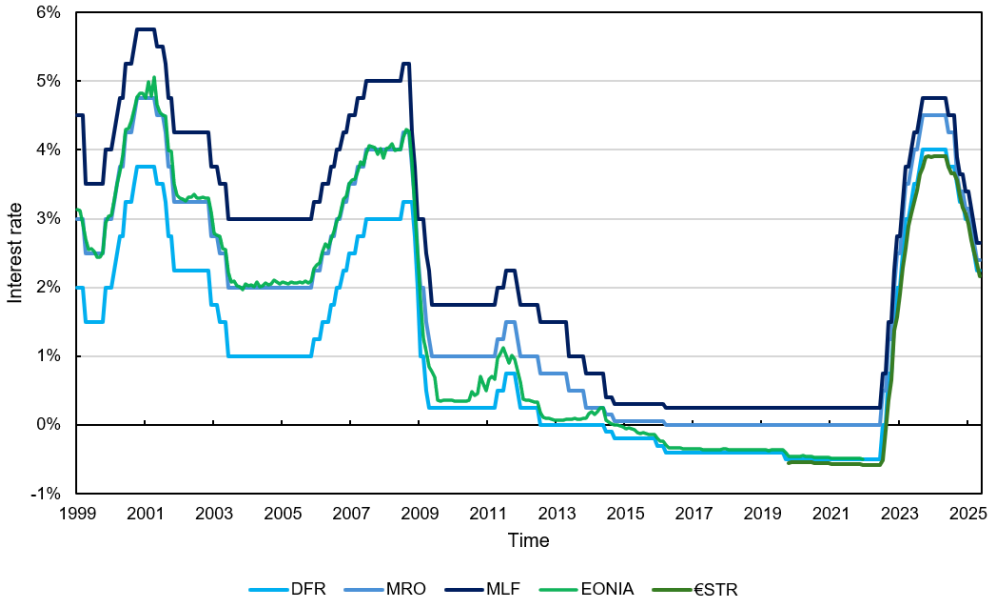

Figure 4 - ECB key interest rates, EONIA and €STR (in percentage, 1999 - 2025)

Source: (1) European Central Bank Data Portal. (2024). *Eonia rate - Historical close, average of observations through period, Euro Area (changing composition), Monthly (Dataset)*.
(2) European Central Bank Data Portal. (2025). *Euro short-term rate - Volume-weighted trimmed mean rate, Daily - businessweek (Dataset)*.
(3) European Central Bank Data Portal. (2025). *Key ECB interest rates (Dataset)*.

As mentioned in the introduction, the primary objective of asset purchases was to further accommodate monetary policy at a time of declining inflation expectations and the policy rate being constrained at the effective lower bound (*ELB*). When the ECB first announced its decision to buy sovereign bonds in 2015, the DFR was already at -0.3%, indicating that policy rates were already reaching its limits. In an effort to provide additional stimulus, the ECB focused on purchasing longer-term bonds to reduce yields at the long end of the yield curve. This would, in turn, lower borrowing costs and potentially stimulate the broader economy. Theoretically, Krishnamurthy and Vissing-Jorgensen (2011) identify three key channels through which asset purchases influence yields at the long end of the curve: (i) the signaling channel, (ii) the portfolio balance channel, and (iii) the inflation channel (Krishnamurthy and Vissing-Jorgensen, 2011).

The first refers to how asset purchases shape expectations about the ECB's future monetary policy stance. According to Eggertsson and Woodford (2003), QE can effectively lower long-term bond yields if it represents a credible commitment by the central bank to keep policy rates lower for longer. The second, the portfolio rebalance channel, operates through changes in the supply of available assets. Given the ECB's large-scale asset purchases, the supply of certain assets, such as sovereign bonds, decreases. This reduction causes investors to shift their holdings to alternative assets, such as equities or corporate bonds, leading to lower risk premia and improved financial conditions. Krishnamurthy and Vissing-Jorgensen (2011) further decompose this channel into several channels: (i) duration risk channel, (ii) liquidity channel, (iii) safety premium channel, (iv) prepayment risk premium channel and (v) default risk channel. Finally, the inflation channel influences real interest rates. Increasing liquidity can stimulate economic activity and subsequently raise inflation expectations. As a result, for a given nominal interest rate, real rates would decrease, fostering more favorable economic conditions.

The effects of asset purchases appear to have been successful. Gagnon and Sack (2018) estimate that across a range of globally advanced economies, purchasing long-term bonds equivalent to 1.5% of GDP, yields a stimulative effect comparable to a 25 basis points cut in the policy rate. Eser et al. (2019) report that the stock of current and expected future holdings led to a reduction of 95 basis points in the term premium on a hypothetical 10-year bond for the four largest euro area countries. Of this estimate, 50 bps can be attributed to the announcement effect, with the impact growing to 95 bps as the APP was extended over time (until June 2018). There is, however, notable heterogeneity between countries. Urbschat and Watzka (2020) find that bond yields in peripheral countries, such as Portugal and Italy, experienced larger effects than those in core countries, such as Germany and Belgium, with diminishing marginal impacts for each additional asset purchase package. For instance, between June 2014 and March 2016, the cumulative impact of APP announcements on 10-year Bund yields in Germany was just 8.23 basis points, whereas the effects for Italy and Spain exceeded 60 basis points. This suggests that APP primarily reduced default premia and sovereign bond spreads for peripheral countries.

Given these effects observed in bond yields, it is crucial to understand the underlying transmission channels through which QE exerted its influence. Urbschat and Watzka (2020) find that, while the signaling channel played a role, its impact was less pronounced than the portfolio balance channel. Although the signaling channel (as indicated by the OIS rate) showed effects in

the expected direction, these were largely insignificant across the countries studied. In contrast, the portfolio rebalancing channel, indicated by changes in the bond-OIS spread, demonstrated more substantial and significant effects across all countries. Notably, for peripheral countries, the dominant drivers of these effects were the default risk and liquidity channels, further reinforcing the broader impact of QE on bond yields.

When comparing the effects of the ECB's APP to similar QE programs implemented in other economies, it becomes evident that the impact of the ECB's programme has been relatively weaker. For example, a study by Gagnon et al. (2011) estimated that, in the United States, the implementation of QE programs led to a reduction in yields ranging from 30 to 100 basis points. Nevertheless, such comparisons should be interpreted with caution, as structural differences between the euro area's bank-financed system and the United States' capital markets-based system may significantly affect the transmission and overall effectiveness of QE measures on the real economy. Urbschat and Watzka (2020) however offer three key explanations for the difference in the announcement effects on interest rates.

First, the APP was introduced during a period of relative market calmness, while the Federal Reserve's QE measures were implemented in the aftermath of the financial crisis, a time of much greater market stress. Second, the initial institutional framework designed to prevent losses on bonds in the future dampens the impact for shorter maturities and core euro area countries. Specifically, the ECB initially imposed a self-imposed restriction that prohibited the purchase of bonds trading at yields below the prevailing deposit facility rate. This limitation posed a significant burden on the implementation of the APP, particularly in the case of short-term sovereign bonds and those issued by core euro area countries, where risk premia are typically lower. As a result, the range of eligible assets was narrowed, reducing the programme's overall effectiveness. Recognizing these limitations, the Governing Council decided in January 2017 to lift this constraint under the PSPP, thereby expanding the pool of eligible securities and enhancing the flexibility of QE (Suomen Pankki, 2019). Finally, the effects on German Bund yields may have been not as profound due to a relatively muted portfolio rebalancing channel. According to Bernanke (2014), *"the problem with quantitative easing is that it works in practice, but it doesn't work in theory."* This observation holds particularly in the case of Bunds, which might be considered close to perfect substitutes for risk-free assets. If assets are indeed perfect substitutes, then the portfolio rebalancing effect is weakened, limiting the impact of QE at the ELB. As a result, the anticipated effects on Bund yields were minimal, with more significant effects observed in riskier sovereign bonds.

The reduction in borrowing rates and the increased liquidity through the ECB's QE programme appear to have had only a limited effect on credit creation. Figure 5 indicates that credit to the private non-financial sector, as a percentage of GDP, remained relatively stable from 2010 to 2020, with no significant increase following the introduction of QE in the euro area. This subdued response in credit creation can be attributed to several key factors.

One of the key factors, as highlighted by Schnabel (2024), is the presence of non-linearities in response to aggregate demand for monetary policy shocks, especially when policy rates are already at historically low levels. In such a scenario, the potential for further stimulating economic activity through intertemporal substitution diminishes. With borrowing costs already at or near the lower bound, both consumers and businesses may be less responsive to additional reductions in interest rates, further limiting the impact of QE on credit creation and thus economic activity. Moreover, for QE to effectively stimulate credit creation, economic agents must be willing to respond to these lower rates. At the time the ECB initiated its asset purchase programmes, both banks and governments were still struggling with the aftermath of the Global Financial Crisis and the subsequent euro area sovereign debt crisis. Banks were hindered by debt overhang and needed to recapitalize, while governments were focused on restoring fiscal stability following extensive bailouts. These challenges likely contributed to the relatively muted credit creation observed in the euro area despite the accommodative monetary policy stance.

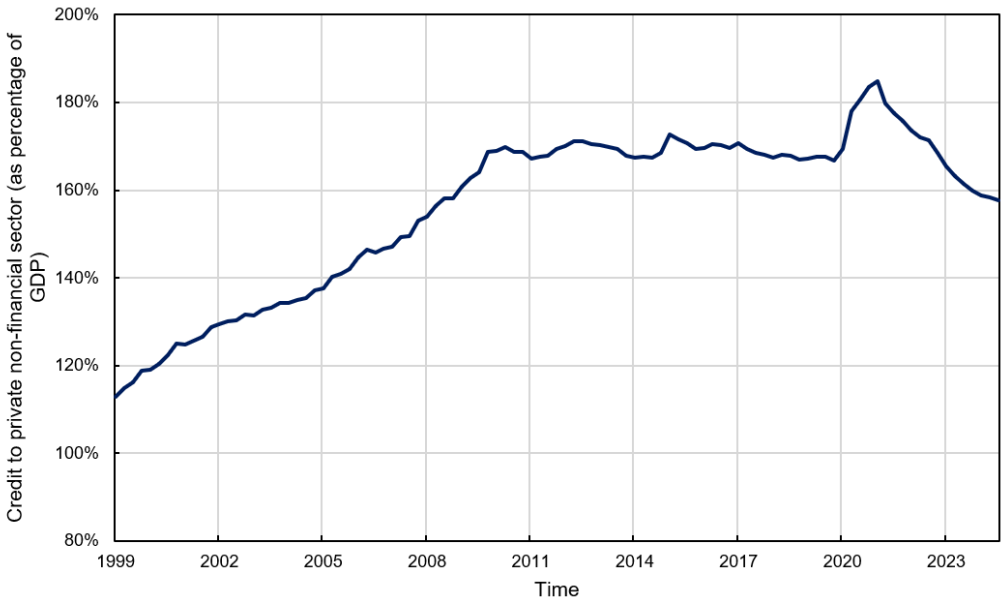

Figure 5 - Total credit to the private non-financial sector in the euro area (as percentage of GDP, 1999 - 2024)

Source: Federal Reserve Bank of St. Louis. (2025). *Total credit to Private Non-Financial sector, for euro area (Dataset)*

Ultimately, the effectiveness of the ECB's purchase programme must be evaluated in light of its primary objective: the achievement of price stability, which was defined (before the 2021 strategic review) as inflation close to, but below 2%. This benchmark remains the fundamental criterion by which the success of the programme should be judged. In this regard, Hohberger et al. (2019) estimated that the ECB's asset purchases contributed approximately 50 basis points to CPI inflation and 30 basis points to GDP growth between 2015 and 2018. Similarly, Mouabbi and Sahuc (2019) concluded that unconventional monetary policy measures, including QE, were able to increase inflation by 61 basis points. These results suggest that, while the ECB's QE programme had a positive impact on inflation and economic growth, its effects were likely tempered by the broader economic conditions which may have hindered a more robust transmission of the policy.

The outbreak of the COVID-19 pandemic in Europe prompted the ECB to introduce a new, temporary asset purchase programme. On March 18 2020, the Governing Council announced the start of the Pandemic Emergency Purchase Programme (*PEPP*), which was designed to mitigate the severe economic consequences of the pandemic (NBB, 2020). The programme executed more than 110,000 transactions and concluded with an unprecedented total envelope of €1,850 billion, allocated to both public and private sector securities, at a pace unmatched by previous asset purchase initiatives. This is shown in figure 1. The launch of PEPP, alongside the continued expansion of APP, led to a near doubling of the ECB's securities holdings within just two years. As illustrated in figure 3, this substantial increase in securities on the Eurosystem's balance sheet significantly raised excess liquidity in the Eurosystem. With an envelope of €1,850 billion, PEPP rapidly became one of the central components of the ECB's monetary policy toolkit, accounting for approximately 40 percent of the ECB's total monetary policy-related asset holdings at its peak (see figure 2). In contrast to the APP, the PEPP provided greater flexibility, allowing deviations from the ECB's capital key, which will be later discussed in section 2.3.4. On top of this, Greek sovereign bonds, which were excluded from APP, became eligible for purchase under PEPP. The Deutsche Bundesbank (2023) estimated that, by the end of 2020, this programme had a cumulative impact of 100 basis points on 10-year Bund yields compared to a counterfactual scenario. However, by the end of 2022, the effect had diminished to approximately 70 basis points. As shown in figure 5, the effect on lending to the non-financial private sector was comparatively more pronounced than under previous asset purchase programmes, with credit reaching a peak of 185% of GDP. This may be attributable to increased credit demand and comprehensive government support measures aimed at preventing corporate bankruptcies and sustaining economic activity.

2.2. The Justifications of the Balance Sheet Reduction

In the wake of the war in Ukraine in 2022, energy prices across the euro area rose sharply, triggering a surge in inflation. Consequently, the Harmonized Index of Consumer Prices (*HICP*) inflation climbed to 10.6%, the highest level recorded since the creation of the European Monetary Union (ECB, 2025). In response to these inflationary pressures, the ECB initiated a policy rate hike in July 2022, its first in over a decade. This move effectively ended the negative interest rate policy that had been in place since 2014, originally introduced to combat deflationary dynamics and support economic recovery.

In addition to raising interest rates, the ECB also announced its intention to gradually reduce the size of its balance sheet after years of unprecedented expansion. This move marked a significant shift in the ECB's post-GFC monetary policy, which had long relied on large-scale asset purchases to provide accommodative financial conditions. Nonetheless, the necessity of balance sheet reduction remains a matter of debate. Given that the ECB can influence financial conditions primarily through adjustments to its key policy rates, reducing the balance sheet is not strictly a requirement to achieve its price stability mandate. This observation suggests that a leaner balance sheet is not a prerequisite for effective monetary tightening.

However, several arguments can be made in favour of normalising the size of the central bank's balance sheet. The following sections explore these justifications in detail. Section 2.2.1 discusses the need to scale back the effects of asset holdings, which have persistent effects on financial conditions. Section 2.2.2 examines how quantitative easing has contributed to distortions in asset valuations, and how quantitative tightening can help realign these valuations with their underlying economic fundamentals. Section 2.2.3 focuses on restoring monetary policy space, highlighting how a leaner balance sheet can provide central banks with greater flexibility to respond to future economic shocks. Section 2.2.4 addresses the issue of collateral scarcity, explaining how reducing the balance sheet can improve the availability of high-quality securities necessary for smooth market functioning. Finally, section 2.2.5 analyses the potential risks a large balance sheet poses to the central bank's credibility, highlighting how balance sheet normalisation helps preserve the central bank's financial independence and sustain public confidence.

2.2.1. Scaling back the impact of asset holdings

According to the National Bank of Belgium (*NBB*, 2022), quantitative easing exerts persistent downward pressure on bond yields, primarily by reducing the term premium. This poses a potential challenge for the ECB in the context of its monetary policy tightening phase. Since the ECB's key interest rate instruments primarily affect short-term interest rates, its direct influence on the longer end of the yield curve remains limited. Consequently, the size of the ECB's asset portfolio may be misaligned with its intended policy stance during the monetary tightening phase.

From a theoretical perspective, long-term bond yields can be decomposed into two components: the expected path of short-term interest rates and the term premium. As the ECB began increasing its key policy rates in the context of its restrictive policy cycle, market expectations regarding the future trajectory of short-term rates adjusted accordingly, contributing to an upward movement in long-term yields. Nevertheless, the sizable bond holdings accumulated under QE have continued to exert a dampening effect on the term premium. Consequently, long-term yields have risen less than they likely would have without the dampening influence of the ECB's bond holdings. This dynamic may lead the ECB to assess that long-term yields are not fully reflecting its intended monetary policy stance. In this context, balance sheet normalisation through quantitative tightening could play a supportive role. By reducing the size of its bond holdings, the ECB could exert upward pressure on the term premium, thereby steepening the yield curve and strengthening the transmission of its policy tightening. This would contribute to a broader tightening of financial conditions and support the ECB's objective of returning inflation to its target in a timely manner.

The impact of QE on bond yields can be categorized into two components. The first is the flow effect, which results from the continuous purchase programmes, which can impair market liquidity and efficiency, leading to sluggish price discovery (D'amico and King, 2013). The second are the stock effects, which refer to long-term changes in Treasury bond prices (or yield) driven by shifts along the demand curve for government securities (D'amico and King, 2013). These effects occur as investors adjust their portfolio based on the total amount of bonds available in the market. When the ECB expands its balance sheet, the reduced supply of bonds available to private investors increases their price, thereby lowering their yield, assuming demand remains constant.

Empirical evidence from D'amico and King (2013) suggests that the impact of flow effects are generally smaller in magnitude and short-lived. The influence of flow effects primarily reflect improvement in liquidity and market functioning, particularly during periods of financial market stress. In contrast, stock effects tend to exert a more substantial and persistent impact on yields. Altavilla et al. (2021) estimate that ECB asset purchases equivalent to 10% of euro area GDP reduce 10-year sovereign bond yields by approximately 65 basis points through stock effects. This corresponds to a reduction of approximately 3.6 to 5.4 basis points per €100 billion of asset purchases. Applying these estimates to the total stock of QE purchases, approximately €5 trillion, suggests that the level of accommodation provided to the 10-year weighted zero coupon yields of the four largest euro area economies ranges between 176 and 265 basis points (IMF, 2023). Estimates of the ECB reveal that the impact of APP and PEPP holdings on ten-year sovereign

risk premia was around 175 basis points in 2021 (Cipollone, 2025). Furthermore, as noted by D'Amico and King (2013), the overall impact of QE is likely state-dependent, with stronger effects during periods of financial distress.

This evidence suggests that maintaining a large central bank balance sheet continues to exert accommodative effects, potentially complicating the transition to a more restrictive monetary policy stance. If the central bank is committed to addressing inflation, it must ensure that all instruments are aligned towards this objective. Otherwise, a failure to reduce the balance sheet could necessitate a greater number of policy rate hikes to achieve the same level of monetary tightening, potentially leading to a more pronounced economic and/or financial impact.

If the bank would like to reduce the impact of its bond holdings by reducing the size of the balance sheet, it is important to know how strong these effects will be on yield. In theory, QT could be viewed as symmetrical to QE, equal in magnitude but opposite in direction:

$$QT = -QE$$

If this symmetry holds, QT announcements should trigger a meaningful increase in bond yields, having the effects of QE in the opposite direction.

Empirical evidence, however, suggests that this "symmetry hypothesis" of balance sheet policies does not hold. Du et al. (2024) find that QT announcements across various monetary jurisdictions, not specifically the euro area, are associated with only a modest increase in bond yields of approximately 4 to 8 bps for maturities for 1 year and longer. In the empirical analysis of this paper (section 3 and 4), I will show that the impact specifically in the euro area is similar to the results of Du et al. (2024). Therefore, it can be concluded that the "symmetry hypothesis" is rejected. However, there are some explanations for this muted effect. Specifically, it can be attributed to five factors: (i) presence of non-QT related events, (ii) communication in advance, (iii) different market conditions, (iv) a weaker signaling channel and (v) the gradual approach.

The first explanation, as emphasized by Du et al. (2024), concerns the potential influence of concurrent non-QT-related developments at the time of the announcement, which may confound the observed effects and pose challenges for empirical identification and control. A second explanation is that central banks have typically communicated their normalisation plans well in advance (see section 2.3.1), aiming to minimize market disruptions, such as those observed during the Taper Tantrum in the early 2010s in the United States. Logan (2024) argues that quantitative tightening is often more effectively anticipated by financial markets than quantitative easing, largely because central banks typically present QE as a temporary and time-bound measure. For instance, when the ECB announced the asset purchases under PEPP, it initially communicated that asset purchases would continue until the end of 2020. As a result, markets anticipated net asset purchases to cease by early 2021. However, as the ECB extended the programme, financial markets adjusted their expectations, leading to the repricing of assets. As a result, part of the unwinding happened in advance.

Third, the muted response of QT announcements may have contributed to differences in market conditions at the time of implementation. While QE announcements typically occur during times of distress, QT is often introduced in a relatively stable environment. This difference influences the liquidity channel (Logan, 2024), which raises yields for the most liquid asset while the less-liquid bonds see a decline (Krishnamurthy and Vissing-Jorgenson, 2011). For example, during the COVID-19 pandemic, uncertainty led to severe market dysfunction, and the ECB's asset purchases played a crucial role in restoring liquidity. In contrast, QT is usually implemented only after market stability has been reestablished. Wei (2022) quantifies this effect, showing that the passive roll-off of Treasuries can have an impact up to 2.5 times larger during periods of financial turmoil. This suggests that if QT in the euro area had been announced under conditions similar to those of QE, the absolute value of the magnitude of liquidity effects would have been at least as large as during QE.

A fourth possible explanation for the smaller market response to quantitative tightening relates to a weaker signaling channel. In contrast to QE, quantitative tightening is not typically accompanied by forward guidance on maintaining interest rates at specific levels, whereas QE is linked to such guidance to reinforce policy accommodation near the effective lower bound. The absence of such explicit forward guidance in QT creates ambiguity in how markets should interpret its announcements in relation to the broader policy stance. There are two contradictory perspectives on how QT might influence expectations regarding policy rates: it can be perceived as either a substitute or a complement to conventional monetary policy (Du et al., 2024). Under the "substitutability hypothesis", markets may interpret QT as strengthening the bank's commitment to tightening financial conditions, reducing the need for further rate hikes. On the other hand, under the "complementarity hypothesis", QT is viewed as imposing additional restrictiveness for a given policy rate. In this scenario, the ECB would achieve the desired tightening in financial conditions while maintaining a lower policy rate than would otherwise be necessary to combat inflation. These contradictory views demonstrate that a signaling channel may be weak or entirely absent. Cúrdia and Woodford (2010) argue that when financial markets are functioning efficiently, a temporary expansion of central bank reserves beyond the satiation point, the level at which banks no longer demand additional reserves, has no direct economic impact under normal conditions (when the policy rate is above the ELB). Given that the policy rate is since 2022 far above the ELB, any signaling effects associated with balance sheet adjustments have likely vanished (Bullard, 2019).

A fifth and final explanation for the muted bond market response is the ECB's gradualist approach to quantitative tightening, which contrasts the more aggressive expansion observed during the balance sheet expansion (also see section 2.3.1). Specifically, when announcing its QT strategy, the ECB initially tapered net asset purchases and subsequently maintained full reinvestment for an extended period, resulting in no immediate reduction in the size of the balance sheet. It was only several months later that the ECB commenced a gradual balance sheet runoff at a controlled pace of €15 billion per month. This measured and gradual approach sharply contrasts with the early phase of APP, during which the ECB expanded its balance sheet at a significantly faster rate of €60 billion per month. The relatively slow pace of QT therefore implies that markets have only modestly adjusted their expectations, leading to minimal upward pressure on bond yields.

Empirical evidence supports this explanation. Du et al. (2024) find that active QT (i.e. outright bond sales) has a significantly stronger impact on bond yields compared to passive QT (i.e. allowing bonds to mature off the balance sheet without reinvestment). Notably, the United Kingdom, which implemented an active QT programme early on, experienced a larger increase in bond yields following QT announcements than countries with a passive strategy. This suggests that the bank's cautious and incremental QT strategy has contributed to the muted market response.

A central question is whether the limited impact of quantitative tightening on bond yields holds substantive significance. The muted market reaction implies that the implementation of QT has not disrupted government bond pricing, an outcome that might be intentional. The ECB might want quantitative tightening to be a process that runs quietly in the background. Like Chair of the Federal Reserve in 2017 Janet Yellen described it as "*watching paint dry*" (Yellen, 2017). This result is not unexpected, as the ECB has thus far avoided the adoption of an active QT approach. By delaying outright bond sales, the central bank has mitigated the risk of abrupt repricing in secondary markets (Du et al., 2024), thereby facilitating a more orderly and gradual process of balance sheet normalisation.

While QT announcements have had minimal announcement effects on euro area bond yields, assessing their cumulative impact on bond markets is most essential. Empirical evidence from previous balance sheet reductions suggests that the effects may be limited. Smith and Valcarcel (2023) find that the Federal Reserve's balance sheet reduction, which began in 2017, had no discernible impact on the term premium. Research about the current reduction in the euro area by Akkaya et al. (2024) attempts to estimate the total impact of a €1 trillion reduction of the ECB's asset portfolio on European bond yields. Using market expectations gathered from the Survey of Monetary Analysts, they estimate that such a reduction would lead to a 35 bps increase in the term premium on German (or French) government bonds. Further supporting this, Du et al. (2024) estimate that all QT announcements made up until the time of their study resulted in an increase of approximately 20 basis points in sovereign yields for securities with a maturity longer than two years. ECB calculations estimate that the total impact of APP and PEPP on ten-year sovereign risk premia reduced from 175 basis points in 2021 to 75 basis points at the start of 2025 (Cipollone, 2025). These findings indicate that, while QT announcements themselves may not trigger significant market reactions, the cumulative effect of balance sheet reduction over time could contribute to higher long-term bond yields in the euro area.

2.2.2. Normalising asset valuations

According to finance theory, prices of assets such as stocks, housing, and bonds are fundamentally determined by underlying economic fundamentals, particularly the present value of expected future cash flows. Within this framework, quantitative easing affects asset prices through several transmission channels. The first of these channels involves an impact on the path of future cash flows. According to Gagnon et al. (2011), if QE can lower borrowing costs, it may, in principle, stimulate economic activity. As a result, enterprises could benefit from higher profits, thereby increasing future cash flows. The second channel is related to the effect of asset purchases on long-term bond yields. As explained in section 2.1, the signaling channel of quantitative easing is a commitment of the bank to keep policy rates lower for longer. When markets believe that this commitment is credible, market prices of bonds should be upwardly adjusted. This should reduce discount rates for future corporate earnings and, in theory, increase stock valuations. The third channel is the portfolio rebalancing effect. As investors move their capital from low-yielding bonds to riskier assets, such as equities, demand for stocks rises, ceteris paribus pushing up stock prices. According to economic theory, this shift should lead to a reduction in the equity (risk) premium, which is the extra return that investors require to compensate for the risks associated with equities (Damodaran, 2022).

Empirical studies, such as the one by Hudepohl et al. (2021), demonstrate that the anticipation, announcement, and implementation of QE led to significant increases in stock prices within the euro area, effects that couldn't be fully explained by changes in macroeconomic fundamentals. However, these effects were usually short-lived, with exuberance disappearing after a while. This suggests that QE contributed to stock price misalignments, challenging the efficient market hypothesis. According to this view, investors underpriced risks for an extended period, under the assumption that financial stability was assured by QE's calming effects on markets.

Although asset prices deviated from their fundamental values due to QE, higher asset prices were warranted to stimulate the economy and get the inflation target towards its 2% target. For instance, Tobin's Q theory suggests that higher asset valuations (a Q greater than 1) results in the market value of a firm's assets exceeding their replacement cost, making it profitable for firms to invest in new capital. This encourages more investment and capital formation, boosting economic growth. Moreover, higher asset prices can increase household wealth, sparking optimism from households. Both of these effects are important transmission channels of monetary policy through assets.

However, since 2022, the economic environment has shifted. The persistence of asset prices deviations from their theoretical values raises questions about whether this is desirable or sustainable in the long term. Some observers, such as financial historian Edward Chancellor (2022), have described the situation as an "everything bubble", a simultaneous inflation of multiple asset classes[4], largely driven by loose monetary policy. This situation has led to concerns

[4] The definition of an asset class can be widely interpreted. This goes from traditional assets, such as stocks and bonds, to alternative asset classes, for example paintings, baseball cards, cryptocurrencies, etc.

about the credibility of central banks, with accusations that they have contributed to wealth inequality and increased financial instability.

Piero Cipollone, member of the Executive Board of the ECB, argued in a recent speech that excessive risk appetite cannot be attributed to larger balance sheets, as stock markets have remained at historically high levels despite the ECB's withdrawal from financial markets (Cipollone, 2025). He rather attributes this to “animal spirits”, a term used to describe the speculative behavior of investors, which has been observed even outside of balance sheet growth, such as during the dot-com bubble. Nonetheless, the size and growth of the central bank’s balance sheet may still play a significant role in influencing asset valuations, and quantitative tightening may even prove insufficient in fully addressing asset price inflation. Over time, the reliance on accommodative monetary policy has contributed to a market environment where financial participants increasingly expect central banks to step in during periods of turbulence. This expectation has fostered a form of moral hazard, wherein investors assume that market volatility will be mitigated by central bank liquidity support. This dynamic can be compared to the “Greenspan put”, a concept that suggests investors perceive downside protection for stocks, knowing that the central bank will stabilize markets during periods of financial distress (Mullin, 2023). This dynamic reflects the core of Minsky’s (1977) “financial instability hypothesis”, which argues that prolonged periods of financial stability, regardless of whether they result from central bank interventions, tend to encourage excessive risk-taking and leverage, thereby increasing systemic vulnerability. In the context of large-scale asset purchases, continued central bank support provides short-term stimulus, but may unintentionally encourage speculative behavior and dampen market discipline. As a result, asset price inflation becomes more persistent, reinforcing financial imbalances and potentially exacerbating instability in the long term.

In light of these concerns, quantitative tightening may be necessary to bring asset prices back in line with their fundamental value. Higher long-term yields (see section 2.2.1) would increase the discount rate, potentially leading to a correction in stock prices. On top of this, Bernanke and Kuttner (2005) explain that restrictive monetary policies, such as QT, could affect the expected equity premium in two ways. First, tighter monetary policy raises the riskiness of stocks, as higher interest rates increase borrowing costs, which directly affect corporate profits. Second, higher interest rates make less risky alternatives, such as sovereign bonds, more attractive to investors, thereby increasing the equity risk premium. Later in this paper, I will show that QT announcements in the euro area led to a decline in stock indices, but their effects were smaller than those of QE announcements (Du et al., 2024). This can be attributed to the lower impact on risk premia discussed earlier, suggesting that the discount factor in financial theory is not as responsive to QT as it is to QE.

2.2.3. Restoring policy space

The ECB has indicated that quantitative easing is likely here to stay. For instance, Piero Cipollone highlighted in a recent speech the important role of balance sheet policies in addressing risks posed by non-bank financial institutions, who are more sensitive to long-term interest rates, and in managing fragmentation risk in the euro area (see section 2.3.4). However, considering the ECB's sizable holdings of euro area securities, quantitative tightening may represent a valuable strategy for preparing the central bank's policy toolkit for potential future crises.

This can be particularly observed from the perspective of interest rate policy. As discussed in section 2.2.1, quantitative easing has generated stock effects on long-term bond yields, with estimates suggesting that it has reduced yields by approximately 176 to 265 basis points (IMF, 2023). While this has provided significant support to economic activity in the past, it also implies that the stance of the balance sheet remains more accommodative than it would under a leaner central bank balance sheet due to its dampening effects on the term premium. If these stock effects are not unwound through QT, the central bank will have limited capacity to lower long-term interest rates through renewed QE in the event of a future crisis. This, in turn, could constrain its ability to effectively stimulate the economy during a period of crisis. Implementing QT in a context where excess liquidity is no longer necessary to control interest rates allows the central bank to gradually reverse these stock effects and reclaim valuable policy space (Claeys, 2023). This ensures that when a downturn or crisis emerges, there is greater flexibility to lower interest rates effectively, making monetary policy more responsive and impactful when needed most.

Beyond the interest rate side of the story, there is also a structural limitation to the supply of eligible bonds for QE purchases. Initially, the ECB set self-imposed on its bond holdings, restricting purchases up to 33% per issuer and 25% per individual bond issue, in order to avoid acquiring a blocking minority in collective action clauses (Gros, 2015). In a move to expand flexibility, the Governing Council raised the bond-specific ceiling to 33% in September 2015, subject to case-by-case verification (Andrade, 2016). Nevertheless, these limits remain a binding constraint for the ECB's capacity to engage in a LSAP policy in future crises, posing the risk of a potential ratchet effect whereby each round of QE becomes more constrained (Claeys, 2023).

The ECB does not publicly disclose the full list of its bond holdings, making it difficult to determine how close the institution is to breaching these limits (Urbschat, 2020). However, Claeys (2016) estimated that the ECB was already nearing these boundaries by 2017. Considering the substantial bond purchases undertaken during the COVID-19 pandemic, it is likely that the ECB is now even closer to these thresholds. To preserve QE as a viable policy instrument without continuously relaxing these self-imposed constraints or risking entry into a blocking minority position, the ECB must reduce the volume of bonds held on its balance sheet[5]. Failing to do so would necessitate further regulatory flexibility in future rounds of QE, thereby diminishing available policy space and concentrating an increasing share of sovereign debt in central bank hands.

[5] Another situation where the constraint will not be binding anymore is by more issuance by Treasuries, while the bank lets the holdings on the balance sheet grow slower than the issuer emits the bonds.

2.2.4. Reducing collateral scarcity

From the perspective of central banks, reducing the volume of bonds held on the balance sheet is essential for ensuring that balance sheet policies remain a viable tool in future crises. However, from the point of the financial sector, it is equally important that a sufficient volume of bonds remains in circulation. Quantitative easing has contributed to a reduction in bond availability, which has adversely affected the efficient functioning of essential financial markets, most notably the repurchase agreement (repo) market. This market, which depends heavily on high-quality liquid assets (*HQLA*) including those acquired through the ECB's APP and PEPP, plays a pivotal role in maintaining liquidity within the financial system. The repo market is by far the largest segment of the euro area money market and is thus a key source of short-term liquidity, making it an important channel for monetary transmission (Arrata et al., 2020). It enables financial institutions to borrow and lend cash against collateral, typically government bonds.

According to monetary theory, within a corridor system characterized by excess liquidity, short-term interest rates are expected to converge towards the deposit facility rate (*DFR*), which functions as a lower bound or "floor" that these rates should not fall below, since banks can always deposit excess funds with the central bank at this rate and thus have no incentive to lend at a lower rate. However, Arrata et al. (2020) find that the purchase of certain assets under PSPP resulted in scarcity, causing repo rates to decline on certain dates, occasionally falling below the DFR. This phenomenon can be attributed to heightened demand coupled with a limited supply of collateral. These distortions have been particularly pronounced since 2020, reaching its peak in 2022, when repo spreads on German bunds declined to -60 basis points, and broader market spreads fell to -30 basis points. Ferrara et al. (2024) shows that almost 50% of all repo volumes were conducted more than 30 basis points below the DFR.

This phenomenon, often referred to as "specialness" [6], is puzzling from a theoretical perspective. Rational market participants should prefer depositing funds with the safest counterparty offering the highest rate, namely, the ECB's marginal deposit facility. Yet arbitrage opportunities are not fully exploited because many participants in the money market lack direct access to the ECB's deposit facility (Arrata et al., 2020). Consequently, specialness persists, complicating monetary transmission, because it impairs the pass-through of policy rates. If the ECB raises the DFR, but repo rates remain subdued due to collateral scarcity, the intended tightening of monetary conditions may not be fully transmitted. This creates a dilemma: continuing with aggressive QE to influence long-term yields risks distorting short-term rates, while halting asset purchases may limit control over the yield curve's longer end. Thus, the ECB faces a policy trade-off between steering short- and long-term interest rates.

[6] This term refers to the distinction between general collateral (*GC*) rates and special collateral (*SC*) rates in repo markets. GC transactions involve a broad pool of eligible securities, allowing borrowers to deliver any acceptable collateral. As a result, GC rates typically reflect overall market liquidity conditions. In contrast, SC transactions require a specific bond deemed particularly valuable by the lender. This targeted demand creates scarcity, driving the SC repo rate below the GC rate.

Given the repo market's central role for the short and the long end of the curve (D'Amico et al., 2018), the ECB has several options to address these distortions. First, it could release a portion of its bond holdings to increase the availability of collateral, thereby reducing repo specialness and realigning repo rates with the policy corridor. If the ECB wishes to stabilize short-term market rates and encourage market-based funding, it could also consider narrowing the interest rate corridor, as it did in its March 2024 monetary policy decision (ECB, 2024). Another structural solution involves adapting the operational framework to expand access to monetary policy instruments. The Federal Reserve's Overnight Reverse Repo Facility (*ON RRP*) serves as a useful model. This instrument allows nonbank financial institutions to access a risk-free, overnight investment vehicle, which strengthens the floor for short-term interest rates by broadening participation in central bank's liquidity-providing operations (Arrata et al., 2020; Frost, 2015). Such a facility ensures that nonbanks will not accept rates below the reverse repo rate, while banks will not accept interest rates under the DFR, thereby supporting the effectiveness of the policy floor (Federal Reserve Bank of New York, n.d.).

In recent years, conditions in the euro area collateral market have shown notable improvement, partly attributable to the ECB's balance sheet normalisation and a rise in sovereign bond issuance. Notably, the share of eligible assets held by the Eurosystem declined from 40% in 2022 to 30% by the end of 2024 (Schnabel, 2024), reflecting a significant reduction in the central bank's market footprint. Consequently, the scarcity premium in repo markets largely disappeared. At the same time, repo market volumes surged by 25% since 2022 (as of September 2024), driven by a gradual decline in excess liquidity and the revitalisation of market-based funding (Schnabel, 2024).

Despite these improvements, it remains uncertain whether repo rates will sustainably exceed the DFR (Schnabel, 2024). This outcome will largely depend on the readiness of market participants to capitalize on arbitrage opportunities through cross-border lending, in light of the uneven distribution of excess liquidity among euro area countries and institutions. Ensuring a robust and inclusive market structure will therefore be key to reinforcing the transmission of monetary policy in both normal and stressed conditions.

2.2.5. Safeguarding credibility and independence

Since its launch, quantitative easing has faced criticism, particularly concerning its implications for the ECB's independence. For instance, German chief economist of the ECB Jürgen Stark resigned in 2011 following the bank's decision to start bond purchasing programmes (BBC, 2011). A central issue in the dispute concerns the compatibility with Article 123 of TFEU. This article explicitly prohibits the ECB from directly purchasing government debt instruments. The rationale behind this prohibition is to prevent the monetary financing of fiscal deficits, thereby safeguarding the principle of central bank independence and maintaining fiscal discipline within the European Union (EUR-Lex, 2007). In order to comply with this legal constraint, the ECB designed its public sector programme to function solely through secondary market transactions. By purchasing government bonds from investors rather than directly from governments, the ECB sought to maintain a market-based distance from fiscal authorities. This approach is permissible under Article 123, insofar as it does not aim to circumvent the objective of the prohibition on monetary financing (ECB Monthly Bulletin, 2012).

Nevertheless, despite this careful implementation, the PSPP was legally challenged in 2015, when a group of EU citizens brought a case arguing that the programme violated Article 123. In response, the Court of Justice of the European Union (*CJEU*) ruled that the PSPP constituted a proportionate monetary policy measure aimed at safeguarding price stability, which falls within the ECB's mandate (EUR-Lex, 2015). However, the CJEU simultaneously underscored the importance of implementing adequate safeguards to ensure that the programme remains proportionate, in accordance with the principle of proportionality in Article 5 of the Treaty on the European Union (*TEU*), and is fully consistent with EU law. These safeguards include a strict prohibition on primary market purchases, as well as the enforcement of issuer and issue limits (see section 2.2.3), thereby preventing the ECB from exerting undue influence over government financing.

Another safeguard, which could be derived from the EU's principle of proportionality, as enshrined in Article 5 TEU, is the requirement that policy measures remain appropriate and necessary in the light of economic conditions. Given that inflation remained persistently above the ECB's target since 2022, the continued stimulus effect generated by its large-scale asset holdings (see section 2.2.1) appears increasingly unnecessary. In this context, the ECB's gradual move toward quantitative tightening can be interpreted as an effort to realign its policy stance with the principle of proportionality.

Quantitative tightening therefore not only signals a shift toward normalisation, but also reinforces the distinction between monetary and fiscal domains. By reducing its footprint in sovereign bond markets, the ECB mitigates the risk of fiscal dominance, where monetary policy becomes subordinated to fiscal needs, and thereby strengthens its institutional independence. This concern is particularly relevant in the euro area, where the absence of a unified fiscal authority complicates the interaction between monetary and fiscal policy. As Schnabel (2023) notes: "*In the euro area, however, there are […] additional considerations relevant for the assessment of whether a large bond portfolio is desirable or not. One is that the lack of a consolidated public*

sector balance sheet raises more fundamental concerns about monetary and fiscal interactions in a currency union with sovereign member states. These concerns may potentially undermine the credibility and independence of the central bank."

While the CJEU upheld the proportionality of PSPP at the time of its implementation to safeguard price stability, subsequent developments have cast doubt on the continued appropriateness of such measures in the light of changing macroeconomic conditions. Although quantitative easing initially contributed to modest upward pressure on inflation (see section 2.1), evidence suggests that extensive bond holdings may produce disproportionately large inflationary effects when inflationary shocks occur, like for instance the inflation surge of the 2020s. Adrian et al. (2024) support the use of QE in periods of deep economic distress, such as during the financial crisis or the COVID-19 pandemic, when its impact on risk premia is most pronounced. However, the authors caution against the use of asset purchases in a scenario where interest rates are constrained at the zero lower bound, primarily due to inflation undershooting its target, despite output nearing potential and unemployment staying at low levels. This scenario is what the authors call a "shallower liquidity trap". Central bankers therefore felt justified to implement asset purchase programmes in response to concerns about de-anchored inflation expectations. However, in light of the inflation surge observed in the 2020s, Adrian et al. (2024) highlights that even modest unexpected shocks, such as fiscal stimulus, that push capacity utilisation to its limits can exert upward pressure on inflation. Under these conditions, quantitative easing may become counterproductive, potentially overheating the economy and exacerbating inflationary pressures. This would be the case when there are non-linearities in the Phillips curve, like modelled by Benigno and Eggertsson (2023). The authors caution that QE, while appearing appropriate ex ante in a low-inflation, low-growth scenario, may carry significant ex post risk if other inflationary shocks materialize.

This evidence suggests that quantitative easing indeed might have jeopardized the bank's price stability objective. The continued presence of asset holdings on the balance sheet may exacerbate future inflationary presence. Such an outcome is detrimental because maintaining price stability is central to the ECB's mandate and essential for anchoring inflation expectations. Taking all of this into account, the potential erosion of the ECB's credibility could trigger a negative dynamic, complicating the central bank's ability to effectively manage future monetary policy challenges. Scaling down the balance sheet through quantitative tightening may be a prudent step to mitigate these risks.

In addition to macroeconomic concerns related to the principle of proportionality and inflationary pressures of the bank's securities holdings, the ECB's expanded balance sheet has introduced substantial financial vulnerabilities. LSAP were primarily intended to absorb duration risk from financial markets and to reinforce the ECB's commitment to a prolonged period of lower-for-longer monetary policy (Schnabel, 2024). However, while these risks were removed from the market, they did not vanish. Instead, they were absorbed onto the ECB's balance sheet. The ECB became not only exposed to duration risk but also to prepayment and credit risk (Vissing-Jorgensen, 2023). These market risks materialised in the form of financial losses, as

demonstrated in 2022 when rising interest rates began to significantly have an impact on the bank's balance sheet.

Initially, the ECB benefited financially from its asset purchase programmes. As central banks acquired large volumes of bonds, they earned steady cash flows from these holdings. At the same time, the ECB's deposit facility carried negative interest rates, thereby reducing its interest expenses. This imbalance contributed to unprecedented profits for the Eurosystem. The financial effects of large-scale securities holdings, however, cuts both ways. As policy rates began to rise following years of ultra-accommodative monetary policy, the ECB began incurring significant losses due to a mismatch between its assets and liabilities. Specifically, the longer-term bonds acquired during the low interest rate era continued to yield fixed, low returns, while bank reserves held at the ECB had to be remunerated at much higher deposit facility rates. Consequently, while interest expenses rose sharply, income couldn't follow this trend, resulting in operating losses. Furthermore, the ECB's bond holdings experienced unrealised losses as their market value declined with rising interest rates. However, it is important to note the specific accounting treatment applied to these securities. While securities on the balance sheet that aren't held for monetary policy purposes follow the prudence principle, where potential losses are recognised early and gains only when realised (Brixx, 2025), those acquired under SMP, APP, or PEPP are accounted for at amortized cost (ECB, n.d.). This means that changes in the market value of these securities do not influence their book value recognised in the balance sheet (ECB, n.d.). As long as these securities aren't actively sold, such losses remain unrecognised in the accounts and do not impact reported financial results. Fitch Ratings estimated that the Eurosystem would have incurred unrealised losses amounting to 3% of euro area GDP on the bonds acquired during the quantitative easing period (Delano, 2024).

Recognising the risk of losses, the ECB started to build up financial buffers as the Eurosystem booked sizable profits (approximately €300 billion) through general provisions and reserves (ECB, 2023). Nevertheless, these provisions have proven insufficient to fully absorb recent losses. According to the ECB's annual reports, it covered its 2022 losses by releasing €1,627 million from its financial risk provisions. However, in 2023, the total provisions of €6,620 million were insufficient, leaving €1,266 million in uncovered losses. By 2024, all provisions were used up, resulting in a record-breaking loss of €7,944 million (ECB, 2025). Similar trends are observed across the national central banks of the Eurosystem, which hold the majority of assets for monetary policy purposes. The Deutsche Bundesbank (2025) and the National Bank of Belgium (2025) both reported depleted general risk provisions in 2024. Fitch Ratings projects that the Eurosystem may incur over €160 billion in losses between 2024 and 2028, although these losses are expected to diminish gradually as interest rates are reduced and balance sheets normalised. (Delano, 2024). Nevertheless, the impact on capital reserves will be substantial.

These developments raise concerns about whether such losses could undermine the operational functioning of the ECB. Unlike private corporations, central banks are not driven by profit maximisation. Their primary mandate is the maintenance of price stability. As ECB economists Ulrich et al. (2004) explains: *"central bank capital still does not seem to matter for monetary policy implementation, in essence because negative levels of capital do not represent any threat to the*

central bank being able to pay for whatever costs it has. Although losses may easily accumulate over a long period of time and lead to a huge negative capital, no reason emerges why this could affect the central bank's ability to control interest rates." Therefore, the ECB can continue to operate and implement monetary policy effectively, even in the face of ongoing losses and weakened solvency (NBB, 2024; Sonnenberg, 2023).

Unlike private corporations, where sustained losses typically result in insolvency, central banks operate under fundamentally different conditions. For a central bank, losses do not inherently cause insolvency and therefore do not directly threaten its operational capacity. This resilience is grounded by two fundamental safeguards that protect the bank from insolvency. First, the ECB possesses the exclusive ability to create money and can therefore continue to operate with negative equity by using seigniorage income (Bunea, 2016). Seigniorage refers to the profit earned from issuing currency at a production cost lower than its face value (ECB, 2017). However, this revenue stream is increasingly constrained by digitalisation, as the shift away from physical cash reduces the scope for traditional seigniorage (Claessens et al., 2025). Furthermore, while money creation can temporarily support central bank operations, relying on it over the long term carries risks. Excessive issuance of central bank money can affect inflation expectations, and ultimately compromise the credibility of monetary policy (Wessels and Broeders, 2022). Secondly, the ECB's capital is ultimately (indirectly) backed by fiscal authorities, as national central banks of the Eurosystem are primarily owned by their respective national governments (Bell et al., 2023). In principle, this means that if the ECB were to face insolvency, member governments could step in to recapitalise it. However, in practice, such fiscal support is not assured. Central bank losses often emerge during periods of wider economic stress, when governments themselves may be facing fiscal constraints, making timely and sufficient recapitalisation politically and financially challenging (Stella, 2008).

Historical evidence suggests that negative equity does not inherently impair a central bank's ability to function. For instance, Bolt et al. (2023) highlights the case of the Deutsche Bundesbank in 1973, when the collapse of the Bretton Woods system triggered significant losses on its USD reserves. Although the Bundesbank operated with negative equity and considered capital injections, it continued operational and eventually returned to profitability, thanks in part to the strength of the Deutsche Mark (Braunberger, 2017).

Nonetheless, Stella (2008) presents empirical evidence that financially "weak" central banks, those with persistent losses, tend to be associated with higher inflation. Del Negro and Sims (2014) argue that ex-ante commitments to recapitalise central banks enhance their credibility and capacity to meet policy objectives. Financial weakness may constrain central banks' independence, especially in policy implementation. In principle, the ECB is designed to be financially independent: its financial arrangements should be separated from EU institutions or member states (ECB, n.d.). The capital of the ECB is paid by euro area NCBs, which themselves must remain adequately capitalised (ECB, 2023). However, persistent losses may require government recapitalisation. For example, De Nederlandsche Bank (*DNB*) governor Klaas Knot warned the Dutch Ministry of Finance that the bank's capital may turn negative, which according

to the governor can be permitted in the short run, but would eventually require recapitalisation to uphold the principle of financial independence (DNB, 2022; ECB, 2022).

The findings of Stella (2008) and Del Negro and Sims (2014) suggest that financially "weak" central banks may face constraints in implementing optimal monetary policy. This potential dependence on national Treasuries for recapitalisation heightens the risk of political interference in monetary policymaking. Since national governments are the shareholders of their respective national central banks, they are ultimately responsible for covering central bank losses through recapitalisation. However, this support isn't guaranteed. Politicians may view the need for recapitalisation as an opportunity to interfere within the bank's operations. The risk for interference is heightened by current conditions of fiscal deficits, elevated public debt, and political polarisation make timely fiscal support less likely (Claessens, 2025). Although monetary policy is not designed to transfer cash flows to Treasuries, insolvency concerns could result in governments pressuring central banks to adopt more accommodative policies to generate profits. Gebauer et al. (2024) estimate that had the ECB adopted a zero-loss strategy, it would have needed to lower interest rates to 1.7% in 2023 and 1.9% in 2024, far below the actual DFR of 4% and 3% at the end of those years respectively. Traditionally, seigniorage income might have offset some losses, but as discussed, its potential is increasingly limited. Such dynamics pose a serious risk to the ECB's credibility and policy independence. Fitch Ratings however stated that they do not expect that the financial losses would influence the ECB's monetary policy decision, since they expect that the consolidated Eurosystem's net equity will remain positive, making recapitalisation unlikely (Delano, 2024).

Nevertheless, it is essential to manage these risks proactively and strengthen the financial resilience of the Eurosystem. Several policy measures may be considered. First, central banks should build up larger provisions during periods of profit instead of transferring money towards national Treasuries (or private shareholders), thereby creating a capital buffer to absorb future losses. A second approach could be the establishment of formal arrangements with fiscal authorities. For instance, the Bank of England (*BoE*) entered into an "indemnity agreement" with HM Treasury in 2012, whereby profits from its QE portfolio were transferred to the Treasury (McLaren and Smith, 2013). However, this agreement cuts both ways. Losses from the QE portfolio would be covered by the HM Treasury. While such agreements enhance financial stability, they may also constrain central bank independence. In the UK's case, the Bank of England sometimes requires Treasury approval for certain balance sheet actions (Cavallo, 2019).

A third potential measure involves adjusting reserve requirements. Currently, credit institutions must hold a minimum reserve of 1% of specified liabilities. As of 2022, only excess reserves are remunerated, not the minimum requirements (ECB, 2023). Increasing this requirement, or eliminating remuneration altogether, could reduce the ECB's interest expenses to credit institutions.

Finally, and most relevant to the focus of this paper, the ECB could reduce the duration risk of its asset portfolio by shrinking its balance sheet. A smaller balance sheet lowers the exposure to interest rate fluctuations and reduces the likelihood of incurring large losses. Cavallo et al. (2019)

finds that in the United States, reducing the Federal Reserve's longer-run reserve balances from $2.3 trillion to $1 trillion decreases the probability of a quarterly net loss in the future from 30% to below 5%. By limiting the size and duration of its holdings, the ECB could reduce the risk that future policy tightening leads to severe financial losses.

In sum, while the ECB's balance sheet policies were proportionate responses to periods of economic distress, continued reliance on large-scale asset holdings may become increasingly difficult to justify for political economy reasons. Therefore, a reduction in the size of the balance sheet might be preferred. It allows the ECB to reinforce the separation between monetary and fiscal policy, reduce the risk of political interference linked to potential recapitalisation needs, and limit perceptions of fiscal dominance. In doing so, QT could be essential not only for preserving the ECB's credibility and operational autonomy, but also for ensuring the long-term resilience of the Eurosystem.

2.3. The Challenges of Quantitative Tightening

While the previous section outlined several arguments in favour of balance sheet normalisation, the implementation of quantitative tightening presents a range of practical challenges that are not yet fully understood. In contrast to the extensive research and experience accumulated during the period of the balance sheet expansion, the dismantling remains relatively unexplored. The process of actively or passively reducing the central bank asset holdings is marked by considerable uncertainty, with only limited empirical evidence and few historical examples available to guide decision-making. As a result, the macroeconomic and financial market consequences of QT are still subject to debate, particularly in the context of a diverse monetary union as the euro area.

This section explores the major challenges the ECB faces as it unwinds its balance sheet. One of the central difficulties lies in determining the appropriate path for the normalisation cycle. QT can take various forms, ranging from active sales to passive runoff strategies, with each approach coming with distinct advantages and drawbacks. In section 2.3.1, the rationale behind the ECB's gradual and passive QT strategy is examined, focusing on its intention to avoid financial market disruption and maintain a controlled pace of normalisation.

The subsequent subsection addresses the theoretical considerations surrounding the optimal size of the central bank's balance sheet. Although no single benchmark exists, establishing a general direction is important for guiding market expectations and supporting effective policy signalling.

In addition to these operational issues, recent academic research suggests that balance sheet policies may have broader implications for monetary policy transmission. In particular, asset holdings could influence the natural rate of interest, complicating the calibration of the overall policy stance. This complication will be discussed in section 2.3.3. Furthermore, the empirical evidence of QT remains sparse, particularly in the context of a monetary union like the euro area. This introduces additional uncertainty regarding the transmission effects of QT across euro area member states. Given the euro area's heterogeneous institutional structures and diverse fiscal capacities, a balance sheet normalisation could trigger fragmentation risks within the union. These risks raise concerns not only about monetary transmission but also about the cohesion and resilience of the monetary union itself.

The subsections that follow will address these challenges in greater detail, combining theoretical insights with empirical perspectives to assess the potential constraints and risks associated with the ECB's quantitative tightening strategy.

2.3.1. The path towards the optimal balance sheet

Having established the rationale behind quantitative tightening, it's equally important to consider how such a process should be implemented. The methods chosen must not only achieve policy objectives, but also minimize disruptions to financial markets. To guide this process, the ECB has emphasized a set of principles in its communication. According to El Joueidi and Vincent (2022), these include optionality, flexibility and gradualism. In addition, the ECB has consistently stressed the importance of maintaining a predictable process, reinforcing its commitment to transparency and clear communication. Clear and early communication enables financial institutions to adapt their strategies accordingly, thereby mitigating potential liquidity shortfalls and reducing the risk of unwarranted market volatility. In this context, transparency becomes a key element in anchoring expectations and maintaining financial stability.

To better understand the ECB's approach to managing market expectations and avoiding unnecessary disruption, it's helpful to examine the three main principles identified by El Joueidi and Vincent (2022). The first, optionality, reflects the ECB's intention to retain access to a broad array of instruments, allowing it to adjust the pace of normalization in response to evolving conditions. The second, flexibility, concerns the application of the monetary policy tools, ensuring that monetary policy is transmitted effectively across all euro area countries. This principle will be discussed in further detail in section 2.3.4. The third, and most relevant for this section, is gradualism, the notion that the ECB intends to reduce the size of its balance sheet in a slow, measured fashion. The principle refers to the bank committing to a step-by-step approach, accelerating the normalisation process over time.

Therefore, QT can be classified into four methods based on their relative speed, ranging from the most gradual to the most aggressive: (i) full reinvestment of maturing assets, (ii) partial reinvestment of maturing assets, (iii) fully passive unwinding of purchased assets and (iv) active sales (Claeys, 2023). The first three approaches fall under the category of passive QT, while the fourth constitutes active QT.

Although full reinvestment nominally preserves the size of the central bank's balance sheet, it represents quantitative tightening as a percentage of GDP. As the economy expands, the ratio of bond holdings to GDP gradually decreases, diminishing the relative footprint of the central bank's balance sheet policy. One of the primary advantages of this strategy is its low risk to financial stability, as it avoids a reduction in the absolute level of central bank liquidity. Ferguson et al. (2015) document that most instances of balance sheet normalizations since 1900 were achieved by maintaining nominal asset levels, while allowing GDP to expand[7]. However, the major drawback of this strategy is its slow pace to get a meaningful normalisation. Figure 6 illustrates this. It presents a counterfactual trajectory of Eurosystem securities holdings as a share of GDP, assuming the nominal stock of the APP and PEPP portfolios had remained constant since their peak of €5.1 trillion in 2022. Under this hypothetical scenario, the ratio of holdings to GDP would have declined from 39% in 2022 to 30.5% over a five-year horizon. In contrast, under the ECB's

[7] A few exceptions are for example the balance sheet of the Norges Bank and Sveriges Riksbank during the Nordic Crisis, as well as the Bank of Japan's asset reductions in 2006 (Ferguson, 2015)

current approach to balance sheet normalisation (outlined later in this section), the ratio is projected to decrease by half over the same period. If euro area GDP growth were to fall short of expectations, the pace of the normalisation process in the counterfactual scenario would slow markedly. This would pose a concern, as it would fail to deliver the benefits associated with quantitative tightening, as outlined in section 2.2.

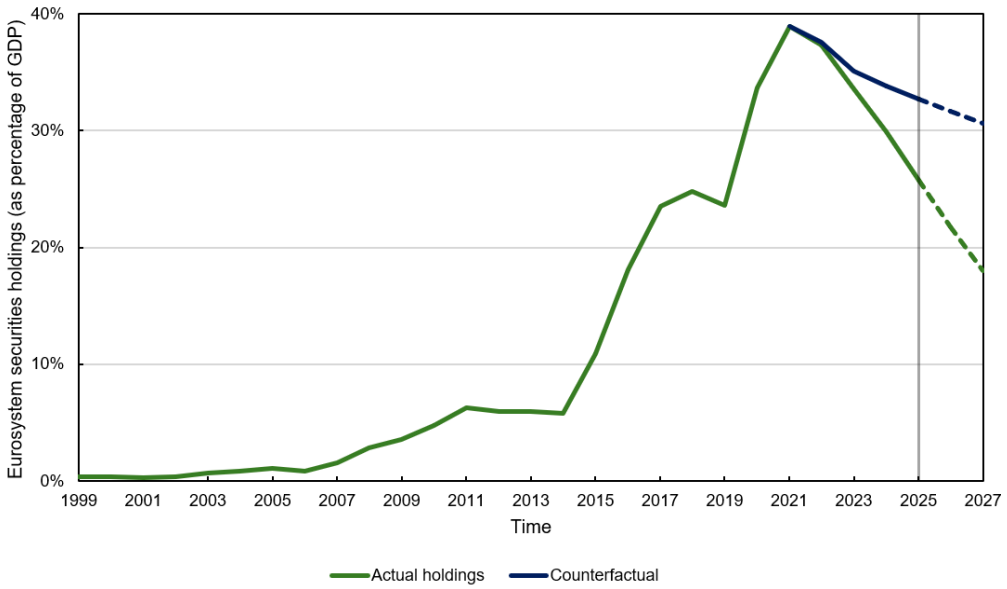

Figure 6 - Eurosystem actual holdings vs. constant counterfactual (% of GDP, 1999 - 2027)

Note: (1) The projection period begins in 2025, as indicated by the vertical grey line. Projections for securities holdings are based on the ECB Survey of Monetary Analysts conducted in April 2025. Analysts were asked to report their expectations for the size of APP and PEPP portfolios at the end of each quarter. For each year (2025, 2026, and 2027), the median response is used in the fourth quarter of that year. Total securities holdings represent the sum of the expected APP and PEPP holdings. DP projections are derived from the ECB staff macroeconomic projections for real GDP growth, adjusted using the GDP deflator (from the same report) to obtain estimates at market prices. (2) This counterfactual assumes that the reduction in asset holdings has no impact on GDP growth. If a nominal reduction in the size of the balance sheet had exerted a negative effect on GDP, then the counterfactual bond holdings would have declined faster as a percentage of GDP, thereby accelerating the pace of the balance sheet normalization under this hypothetical scenario.

Source: (1) European Central Bank. (2025). *Pandemic Emergency Purchase programme.*

(2) European Central Bank. (2025). *Asset purchase programmes*.

(3) European Central Bank Data Portal. (2025). *Gross domestic product at market prices, Euro area (changing composition), Annual (Dataset)*.

(4) European Central Bank. (2025, April). *The ECB Survey of Monetary Analysts: Aggregated Results.*

(5) European Central Bank. (2025, March). *ECB staff macroeconomic projections.*

A central concern surrounding this gradual approach towards the balance sheet normalisation is the potential ratchet effect it could create, as discussed under section 2.2.3. Under this dynamic, the central bank may find itself repeatedly expanding its asset holdings during successive crises, without sufficiently unwinding them in between. Over time, an increasing share of marketable sovereign bonds would be absorbed by the Eurosystem, reducing the availability of bonds for future asset purchase programmes and a good functioning of the money market. To preserve adequate policy space for future crises, it is therefore essential to create sufficient room on the balance sheet in advance. Also from a legal perspective, a meaningful reduction in the balance sheet is important. As explained in section 2.2.5, the TFEU prohibits the monetary financing of fiscal deficits (EUR-Lex, 2007). While the ECB's asset purchases are legally permissible when

conducted on secondary markets, the credibility of this legal safeguard weakens if the balance sheet remains persistently elevated. In such a case, balance sheet policies may be viewed not as a temporary policy adjustment but as a form of indirect fiscal support, potentially exposing the ECB to legal challenges or at least the perception of violating Article 123.

At the other end of the spectrum, a rapid or active approach to balance sheet normalisation entails substantial financial risks. Releasing large volumes of sovereign bonds into the market could significantly depress their prices, leading to broader financial instability through fire sales. Prior to 2022, the Eurosystem had no experience with quantitative tightening, making this a new and uncertain phase of monetary policy. The ECB is therefore currently navigating uncharted territory. While even passive QT carries some uncertainty, active QT introduces a higher level of unpredictability. Such an approach would resemble not merely walking but rushing through unknown terrain without a clear understanding of the consequences. Given the limited empirical evidence on the full effects of (active) QT, such a strategy could result in unintended and destabilizing outcomes.

Having outlined the disadvantages associated with both ends of the QT spectrum, the focus now turns to identifying an appropriate path toward an optimal balance sheet size. The challenge lies in determining whether the ECB should adopt an active approach to the balance sheet reduction, or instead opt for a more gradual trajectory that minimizes market disruptions but extends the duration of the normalisation process.

In line with its guiding principles, the ECB was expected to favour a gradual approach to the balance sheet normalisation. The National Bank of Belgium developed a “textbook” balance sheet normalization cycle, drawing on the U.S. Federal Reserve’s pre-pandemic experience (El Joueidi and Vincent, 2022). This framework provides a structured theoretical approach that central banks can employ when shifting from an accommodative to a smaller balance sheet. The step-by-step approach is illustrated in figure 7.

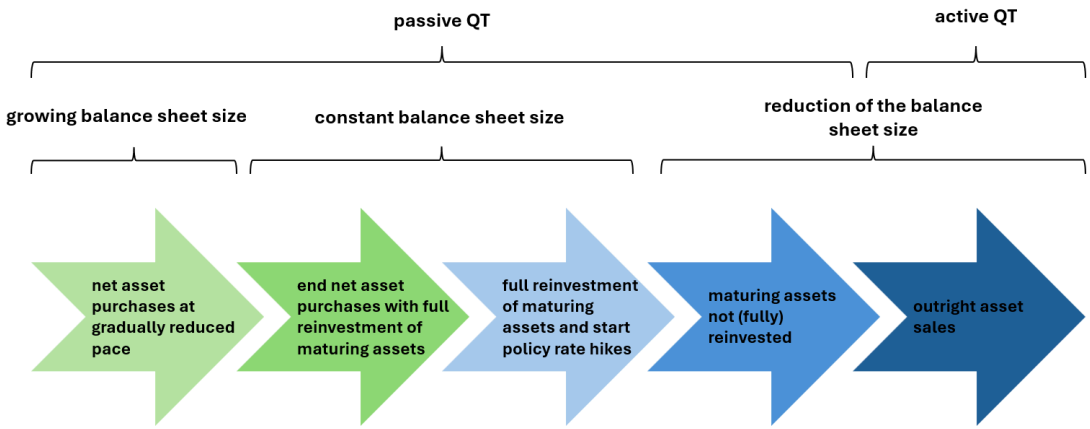

Figure 7 - The “textbook” normalisation cycle
Source: El Joueidi, S., & Vincent, E. (2022). *Towards a normalisation of monetary policy.* In NBB Economic Review #10

The normalisation cycle begins with tapering of asset purchases. This is a gradual reduction in net asset purchases that slows the expansion of the central bank's balance sheet. In the second phase, net purchases cease, but maturing assets on the balance sheet will be fully reinvested. Thereby, the balance sheet maintains a constant nominal size. This is followed by interest rate hikes in the third phase while reinvestments remain unchanged. This sequence is intentional, by regaining conventional monetary policy space, the central bank can get enough buffer to future shocks (Du et al., 2024). Ending net asset purchases before raising interest rates is deliberate, since ending net asset purchases before raising rates also avoids sending mixed signals. Continued asset purchases may be interpreted as expansionary, which would contradict the tightening message conveyed by higher policy rates (El Joueidi et al., 2022).

In the subsequent phase of the normalisation process, provided that macroeconomic conditions remain favourable, central banks may transition towards a passive nominal reduction of their balance sheets. This entails a gradual decline in asset holdings by ceasing the (full) reinvestment of maturing securities. Under this approach, central banks can set a monthly cap on the pace of balance sheet reduction, allowing only partial reinvestments when redemptions exceed the designated cap. The rationale for prioritising policy rate hikes before initiating balance sheet runoff lies in the relatively limited understanding of the economic and financial implications of liquidity withdrawal. By first employing conventional interest rate tools, central banks are able to exert a more predictable influence on financial conditions, while allowing quantitative tightening to proceed in the background at a controlled pace.

In the final stage of the normalisation cycle, central banks might consider outright asset sales. As noted previously, this strategy represents a more aggressive approach, offering a faster balance sheet reduction but with the potential trade-off of elevated financial risk. One practical motivation for adopting active QT arises when the maturity structure of the central bank's asset holdings is skewed toward the long end. For example, had the ECB purchased only 10-year bonds in 2020, the impact of QT would not materialize meaningfully until 2030. While in practice the ECB has acquired a diversified maturity profile, the issue could arise if most bonds would have a longer maturity. In the case of the Bank of England for example, the gilts under the Asset Purchase Facility (*APF*) had an average maturity of 13 years (OBR, 2021). Given this long duration, the BoE moved towards active sales more quickly. By contrast, the ECB's holdings exhibit shorter maturities, with the weighted average maturity (*WAM*) of bonds under the PSPP and the PEPP standing at 6.86 years and 7.17 years, respectively, as of March 2025 (ECB, 2025). This shorter maturity structure reduces the urgency for the ECB to engage in outright sales to achieve timely balance sheet reduction.

In practice, however, the pace and form of balance sheet normalisation will ultimately be determined by the macroeconomic context. Given that the effects of QT, much like QE, are state-dependent and not fully understood, central banks must remain responsive to changing conditions. They should be prepared to slow, pause, or reverse QT in response to adverse developments or shifting market dynamics. For example, the BoE abandoned plans to sell some of its long-term bond holdings after a sharp selloff in global bond markets triggered by movements in U.S. Treasuries (The New York Times, 2025). In the euro area, potential concerns about fiscal discipline, for instance in the wake of German Chancellor Friedrich Merz lifting the

national debt brake (*Schuldenbremse*) and the European Commission's announcement of its "Rearm Europe" defence initiative, could reawaken fears among investors, potentially leading to a resurgence of bond vigilantes.

In this context, QT should be approached not as a fixed path but as a flexible policy tool. Flexibility is essential for maintaining financial stability while pursuing the objective of monetary policy normalisation. Importantly, such a strategy must be accompanied by clear and consistent communication to ensure that market participants understand the ECB's readiness to adjust course in response to financial stress.

Beyond considerations of speed, active QT can also serve to change the composition of its asset portfolio. The Bank of England, for instance, has aimed to fully unwind its holdings of corporate bonds through active sales and buybacks by the issuing firms in order to minimize its private sector footprint (BoE, 2022). Note that a similar effect can be achieved through reinvestment strategies as well. The ECB has employed such an approach by ceasing reinvestments in private sector bonds, with the exception of corporate issuers demonstrating a strong environmental track record (Euractiv, 2023). This strategy allows the ECB to gradually "tilt" its portfolio toward greener investments, aligning its monetary operations with climate policy objectives.

A critical dimension of quantitative tightening lies not solely in the method employed, but in how central banks initiate the process and communicate their intentions to the market. The initial framing of QT sets the tone in shaping market expectations and perceptions of the central bank's policy trajectory. A significant policy change that is communicated well in advance may have a similar market impact as a smaller, unexpected measure introduced abruptly. Thus, clear and timely communication is essential for maintaining financial stability and avoiding unnecessary market volatility.

The initial phase of QT began without a single predefined blueprint. Central banks have adopted a variety of strategies in approaching the initial phase of the balance sheet normalisation. The Federal Reserve, for instance, took a transparent and preemptive approach in its communication (Du et al., 2024). In its "Principles for Reducing the Size of the Federal Reserve's Balance Sheet", the Fed announced that balance sheet reduction would begin only after the process of increasing the federal funds rate (*FFR*) was underway, doing it in a predictable manner (Federal Reserve, 2022). This forward guidance was designed to reduce uncertainty and prevent adverse market reactions, learning their lesson from the 2013 "Taper Tantrum". During that episode, an unanticipated remark by then-Chair Ben Bernanke regarding a potential tapering of asset purchases triggered a sharp increase in bond yields and considerable financial market volatility worldwide. To avoid a recurrence of such events, the Federal Reserve now uses a more careful approach in its communications, placing strong emphasis on predictability.

The Bank of England followed a similar path. In August 2021, it clearly outlined a sequential QT framework: passive QT would commence once the Bank Rate reached 0.5%, while active QT would begin when the rate hit 1%, with a flexible opt-out in the case of inappropriate economic

conditions[8]. This staged communication approach was designed to manage market expectations and ensure a smooth transition. A potential drawback of this approach is that it may cause the central bank to become “locked in” to a predetermined policy trajectory. This rigidity can be problematic if adverse economic conditions coincide with rising inflation. In such a scenario, the Bank of England could use its opt-out. However, if there is no clear indication of near-term, the bank may be pressured to continue postponing the implementation of QT. Such repeated delays risk undermining the institution’s credibility. Over time, the compounding distrust could weaken the effectiveness of the bank’s future communications, whether related to its balance sheet policies or its broader monetary policy stance. By contrast, some central banks opted for a less cautious strategy. The Sveriges Riksbank, for example, moved swiftly toward active QT just two months after concluding its net asset purchase programmes (Du et al., 2024). This unexpected move surprised markets and stands in sharp contrast to the more measured approaches of the Fed and the Bank of England.

The European Central Bank has chosen a cautious and deliberate communication strategy. Rather than abrupt announcements, the ECB has consistently provided advance notice of its intended changes. A notable example of this is the ECB’s clear communication, since December 2018, of the sequencing involved in policy normalisation. This sequencing follows closely the “textbook” normalisation framework, as previously outlined in this section (Claeys, 2023). Throughout this period, the introductory statement of the ECB’s press conferences included a version of the following sentence: *“The Governing Council intends to continue reinvesting, in full, the principal payments from maturing securities purchased under the APP for an extended period of time past the date when it starts raising the key ECB interest rates and, in any case, for as long as necessary to maintain ample liquidity conditions and an appropriate monetary policy stance.”* This consistent messaging reinforced market expectations and reduced the likelihood of disruptive market reactions.

As the COVID-19 pandemic subsided, the ECB began preparing to phase out its asset purchase programmes in a transparent manner. The ECB’s monetary policy decision in December 2021 marked the start of the actual balance sheet normalisation. The Governing Council announced that net asset purchases under PEPP would cease by the end of March 2022. Already in earlier meetings in 2021, the ECB had indicated its broader intention to fully phase out net purchases under PEPP by March 2022, reflecting a transparent wind-down of the balance sheet. Additionally, the ECB provided forward guidance that principal payments from maturing PEPP securities would be reinvested until at least the end of 2024 (ECB, 2021). This marked a shift from previous communications, in which investments were expected to continue at least to 2023 (ECB, 2021).

Simultaneously, the ECB adjusted its APP to manage this transition. The Governing Council outlined a temporary increase in net asset purchases of €40 billion in the second quarter of 2022, €30 billion in the third quarter, and €20 billion from the fourth quarter onwards (ECB, 2021). This

[8] This opt-out was used during the liability-driven investment (*LDI*) crisis, triggered by the announcement of the “mini-budget” by then-UK Prime Minister Liz Truss, which led to heightened interest rate volatility in financial markets.

temporary scaling-up, since net purchases before April were on average €20 billion, was intended to compensate for the end of PEPP net purchases. However, with inflation proving more persistent than previously anticipated, the ECB accelerated the tapering of QE. In March 2022, it decided to maintain €40 billion in net purchases for April, followed by reductions to €30 billion in May and €20 billion in June. Notably, for the third quarter of 2022, the ECB remained hesitant to give detailed forward guidance for the third quarter and onwards, emphasizing instead a data-dependent approach. By April 2022, amid rising inflation expectations, the ECB committed to ending net purchases under the APP in July 2022, while continuing full reinvestment.

In December 2022, the ECB announced that it intended to initiate partial reinvestments under the APP from February onwards, reducing the portfolio by €15 billion, with this policy in place at least until the end of June 2023. According to ECB President Christine Lagarde, this amount represented roughly half of the redemptions expected during that period (Claeys, 2023). The Governing Council stated that the pace of reduction would be determined over time. By May, expectations were communicated that reinvestments would end entirely from the third quarter of 2023 onwards, a decision that was confirmed in June. From that point forward, the APP portfolio began to decline passively as bonds matured.

Developments regarding the PEPP portfolio emerged later. Since the end of net purchases in March 2022, the ECB had been fully reinvesting maturing securities under the programme. It was only in December 2023 that the ECB announced its intention to shift from full to partial reinvestment of the PEPP portfolio, targeting an average monthly reinvestment of €7.5 billion. This plan remained consistent with the ECB's original guidance from December 2021, as reinvestments under PEPP continued until the end of 2024. As of the beginning of 2025, all reinvestments under PEPP terminated, marking an important step in the balance sheet normalisation process.

The process of the actual balance sheet normalisation is visually depicted in figure 8, which presents an index of asset holdings under PEPP, APP and total asset holdings, normalized to 100 at the start of full PEPP reinvestment in March 2022. The ECB’s bond holdings peaked in June 2022, followed by a period of stagnation until February 2023, when partial reinvestment under APP began. Until the second half of 2024, the decline in the ECB’s balance sheet was solely attributable to the APP. Thereafter, the end of reinvestments under PEPP further accelerated the reduction. As of May 2025, the ECB’s asset portfolio has contracted by approximately 15% compared to its initial size in March 2022, with the majority of the reduction stemming from the APP.

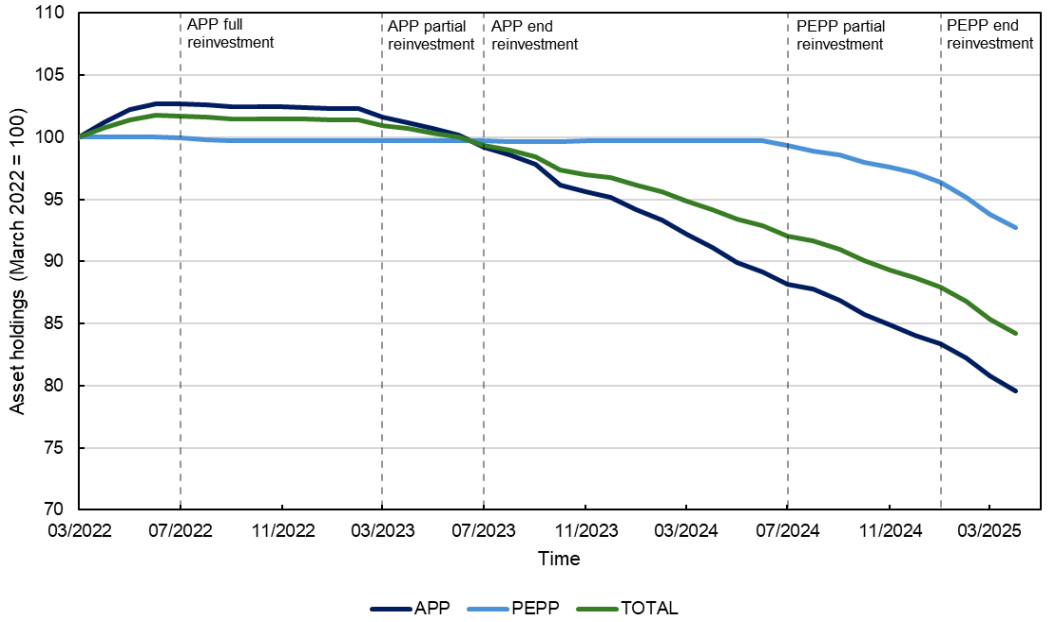

Figure 8 - ECB asset holdings under APP and PEPP indexed to March 2022 (03/2022 - 05/2025)
Source: (1) European Central Bank. (2025). *Pandemic Emergency Purchase programme.*
(2) European Central Bank. (2025). *Asset purchase programmes.*

The trajectory of the normalisation process is closely aligned with the ECB's broader communication strategy, which has been guided by the principle of gradualism. As mentioned, it follows the theoretical "textbook" normalization process closely: net asset purchases were first tapered, followed by a phase of full reinvestment under APP. The ECB initiated its policy rate hikes only after net asset purchases had concluded and fully reinvestments commenced in July 2022, with the first increase implemented in July 2022. The passive reduction of the APP portfolio began in 2023, while a similar process for PEPP started in 2024. This progression illustrates the ECB's structured approach to normalisation. With the active sale of securities being the final step yet to be implemented, with no announcements from the ECB thus far, attention now turns to the potential trajectory of future balance sheet policy.

Looking ahead, researchers at the Bank of America have raised doubts about the likelihood of the ECB adopting active asset sales as part of its quantitative tightening strategy (Delano, 2025). They argue that, with inflation converging towards the target, a more aggressive pace of balance sheet reduction could excessively tighten financial conditions, particularly given the heightened uncertainty surrounding economic growth, which may prove weaker than anticipated. Additionally, the researchers highlight the potential implications of unrealised losses. As outlined in section 2.2.5, the ECB's accounting framework does not recognise unrealised losses for securities held for monetary policy purposes. However, if these securities are sold before maturity, the associated losses would be realised and recorded, potentially increasing the ECB's financial exposure. Finally, the researchers caution that active sales could contribute to a widening of sovereign bond spreads, an issue further explored in section 2.3.4.

Given these considerations, the ECB appears likely to continue relying on a passive balance sheet reduction as the primary mechanism for normalisation. In line with this expectation, current projections suggest a continued, though moderated, decline in total asset holdings. According to the ECB Survey of Monetary Analysts (*SMA*) conducted in April 2025, the Eurosystem's stock of bonds held under the APP is projected to decline by an average of €82 billion per quarter until the end of 2027 (ECB, 2025). Similarly, holdings under PEPP are expected to decrease by approximately €44 billion per quarter over the same period (ECB, 2025). In addition to these projections, analysts at the Bank of America forecast a reduction in the Eurosystem's total balance sheet from €6.4 trillion at the end of 2024 to approximately €5.7 trillion by December 2026 (Delano, 2025). This pace is notably slower than during the earlier phase of the balance sheet contraction, between the September 2022 peak of €8.8 trillion and the end of 2024 (€6.4 trillion). During that period, the reduction was largely driven by the substantial maturing of LTROs, which contributed to an immediate drop in total assets (ECB, 2025). In contrast, with the vast majority of LTROs having already matured, the projected balance sheet reduction now primarily reflects the gradual unwinding of the asset portfolio rather than the expiry of lending operations.

2.3.2. The size of the optimal balance sheet

While the previous section discussed the trajectory toward a more appropriate balance sheet size, it did not address the question of what constitutes an optimal endpoint for the process. Determining the optimal size of a central bank's balance sheet is inherently complex and is not an exact science. Although several researchers have attempted to provide estimates, their findings vary considerably, reflecting the significant uncertainty surrounding this issue. Moreover, the ECB has, at the time of writing, not communicated a specific numerical target or timeline for completing its quantitative tightening process, underscoring the cautious and adaptive nature of its approach.

A key consideration in evaluating the optimal size of the central bank's balance sheet is the structural demand for central bank reserves. As balance sheet normalisation progresses, the withdrawal of reserves from the financial system can have significant implications for market functioning. This is particularly relevant given the increased reliance on central bank liquidity that has emerged since the global financial crisis. To illustrate this mechanism, I refer to figure 9 as a theoretical representation of the money market, based on Heylen (2021). The horizontal axis depicts the real money supply (*M/P*), while the vertical axis represents the market interest rate (*R*). The money supply (*MS*) is determined exogenously by the central bank and is therefore independent of the interest rate[9]. As a result, the MS-curve is vertical. Conversely, the money demand (*MD*) exhibits a negative relationship with interest rates, consistent with economic theory, like Keynes' speculative motive of money demand[10]. Vissing-Jorgensen (2023) shows specifically that the demand for reserves follows a convex curve.

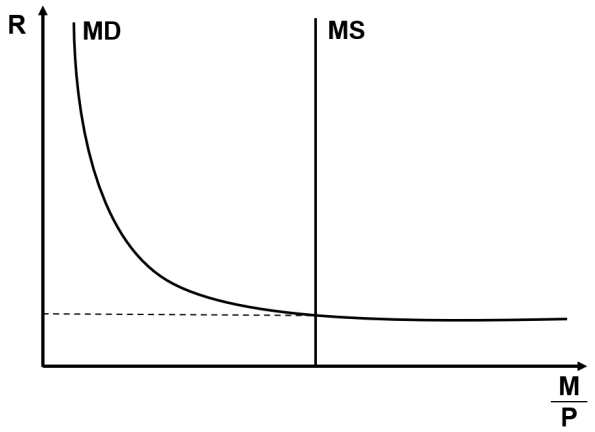

Figure 9 - Supply and demand on the money market
Source: Heylen, F. (2020). *Macro-economie (fourth edition).* Owl Press.

[9] It should be noted that a vertical money supply curve reflects the classical monetarist view of interest rate determination, whereas modern frameworks assume an endogenous money supply.
[10] The speculative motive offers a theoretical explanation for the negative relationship between money demand and the interest rate. When the interest rate is high, the likelihood of a future decline in rates increases. In this context, rational investors anticipate capital gains from bond price appreciation, as bond prices move inversely with interest rates. Consequently, holding bonds becomes a more attractive option than holding money, leading to a reduction in money demand. Conversely, when interest rates are low, the probability of a rate increase becomes higher. This implies a potential decrease in bond prices, which would result in capital losses for bondholders. To avoid such welfare-reducing outcomes, investors prefer to hold liquid assets—such as cash—rather than risk exposure to interest rate fluctuations.

Figure 10 builds on the preceding graph by illustrating the effects of a positive demand shock in the money market, for instance due to heightened uncertainty regarding political tensions, under two distinct operational regimes. In the left-hand panel, where reserves are ample, a shift in money demand has little effect on interest rates. As a result, the framework shown in the left-hand panel is referred to as a floor system, since the DFR creates a floor below the money market rate. Commercial banks will not generally want to earn less in money markets than they can earn by keeping cash at the central bank. In contrast, the right-hand panel demonstrates that under the conditions of reserve scarcity, the same shock produces a much sharper increase in rates, driven by intensified competition for limited funds. Figure 10 illustrates that when liquidity is scarce, a minor shift in supply or demand could lead to volatility in interest rates. This would require the central bank to actively manage the supply of reserves to offset shocks, a challenging task since demand shocks are inherently difficult to predict (Logan, 2023).

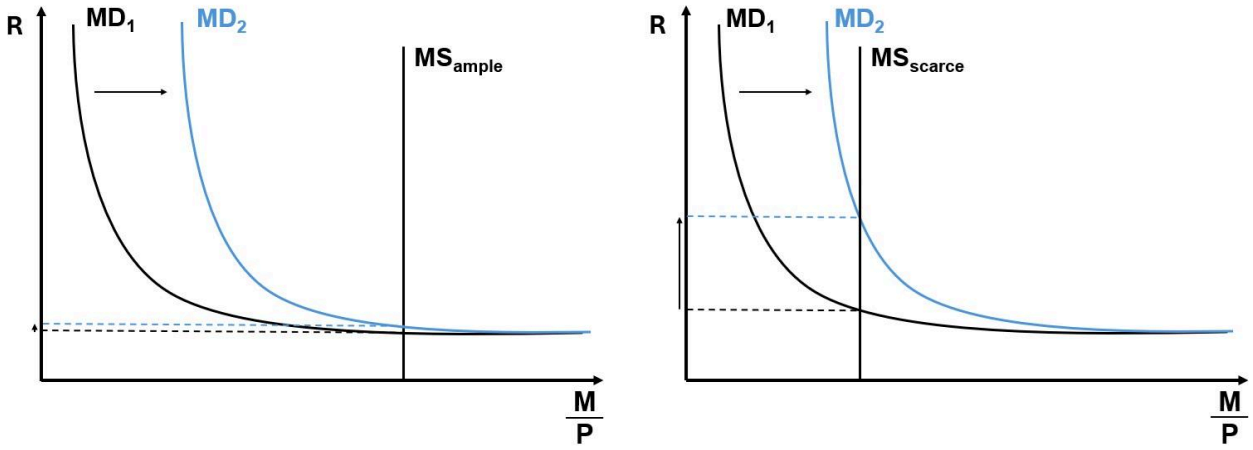

Figure 10 - Supply and demand on the money market after a positive demand shock in the case of ample liquidity (left panel) and scarce liquidity (right panel)
Source: Heylen, F. (2020). *Macro-economie (fourth edition)*. Owl Press.

This theoretical insight is supported by empirical evidence, for instance by Lopez and Vissing-Jorgensen (2021), who examine the relationship between central bank reserves and short-term interest rates in the United States. Their analysis reveals a statistically significant negative relationship between the aggregate level of reserves in the banking system and the EFFR-IORB spread (i.e. the difference between the effective federal funds rate and the interest on reserve balances). In principle, this spread should be small due to arbitrage possibilities, but could be positive due to nonbanks not having access to the IORB. However, as reserves become scarce due to the balance sheet normalisation, the competition for funds within the money market becomes more tense, which puts upward pressure on the interest rate on reserves. This suggests that reserves aren't just passive, but play an active role in maintaining control over short-term market rates. Similarly, Duffie et al. (2023) document a strong positive correlation between interest rate volatility and the Bloomberg Government Bond Liquidity Index, underscoring the stabilizing role of abundant reserves[11]. Consequently, managing the supply of reserves becomes critical in ensuring smooth monetary transmission, particularly during periods of balance sheet

[11] A higher value of the index indicates worse liquidity conditions within the U.S. government bond market.

reduction. A rapid or excessive reduction in reserves through QT could increase interest rate volatility and impair market liquidity. These findings underscore the potential risks of overly aggressive QT strategies, which could inadvertently destabilise short-term funding markets.

The events in U.S. financial markets in September 2019 provide a compelling example of the sensitivity of short-term interest rates to reserve scarcity. On September 16 and 17, the Secured Overnight Financing Rate (*SOFR*), a key overnight money market rate in the U.S., exhibited sharp and unexpected volatility. This was largely driven by a sudden shortage of liquidity in the financial system. Two major reserve-draining operations occurred on September 16: the withdrawal of quarterly corporate tax payments and the settlement of newly issued Treasury securities (Anbil et al., 2020). Combined, these transactions removed approximately $120 billion in reserves from the system within a two-day period. Moreover, primary dealers were simultaneously absorbing large volumes of newly issued Treasuries, financing these purchases through the repo market. As demand for repo funding surged and supply remained constrained, the resulting mismatch spilled over into the broader money market, driving short-term rates sharply higher, as illustrated in the left-hand panel of figure 10. In response, the Federal Reserve intervened by conducting an overnight repo operation, which promptly alleviated funding pressures and restored stability (Anbil et al., 2020). Notably, this disruption took place within the broader context of the Federal Reserve's ongoing balance sheet reduction ("QT1"), which had been in progress since 2017 (Anbil et al., 2020).

This illustration may suggest that quantitative tightening is inadvisable due to the risk it poses to market stability. Nevertheless, financial instability has occurred in recent years even in periods of more ample liquidity. A prominent example is the liability-driven investment (*LDI*) crisis in the United Kingdom. This episode unfolded following the announcement of a "mini-budget" by the newly appointed Prime Minister Liz Truss. While the intention was to stimulate economic growth, the proposal included £45 billion in unfunded tax cuts, introduced against the backdrop of historically high inflation (Chen and Kemp, 2023). The announcement triggered significant market concern over fiscal sustainability and doubts about the government's ability to restore inflation to target. These concerns prompted a rapid selloff in UK assets, which, in turn, generated substantial margin calls for pension funds. The resulting feedback loop intensified the market reaction, leading to a dramatic collapse in gilt prices, most notably the yield on the 30-year gilt surged by 140 basis points (Chen and Kemp, 2023). To restore market functioning, the Bank of England intervened by purchasing government bonds. The intervention proved effective, calming markets almost immediately.

Remarkably, this episode of market turmoil took place prior to the Bank of England's initiation of outright asset sales, during a period characterised by abundant liquidity. The United Kingdom operated under a floor system, comparable to the framework depicted in the left-hand panel of Figure 10, which is designed to mitigate liquidity risk. However, this event suggests that it does not fully eliminate that risk (Logan, 2023). This presents a paradox: despite a system with central bank reserves, financial stress materialized. Rajan and Acharya (2022) offer an explanation, arguing that not all reserves are functionally liquid or even usable during episodes of financial stress. While commercial banks held large quantities of reserves, these were often encumbered, which means that they used reserves to back remunerated commitments such as credit lines or

guarantees on leveraged transactions. When market disruptions triggered margin calls or the drawing down of these credit lines, many of the associated obligations could not be liquidated promptly without incurring losses. As such, these assets were not truly liquid nor safe under stress conditions. In response, banks turned to the interbank market for liquidity. However, heightened counterparty risk led to a breakdown in trust, with more cautious institutions reluctant to lend to those perceived as exposed. This eroded interbank lending, compounding the liquidity shortfall. Consequently, the financial system had become overly reliant on apparent “excess liquidity,” part of which was inaccessible in practice. As long as commercial banks retain the discretion to deploy reserves for private purposes, systemic liquidity can quickly prove illusory. The work of Rajan and Acharya (2022) thus challenges the presumption that a large central bank balance sheet is inherently stabilizing. Instead, it highlights how financial institutions adjust their strategies to financial conditions. If QT proceeds gradually, allowing time for the system to adapt, the level of effectively "available" liquidity can be preserved despite a shrinking balance sheet.

This insight does not imply that a smaller balance sheet offers the same degree of financial stability as a larger one. However, it underscores the need for a more nuanced understanding of what constitutes an optimal balance sheet size. Central to this is the commercial banks’ demand for liquidity. Central banks should accurately follow this up, which requires close monitoring of financial market conditions to ensure that the central bank does not undersupply reserves relative to the system’s needs.

In this context, the framework proposed by Lopez-Salido and Vissing-Jorgensen (2021) offers a useful lens through which to evaluate the drivers of banks’ demand for central bank reserves. According to their analysis, three key factors determine reserve demand: (i) the spread between market interest rates and the DFR, (ii) banks’ intrinsic liquidity needs, and (iii) the costs associated with holding a larger balance sheet.

The first driver reflects a basic arbitrage incentive. Reserves earn interest, so when market rates exceed the DFR, banks are incentivized to reallocate liquidity towards the financial market. Beyond this interest rate differential, banks also value reserves for their intrinsic utility. Reserves serve as a highly liquid and risk-free asset, facilitating short-term payments, meeting regulatory liquidity requirements (such as those under Basel III), and providing a buffer against unexpected outflows. They provide "convenience services” on reserves, a benefit that increases the banks’ willingness to hold them (Vissing-Jorgensen, 2023). This reflects a so-called “convenience yield” (see section 2.3.3 for a detailed discussion). Vissing-Jorgensen (2023) argues that this yield can be welfare-enhancing, reflecting the role reserves play in improving the operational efficiency and resilience of the banking sector.

Finally, banks face constraints in expanding their balance sheets to hold additional reserves due to costly regulatory requirements, such as capital and leverage requirements. These balance sheet costs, as outlined by Lopez-Salido and Vissing-Jorgensen (2021), can limit the banks’ ability to arbitrage spreads by borrowing at market rates and investing at the DFR (Lopez-Salido and Vissing-Jorgensen, 2021).

Taken together, these factors clarify the underlying determinants of banks' demand for central bank reserves. However, understanding these drivers also requires contextualizing the broader shift in the financial system's structure. In particular, liquidity demand has increased substantially in the post-crisis period due to changes within the banking sector.

Three main developments account for this structural rise in liquidity demand: (i) post-crisis regulatory requirements, (ii) more cautious liquidity risk management and (iii) new technologies.

The first refers to the Basel III regulatory framework introduced after the global financial crisis. This framework imposed binding liquidity standards, such as the Net Stable Funding Ratio (*NSFR*), which restricts excessive reliance on maturity transformation, and the Liquidity Coverage Ratio (*LCR*), which requires banks to hold a sufficient stock of high-quality liquid assets (Karadi, 2024). Central bank reserves qualify as such assets, and their inclusion in regulatory compliance has increased demand for them.

The second factor reflects a behavioral shift among banks, which have become more cautious in managing liquidity risks. The painful lessons of the GFC and the eurozone sovereign debt crisis would have led institutions to strengthen their liquidity buffers. Greenwood et al. (2016), however, caution that this shift may be overstated. In the pre-GFC era, many banks held assets issued by shadow banks that appeared to be liquid under normal conditions. The crisis revealed these instruments were not robust under stress, prompting a reallocation toward genuinely safe, money-like assets—such as central bank reserves.

Finally, the last factor which explains the increased demand for reserves is the advancement of financial technology, particularly the rise of online banking. The events in the United States in March 2023 reveals the potential vulnerabilities associated with the creation of new technologies. While digital banking has enhanced the convenience and speed of financial transactions, it also facilitated the transfers of funds during stress. As information spreads rapidly online, the risk of a sudden and severe bank run has increased. In this environment, commercial banks face heightened liquidity risk and must therefore maintain more liquidity buffers to meet potential withdrawals.

On top of this, Aberg et al. (2021) argued that a prolonged period of ample reserves may increase the demand for them if a "hysteresis effect" comes into play. Ample reserves have a negative impact on money market activity, since the majority of demand for liquidity can be met by the deposit facility. This resulted in a higher demand for reserves. If such a hysteresis effect exists, then a long-lasting implementation of the floor system with ample reserves could therefore lead to an endogenous increase of the demand for excess liquidity (Aberg et al., 2021).

This growing demand for liquidity cannot be met entirely by the private sector. Deposits, while liquid under normal conditions, are runnable and are therefore inherently risky. As Stein (2012) emphasizes, deposits embody a fundamental tension between liquidity and safety. A heightened reliance on market funding would trigger volatility, like it did in the U.S. in 2019, potentially causing runs on banks. In contrast, central bank reserves are both perfectly liquid and entirely safe, making them uniquely suited to fulfill systemic liquidity needs without introducing fragility

and as a result, they yield a convenience premium for these services (see section 2.3.3). A larger balance sheet enables the central bank to maintain a sufficient supply of these safe assets, providing a stabilizing influence that private institutions are structurally incapable of replicating.

Accordingly, the heightened demand for reserves necessitates a larger central bank balance sheet than in the pre-GFC era. If reserve levels fall too low, interest rate volatility may reemerge, similar to the dynamics illustrated in the right-hand panel of figure 10. Therefore, the demand for reserves is arguably the most critical determinant of the optimal balance sheet size. On top of this, it is important to recognize that this demand is not constant. The volatility experienced in U.S. financial markets in September 2019 demonstrated that reserve demand can fluctuate significantly from day to day. As a result, maintaining a liquidity buffer that exceeds average demand may be prudent. Karadi (2024) supports this view, suggesting that a modest oversupply of liquidity serves as a safeguard against unanticipated shocks, thereby enhancing systemic resilience. To conclude, the optimal size of the central bank's balance sheet should, at a minimum, accommodate the structural demand for reserves. In addition, it should include a buffer to absorb unexpected spikes in liquidity demand, thereby limiting excessive volatility in money market interest rates.

Building on this foundation, a more precise determination of the optimal balance sheet size can be guided by theoretical frameworks that link the supply of reserves to their marginal value in the financial system. In particular, recent work by Vissing-Jorgensen (2023) proposes that the money supply should be guided by the "Friedman rule" for central bank money[12]. The application of this principle depends on the type of the assets used to inject reserves into the financial system. In the first case, where reserves are provided through non-convenient assets, such as via short-term lending operations, as was typical prior to 2015, the central bank should supply liquidity until the convenience yield on reserves falls to zero. In practical terms, this implies that the ECB should supply enough reserves such that they eliminate the scarcity: the marginal value of reserves for banks in managing payments should be nearing zero. Under such conditions, the market interest rate would align closely with the DFR.

In contrast, when reserves are created through the purchase of convenient assets, such as sovereign bonds, as has been the case since 2015, the central bank should expand its balance sheet only until the marginal convenience yield on reserves equals that of the bonds being withdrawn from the market (Vissing-Jorgensen, 2023). Supplying reserves beyond this point reduces the availability of highly valued liquid assets, while replacing them with assets that offer lower utility to investors. Consequently, this diminishes the overall convenience or liquidity premium in the financial system. Ensuring that the marginal convenience yields of reserves and bonds are equalized thus provides the most efficient allocation of liquidity, avoiding both under- and over-supplying.

[12] The original Friedman rule, formulated by Milton Friedman (1969), posits that the optimal quantity of money is achieved when the nominal interest rate is zero. The underlying rationale is that, since the social cost of creating additional money is negligible, the opportunity cost of holding money should also be minimized. By setting the nominal interest rate to zero, the opportunity cost of holding cash is eliminated, thereby promoting allocative efficiency and maximizing welfare in the economy.

Gali (2023) argues based on this framework that, prior to 2008, the ECB undersupplied reserves. During this period, the overnight market rate (EONIA) tended to fluctuate around the MRO rate, rather than the DFR. This suggests that reserves were still scarce and thus carried a positive convenience yield. In the post-2015 period, where the ECB bought convenient securities on the secondary market, estimates by Vissing-Jorgensen (2023) reveal that the convenience yield on German Bunds remained positive, while the yield on reserves was slightly negative. This divergence implies that the marginal value of convenience services of reserves exceeded that of Treasuries, indicating an oversupply of central bank liquidity during this time. However, it is important to note that maximizing the aggregate convenience value of the economy was not the ECB's objective during this time (Gali, 2023). The policy was primarily aimed at meeting the 2% inflation target, as outlined in section 2.1 (Gali, 2023).

Given the post-pandemic context of inflation exceeding target levels, aligning the balance sheet with the convenience-maximising level would now be desirable. Vissing-Jorgensen (2023) estimates that the optimal level of excess liquidity for the euro area, assuming reserves are supplied via non-convenient assets, stands at approximately €1.25 trillion. By contrast, current excess liquidity remains close to €4 trillion (Hudepohl et al., 2024), suggesting that a substantial reduction in the size of the ECB's balance sheet would be necessary to reach the optimal level.

This leads to the question whether the optimal balance sheet can be operationally implemented. Gali (2023) contends that a balance sheet optimised for convenience yield is incompatible with a supply-driven floor system. Within such a framework, the central bank determines the aggregate quantity of liquidity in the market, thereby exerting direct control over the aggregate level of reserves. For the balance sheet to align with optimal convenience considerations, the system would require either a zero convenience yield (such as non-convenient assets as counterparts) or a strictly positive convenience yield, wherein reserves are adjusted via purchases or sales of Treasury securities, assuming that these securities confer a positive convenience yield. By contrast, a corridor system can accommodate an optimal level of excess liquidity under any strictly positive convenience yield, as long as that the money market rate exceeds the DFR (Gali, 2023). However, as illustrated in Figure 10, such a framework may lead to volatility in market rates in response to unanticipated shifts in the demand for reserves.

It is noteworthy, however, that a floor system can align with a convenience-maximizing balance sheet if it is structured as a demand-driven regime. Following its comprehensive review of operational frameworks in 2024, the ECB announced a transition from a supply-driven to a demand-driven floor system (Banque de France, 2024). Under this new framework, similar to the model adopted by the Bank of England (Intesa Sanpaolo, 2023), the central bank maintains a reduced bond portfolio while supplying marginal reserves on demand through regular refinancing operations (Schnabel, 2024). This structure allows the central bank to respond elastically to banks' liquidity needs as the balance sheet normalisation proceeds. Consequently, the ECB can, theoretically, set the policy rate above the DFR, making holding reserves costly and ensuring a positive convenience yield (Gali, 2023). This allows the central bank to equate the marginal liquidity value of reserves with that of Treasuries, while simultaneously preserving rate stability and mitigating the volatility risks inherent in a corridor system. Importantly, this model is distinct

from the corridor system, which entails active liquidity management and presumes efficient redistribution of reserves across institutions in the presence of a structural reserve shortage (Intesa Sanpaolo, 2023)[13].

A key advantage of this approach is that it enables individual banks to hold reserve levels that align with their own risk preferences, thus providing insurance against sudden liquidity imbalances (Schnabel, 2024). On top of this, as observed in the experience with corridor systems, asset purchases under a supply-driven system tend to concentrate reserves among a small number of financial institutions, typically located in a limited set of member states (Baldo et al., 2017). By contrast, lending operations under a demand-driven system facilitates a more even distribution of liquidity across both banks and countries. This helps to mitigate potential reserve shortages that could destabilise the interbank market and generate broader financial risks. Nevertheless, the ECB does not intend to limit its liquidity provision toolbox to short-term lending instruments such as the MRO, as this approach carries certain risks. As argued by Rajan and Acharya (2022) and referenced earlier, relying solely on lending operations can reduce the pool of unencumbered assets available to banks, thereby heightening their vulnerability during periods of financial stress. To address this, the ECB plans to diversify its liquidity provision tools. In practice, this would involve complementing short-term refinancing operations with longer-term financing instruments, as well as maintaining a permanent, as well as maintaining a permanent bond portfolio, albeit in a reduced form (Schnabel, 2024).

Although Vissing-Jorgensen (2023) estimates the optimal level of excess liquidity in the euro area to be around €1.25 trillion, it is unlikely that the ECB will reduce its balance sheet to that level in the foreseeable future. As noted in the previous section, the balance sheet normalisation is expected to proceed gradually, with no indication of active QT in the euro area. Nonetheless, the ECB's shift to a demand-driven floor system creates room for a smaller balance sheet, while avoiding financial volatility.

Among the major central banks globally, the Bank of Canada stands out as the only institution to have formally declared an end to its quantitative tightening programme. In January 2025, the bank announced that it would conclude QT during the first half of the year and transition to standard balance sheet operations, including asset purchases aimed at accommodating the structural growth in currency in circulation (Bank of Canada, 2025). The Federal Reserve on the other hand has opted to decelerate the pace of QT, initially in response to uncertainties surrounding the federal debt ceiling. Notably, however, during the FOMC press conference, Chair Jerome Powell indicated that this slower pace may represent a longer-term policy shift, even after the debt ceiling was lifted (Reuters, 2025). According to Powell, a more gradual reduction allows for a smoother transition toward the eventual conclusion of QT (Reuters, 2025). Market expectations suggest that the Federal Reserve will likely cease balance sheet reduction altogether in the coming year (Reuters, 2025). By comparison, the ECB has not yet communicated a definitive timeline or endpoint for the normalisation of its balance sheet. Instead, it continues to reduce its asset holdings at a steady pace.

[13] For instance, the distribution of liquidity failed at the start of the global financial crisis. Banks hoarded reserves, which resulted in a frozen money market, which spiked interbank funding costs (Schnabel, 2024)

2.3.3. Challenges to monetary policy effectiveness

As central banks unwind their asset purchase programmes, the resulting increase in the supply of government bonds impacts more than just market liquidity. It also affects the natural rate of interest, through a "convenience yield channel". In this section, I will explain how this dynamic complicates the implementation of monetary policy, making it more difficult for the ECB to achieve its desired policy stance.

The neutral interest rate, often referred to as r-star (*r**), is a key benchmark in assessing the stance of monetary policy. Laubach and Williams (2016) defines it as the real short-term interest rate consistent with the economy operating at its full potential, once transitory shocks to aggregate supply or demand have abated. More concisely, it is the real interest rate that is neither expansionary nor contractionary (Seim, 2024). Over the past few decades, numerous studies have documented a persistent decline in r* within the euro area. For example, figure 11 displays estimates of the natural rate of interest for the euro area from Holston et al. (*HLW*, 2023), highlighting a gradual decline in the neutral rate since the 1990s, with the trend accelerating after the global financial crisis.

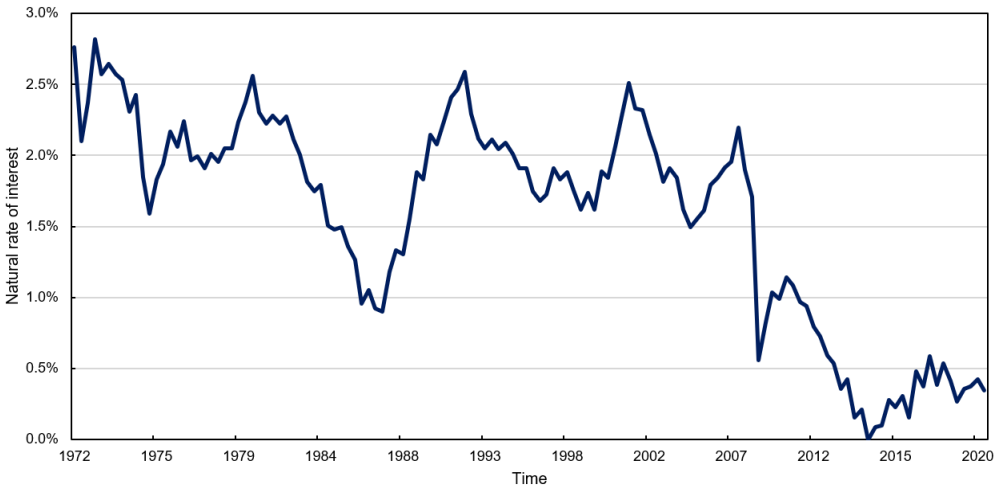

Figure 11 - Estimates of the natural rate of interest (*r**) in the euro area using the HLW (2023) model (1972 - 2020)

Source: Holston, K., Laubach, T. & Williams, J. (2023). *Measuring the Natural Rate of Interest After COVID-19*. Federal Reserve of New York.

Ferreira and Shousha (2023) attempt to explain this downward trajectory by emphasizing the role of safe asset supply. Their analysis finds that an increase in the availability of safe assets exerts upward pressure on r*, while the greater demand (see section 2.3.2) has the opposite effect, placing downward pressure on r*. The dynamic interaction between the supply and demand for safe assets is associated with what is often referred to as the convenience yield. Del Negro et al. (2019) interpret this yield as a reflection of the imbalance between global demand for safety and liquidity, and their available supply.

The convenience yield captures the premium that investors are prepared to pay for holding bonds that are both safe and liquid. Such securities help reduce information costs, due to their minimal credit risk, and lower transaction costs, due to their market depth (Vissing-Jorgensen, 2023). They provide “convenience services”, which are reflected in a higher market price, referred to as a convenience premium. As a result, investors are willing to accept a lower return on these assets in exchange for their safety and liquidity, since these characteristics are valuable for holders. Figure 12, based on Vissing-Jorgensen (2023), illustrates this mechanism. The green dot represents a German Bund, which is both liquid and safe and thus implies that it is convenient. This is reflected by its low return (y-axis). Conversely, the red dot represents a less convenient bond, marked by higher credit risk and potentially lower liquidity, which necessitates a higher yield to attract investors. Note that the vertical distance between these two dots does not represent the pure convenience yield, since it also includes a default risk premium. Isolating this component allows for the identification of the convenience yield, measured as the difference in yield between the blue and green dots.

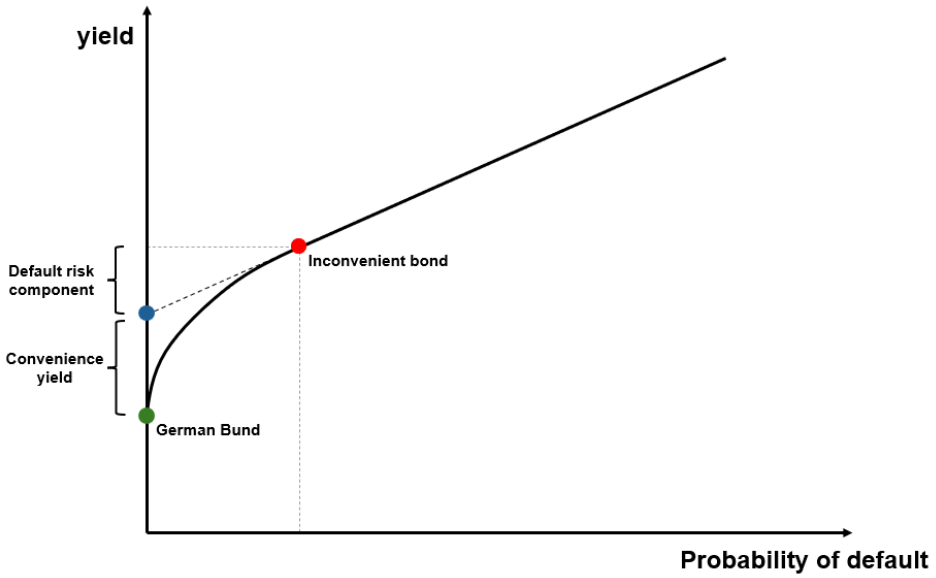

Figure 12 - Illustration of the convenience yield on German sovereign bonds

Note: For simplicity, the relationship between yield and the probability of default (ignoring convenience services) is illustrated as a straight line. In reality, however, it’s a convex curve. This means that as the probability of default increases, the default risk component of the yield rises more than proportionally. The red dot represents the most safe inconvenient bond on the market (i.e. the safest bond which has no convenience services).

Source: Vissing-Jorgensen, A. (2023). *Balance sheet policy above the effective lower bound.* European Central Bank.

Krishnamurthy and Vissing-Jorgensen (2012) find that an increase in the supply of convenient bonds reduces the convenience yield. Similarly, Jiang et al. (2022) observe the same negative relationship in the euro area. This relationship appears to hold even when the supply of safe assets increases in other euro area countries, indicating cross-border spillover effects (Arcidiacono, 2024). This means that, when more government bonds are circulating in the market, their convenience services become less scarce, reducing the valuation of these services. This dynamic can be explained through figure 12, where the curvature of the graph (left from the inconvenient bond) flattens and converges to the dotted line when safe asset supply increases.

Ferreira and Shousha (2023) emphasize the relevance of the convenience yield for the natural rate of interest. They argue that fluctuations in the convenience yield can help explain changes in r* over time. A higher convenience yield, indicating a greater premium for “convenience services” of safe and liquid assets, is associated with a lower level of r*. This relationship has important implications for balance sheet policies, as changes in the supply of safe assets can influence the convenience yield and thereby affect the equilibrium interest rate. When the ECB engages in asset purchasing programs, it absorbs government bonds from the market, reducing the supply of safe assets. This creates a positive relationship between quantitative easing and the convenience yield. Figure 13 illustrates this effect, using the asset swap spread, defined as the difference between the 10-year bund yield and the overnight index swap (OIS) rate. A more negative spread reflects a higher valuation placed by investors on the convenience services provided by safe and liquid assets. On figure 12, this corresponds to the vertical gap between the green and the blue dots. Notably, this spread declined following the introduction of PSPP in 2015 and PEPP in 2020. This trend may be interpreted as evidence of persistent demand for convenience, while the supply of these services diminished as the ECB absorbed a significant share of these assets through its purchase programmes. In 2019, however, a different development can be observed: following the temporary pause in net asset purchases under the APP, the spread began to narrow gradually. This increase likely reflects the fact that new sovereign bond issuance was no longer being absorbed by the Eurosystem, leading to an increase in the supply of convenient assets. As a result, the marginal value investors placed on these securities declined. Combining these results with that of Ferreira and Shousha (2023) reveals that quantitative easing could exert downward pressure on the neutral rate of interest.

Figure 13 - 10-year asset swap spread with German 10-year sovereign bonds (in percentage points, 2015 - 2025)

Source: (1) Refinitiv. (2025). *Euro 10 Year Overnight Index Swap (Dataset)*.
(2) Refinitiv. (2025). *Germany 10 Year Benchmark (Dataset)*.

These interactions carry crucial implications for monetary policy. Quantitative easing is intended to alleviate deflationary pressures by reducing long-term bond yields, making the spread between bond yields and the neutral rate more negative. However, as QE reduces the supply of safe assets, it raises the convenience yield, which in turn lowers the neutral rate. This (partially) neutralizes the intended stimulus of the policy. Schnabel (2025) refers to this phenomenon as the "convenience yield channel". It is akin to climbing up a hill, just as one adjusts their effort to reach the top, the summit moves farther away in the distance.

Consequently, QE may have been less effective than previously assumed. Conversely, this channel implies that quantitative tightening during periods of restrictive monetary policy presents the same challenge. When the ECB raises policy rates, it aims to increase the spread between the policy rate and the neutral rate. However, as the central bank releases (or doesn't refinance) bonds into the market during QT, the perceived value of safety and liquidity diminishes. Du et al. (2024) quantify this effect, estimating that a 10% reduction in the share of government bonds held by the central bank leads to a 10 basis points decrease in the swap spread (i.e. the convenience yield). A lower convenience yield, in turn, raises r* (Ferreira and Shousha, 2023), reducing the gap between the policy rate and the neutral rate, thereby making rate hikes less effective.

This mechanism has played out since 2022, during which the convenience yield declined significantly, as illustrated in figure 13. As the availability of safe bonds in the market increased, the marginal value of the associated convenience services diminished. It is important to note, however, that this measurable change was likely not driven solely by the balance sheet normalisation. Next to the release by the Eurosystem, it appears that it's also driven by an increase in public borrowing in nominal terms. Government consolidated gross debt in the euro area is illustrated in figure 14. Since the official start of the balance sheet normalisation in March 2022, public debt has risen by more than 10%. Consequently, the supply of government bonds available in the market has risen considerably. As a result of this, the increase in public debt would have had an impact on the convenience yield as well[14].

Nevertheless, these trends show that the euro area is transitioning from a "savings glut" towards a "bond glut", contributing to the notable decline in the convenience yield (Schnabel, 2025). However, current estimates of the natural rate of interest remain inconclusive regarding whether this decline has exerted upward pressure on r*. Different estimation methods give varying results. According to the ECB, r* estimates range from -0.5% to 0.5%, which translates to a nominal rate of 1.5% to 2.5% (ECB, 2025). These estimates are only slightly higher than those recorded before the energy crisis, although earlier estimates featured broader confidence intervals (ECB, 2025). Meanwhile, a survey of monetary analysts suggests that r* has increased but remains close to 0%, which is still below its pre-pandemic level.

[14] This represents a simplified interpretation of the convenience yield, based on the assumption that all public debt in the EU provides convenience services. In practice, however, not all sovereign bonds are safe and liquid.

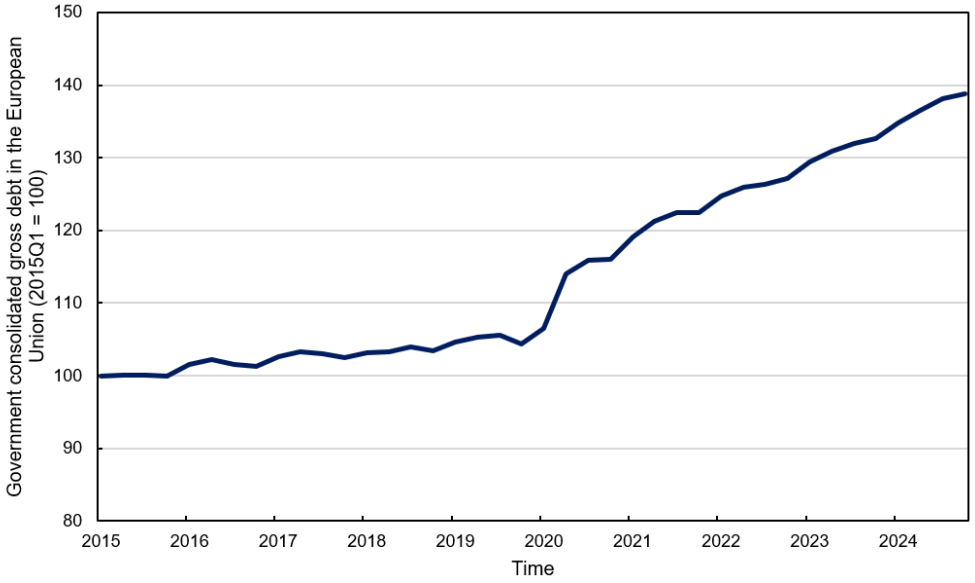

Figure 14 - Government consolidated gross debt in the European Union indexed to 2015Q1 (2015 - 2024)

Source: European Commission. (2025). *Quarterly government debt: Million euro (Dataset)*.

Interestly, in June 2024, the ECB initiated a cycle of policy rate cuts while simultaneously continuing its balance sheet normalization process. At first glance, this combination of actions might appear counterintuitive. However, when viewed from the perspective of the convenience yield channel, the strategy becomes more coherent. As quantitative tightening increases the supply of safe and liquid assets, it lowers the convenience yield. This, in turn, puts upward pressure on the natural rate of interest. As a result, the policy rates do not need to be reduced as aggressively to reach a neutral monetary stance. This is particularly beneficial as it preserves valuable policy space for responding to future crises. If the neutral rate were to rise due to an increase in bond supply, then a potential policy rate reduction would increase the spread with r* even further than was possible before, assuming that r* remains elevated. This would make it possible to react more forcefully to a potential shock.

These dynamics highlight that the convenience yield channel poses a structural challenge for monetary policy. By influencing the natural rate of interest through changes in the supply of safe assets, balance sheet policies can unintentionally offset the effectiveness of interest rate decisions. This complicates the central bank's ability to gauge the true stance of policy and affects the correct implementation of its tools. As such, the convenience yield channel adds complexity in achieving effective monetary outcomes.

2.3.4. Fragmentation risks in the euro area

A central challenge within a monetary union composed of multiple member states is the risk of asymmetric transmission of monetary policy. According to the theory of the optimal currency area (*OCA*), when member states are subject to asymmetric shocks, a uniform policy stance may prove inappropriate for some economies, as it cannot be simultaneously suited to the divergent conditions across countries. In such scenarios, monetary policy may exert excessively expansionary effects in some economies, amplifying inflationary pressures, while remaining insufficiently accommodative in other member states, thereby failing to provide sufficient stimulus. This concern is particularly noticeable in unions marked by substantial economic heterogeneity, where differences in economic structures, fiscal capacity, and monetary transmission mechanisms can further exacerbate the uneven impact of policy measures. The euro area serves as an illustration of this dynamic. Its 20 member states vary significantly in terms of fiscal capacity, financial system characteristics, and underlying macroeconomic fundamentals, leading to divergent responses to a uniform monetary policy. These disparities were already highlighted by Bayoumi and Eichengreen (1997), even prior to the public adoption of the euro.

While these divergences have long been recognized in the context of conventional monetary policy, an important concern is whether similar heterogeneity manifests under the bank's balance sheet policies. Evidence from net purchases under APP suggests that this is indeed the case. As discussed in section 2.1, Urbschat and Watzka (2020) found that the cumulative impact of APP press releases on 10-year sovereign bond yields was significantly larger for Southern European countries, namely Spain, Italy, and Portugal, compared to other member states. Drawing on this observed effectiveness, the ECB turned to balance sheet tools during the COVID-19 pandemic. At that time, sovereign bond spreads in Southern Europe widened considerably more than those in Northern countries (El Joueidi and Vincent, 2022). In response, the ECB launched PEPP, which unlike the APP, was granted the flexibility to deviate from the capital key allocation. For the first time, Greek sovereign bonds and shorter-dated assets, previously ineligible under APP, became eligible for purchase. This increased flexibility was intended to counteract financial fragmentation and enhance the uniform transmission of monetary policy across the euro area.

Similar concerns arise with the implementation of QT. As mentioned in section 2.2.1, quantitative tightening could raise the term premium by lowering demand for long-duration sovereign bonds. Akkaya et al. (2024) estimate that a €1 trillion reduction in the ECB's portfolio would increase the 10-year premium by approximately 35 basis points for Germany and France, but by 45 and 48 basis points for Spain and Italy respectively. This divergence implies that QT may unintentionally tighten monetary conditions more aggressively in Southern economies. While stronger tightening could be appropriate in cases where inflationary pressures are more persistent in these economies, this asymmetry raises broader concerns. In particular, the elevated debt levels of the mentioned economies heighten their vulnerability to rising borrowing costs. As of the fourth quarter of 2024, government debt stood at 104.3% of GDP in Spain and 136.3% in Italy (European Commission, 2025). Under such conditions, a sharp increase in long-term yields risks exacerbating debt sustainability challenges and could complicate the ECB's efforts to bring inflation back to its 2% target in an orderly manner across all euro area states.

The distribution of liquidity within the euro area amplifies these effects. Following the implementation of APP, excess liquidity became highly concentrated in a small group of countries, specifically Germany, France, the Netherlands, Finland, and Luxembourg, which all together hold an estimated 80 to 90% of the total liquidity (Baldo et al., 2017). This concentration originated from the euro crisis, where investors pursued a “flight to quality”, reallocating funds towards safer jurisdictions. As De Grauwe (2012) argues, such capital movements tend to be more pronounced within a monetary union. When concerns about a member state’s creditworthiness arise, investors can easily divest from that country’s sovereign bonds and reallocate funds across borders without facing exchange rate risk, given the shared currency. Although risk appetite recovered after the crisis, the distribution of liquidity remained uneven due to stricter post-crisis regulatory frameworks such as Basel III. As a result, core-country banks often parked excess funds in the ECB’s deposit facility rather than allocating them to riskier assets from peripheral countries (Baldo et al., 2017). Alongside this, commercial banks in the peripheral countries maintained a strong “home bias” in their sovereign bond holdings. On average, approximately 70% of euro area banks’ sovereign portfolios consist of domestic government bonds (Acharya, 2012). Ongena et al. (2019) find that this bias increased during the euro crisis, particularly in Southern countries, tying their creditworthiness to that of its domestic sovereign issuer. This interdependence between banks and their domestic government is referred to as the sovereign-bank nexus and raises systemic risks (Dunz et al., 2024). Banks depend on sovereign bonds for stable returns, while governments rely on domestic banks to hold public debt. In times of stress, declining bond prices can erode banks balance sheets, prompting government intervention through bail-outs, which in turn places pressure on public finances (ECB, 2024).

Quantitative tightening could intensify these risks. If a reduction in the ECB’s bond holdings leads to an abrupt rise in yields, especially in more vulnerable sovereigns, banks heavily exposed to domestic debt may suffer mark-to-market losses. These losses can trigger forced fire sales due to internal risk limits, which starts a negative feedback loop, deepens sovereign stress and reinforces the bank-sovereign doom-loop dynamic. The resulting interest rate volatility and widening spreads can significantly impair sovereign refinancing conditions, particularly for highly indebted member states.

On top of this, these financial stresses could also occur due to the effect on liquidity. As the ECB passively unwinds its balance sheet, overall liquidity in the euro area banking system contracts. This reduction heightens refinancing risks for national governments. This is referred to as the risk that borrowers may be unable to roll over existing debt under reasonable terms and prevailing market conditions (OCC, 2024). With the ECB withdrawing as a major purchaser of sovereign debt, governments rely on other market participants. However, unless these banks possess sufficient liquidity to absorb the additional bond supply, demand may be unable to absorb, exerting downward pressure on prices and upward pressure on yields. Consequently, the combination of heightened market volatility and reduced liquidity could significantly complicate sovereign refinancing efforts. This problem is likely to be more severe in specific countries rather than uniformly across the euro area. As previously noted, most excess liquidity is concentrated in a few countries, while Southern sovereign bonds are predominantly held by Southern banks. If the ECB allows assets to roll off its balance sheet in proportion to the capital key, banks in

peripheral member states may disproportionately shoulder the responsibility for refinancing their governments' debt. Given the relatively low concentration of liquidity (Baldo et al., 2017), this could significantly hinder their ability to absorb new issuance[15]. Cross-border lending could, in theory, weaken the imbalance by allowing liquidity-abundant banks to lend to liquidity-scarce ones in the South. However, in practice, such lending remains limited, with only cross-border lending remaining only 14% of total euro area lending (ECB, 2024). Moreover, experience from the euro crisis shows that cross-border lending tends to dry up during periods of market stress due to rising counterparty risk and distrust (Emter, 2018).

Taken all of this together, these dynamics suggest that QT could unintentionally trigger a refinancing crisis in certain euro area countries. The combination of liquidity asymmetries, concentrated sovereign exposures, and limited cross-border financial integration raises the risk of rising yields, financial fragmentation, and ultimately, instability within the monetary union. As a result of this, the process of balance sheet normalisation should be done in a flexible manner. One strategy involves directing reinvestments of maturing assets towards more vulnerable member states. This targeted reinvestment can help prevent significant increases in sovereign spreads, thereby maintaining financial stability and ensuring the uniform transmission of monetary policy across the euro area.

This need for flexibility was quickly reflected in the ECB's operational framework. Flexibility has been, as mentioned in section 2.3.1, a cornerstone of the ECB's communication strategy since the initiation of the balance sheet normalisation in 2022 (El Joueidi et al., 2022). This principle was operationalised through the reinvestment strategy of PEPP. To preserve the flexibility that PEPP offered during the pandemic, the ECB retained some latitude in reinvesting the PEPP portfolio. In the event of new fragmentation risks, reinvestments could be adjusted over time, across asset classes, and among euro area countries (El Joueidi and Vincent., 2022). This approach allowed for positive net purchases in certain countries and negative in others, while cumulative sticking to the overall reinvestment cap set by the ECB. For example, this could involve purchasing Greek sovereign bonds beyond the amount of maturing redemptions. Nonetheless, the capital key remained the benchmark for public sector purchase allocations under PEPP, albeit with increased flexibility.

The ECB exercised this flexibility on two occasions, highlighted in light blue in figure 15. The green bars represent net purchases aligned with the capital key, while the blue bars illustrate deviations from it. The first instance of flexible purchases under PEPP took place during the COVID-19 pandemic, when public sector purchases were intensified in jurisdictions most affected by pandemic-related fragmentation risks, as previously discussed in this section. The second episode occurred during the reinvestment phase in the summer of 2022, when fragmentation risks re-emerged. In June 2022, the Governing Council decided to utilise this flexibility in response to widening credit and sovereign spreads in countries such as Italy, Greece, Portugal, and Spain (ECB, 2022). For Italy and Greece for instance, sovereign spreads had doubled within a year. To maintain the efficacy of monetary policy transmission, the ECB increased

[15] In practice, the absorption of government securities mostly happened by foreign investors and households (Ferrara et al., 2024).

reinvestments in these countries' bonds (ECB, 2022). Subsequently, as fragmentation risks subsided, the need for active flexibility diminished.

Beyond addressing fragmentation, the ECB also uses its reinvestment flexibility by implementing a "double-smoothing mechanism" to ensure stable reinvestment flows. This aimed to smooth redemptions both over time and across countries, contributing to regular and balanced market presence throughout the calendar year (ECB, 2024). This smoothing mechanism wouldn't have been needed if redemptions were spread evenly over the year. However, in practice, this mechanism is important when redemptions are heavily concentrated. For example, all of Cyprus' 2023 redemptions occurred in July. Instead of reinvesting all proceeds in one month, the ECB favours spreading them throughout the year to avoid disrupting market functioning (ECB, 2024). This smoothing was not only temporal, but also geographic. Aggregate monthly redemptions were redistributed proportionally across euro area countries to have stable holdings without excessive PEPP portfolio fluctuations. The usage of this mechanism can be seen on figure 15 as well. Outside of the two episodes discussed earlier, there are deviations from the capital key, which indicates the usage of the double-smoothing mechanism.

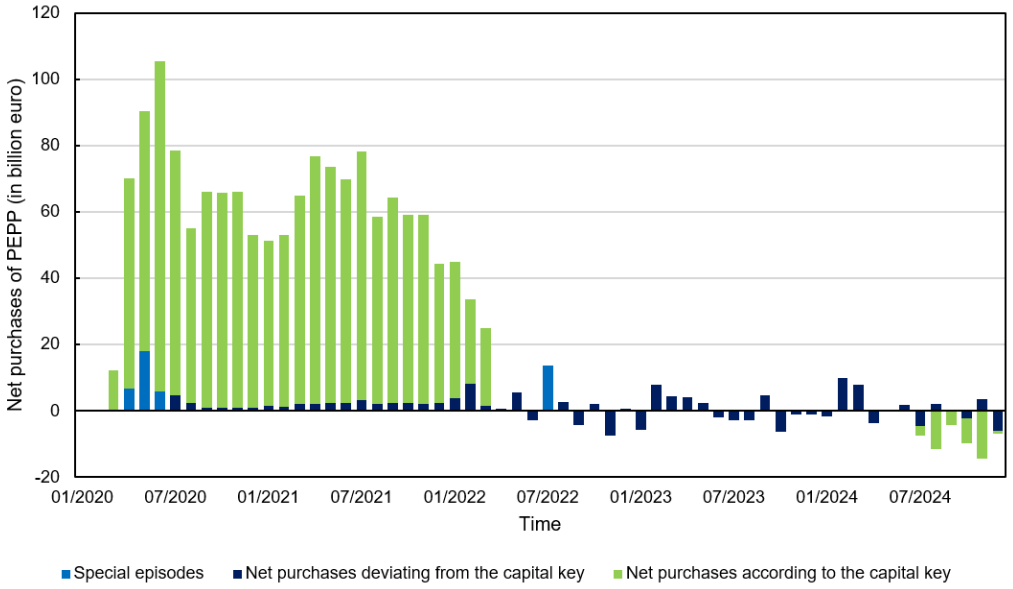

Figure 15 - Net purchases of PEPP, divided into purchases according to the capital key and deviating from the capital key (2020 - 2024, in billion euro)

Note: The special episodes refer to two instances in which the ECB applied flexibility in its asset purchases or reinvestments, temporarily deviating from the capital key. The first occurred at the onset of the pandemic, when the ECB directed purchases toward economies more severely impacted by the crisis. The second took place in 2022, when reinvestments were tilted toward member states experiencing widening sovereign bond spreads.

Source: Rahmouni-Rousseau, I. & Schnabel, I. (2025, April 29). *Looking back at PEPP implementation since the end of reinvestments*. The ECB blog.

In light of the increased attention towards fragmentation risks under the balance sheet normalisation, ECB President Christine Lagarde emphasized the central bank's readiness to safeguard monetary policy transmission during the policy normalisation phase. In her March 2022 speech, she declared: "*If necessary, we can design and deploy new instruments to secure*

monetary policy transmission as we move along the path of policy normalisation" (Lagarde, 2022). Following this, during the ad-hoc meeting of the Governing Council in June 2022, the ECB confirmed the creation of a new anti-fragmentation instrument, which would later become the Transmission Protection Instrument (*TPI*) (ECB, 2022).

TPI would become an addition to the bank's toolkit, which will be activated *"to counter unwarranted, disorderly market dynamics that pose a serious threat to the transmission of monetary policy across the euro area."* (ECB, 2022). It's designed to operate through secondary market purchases of securities issued in jurisdictions facing a deterioration in financing conditions that isn't warranted by country-specific fundamentals (Bernoth et al., 2022). The TPI is not aimed at changing the policy stance itself. Conventional rates remain the main instrument to achieve this.

Eligibility for TPI activation is subject to the fulfilment of four cumulative conditions (ECB, 2022). First, a country must comply with the European Union's fiscal framework, meaning it must not be subject to an excessive deficit procedure nor be found to have disregarded recommendations issued by the European Council. Second, the country must exhibit no severe macroeconomic imbalances, which would otherwise result in an excessive imbalance procedure. Third, the trajectory of public debt must be assessed as fiscally sustainable, ensuring that long-term debt obligations remain manageable. Finally, the country must demonstrate a commitment to sound macroeconomic policies, particularly through adherence to its national recovery and resilience plans, which were designed to support post-pandemic economic recovery. These criteria aim to address concerns about fiscal dominance and avoid violations of the monetary financing prohibition under Article 123 of TFEU. Nevertheless, legal concerns persist. To justify using the TPI, the ECB must demonstrate that spread widening stems from market failures rather than justified risk premia. Otherwise, the central bank risks supporting sovereign debt inappropriately.

A central challenge lies in defining what qualifies as "unwarranted market dynamics". Theoretically, this question could be answered by assessing whether yield spreads can be explained by macroeconomic fundamentals, such as debt-to-GDP ratios, fiscal deficits, or global risk aversion (Bernoth et al., 2022). During the euro area crisis, econometric models showed that some spreads deviated from what fundamentals would predict, indicating "unwarranted" behaviour (Bernoth et al., 2022). However, during the 2022 episode, prior to the implementation of the TPI, comparable models detected no significant deviations from fundamentals (Bernoth et al., 2022). This implies that, had the ECB activated the TPI at that time, it might have encountered challenges in demonstrating that market conditions met the required threshold of dysfunction. To address the fragmentation risk during that period, the ECB opted instead to use its flexibility in reinvestment under PEPP. In the official announcement of the TPI, the ECB emphasized its preference to rely on its "flexibility tool" before resorting to the anti-fragmentation instrument, reserving the latter for exceptional circumstances.

Nevertheless, characterizing market dynamics as "unwarranted" assumes that the ECB possesses superior foresight into future market developments (Arnold, 2023). Bond markets are inherently forward-looking, and any assertion by the ECB regarding unjustified spreads implicitly challenges the efficient market hypothesis (*EMH*). Central to this discussion is the issue of debt sustainability, which remains highly uncertain due to the inherent difficulty of forecasting long-term

fiscal and macroeconomic trends (Arnold, 2023). In this context, the usage of the TPI could diminish the informational value of bond prices by distorting the market's ability to signal risks.

Moreover, the ambiguity surrounding the specific criteria for TPI activation creates room for political lobbying and unwarranted influence. Without clearly defined thresholds, member states experiencing market pressure may attempt to persuade the ECB to intervene by arguing that their circumstances qualify as “unwarranted”, even when their yield spreads reflect deteriorating fundamentals. This poses a threat to the ECB’s institutional independence and raises concerns about moral hazard. The absence of market discipline, enabled by vague activation conditions, could incentivize governments to pursue unsustainable fiscal policies.

Until the point of writing, the anti-fragmentation tool has not been activated yet. However, two significant episodes in the last few years sparked the debate regarding the implementation of the instrument. The first took place in the second half of 2022, when Italian Prime Minister Mario Draghi resigned after losing support from his coalition partners (Politico, 2022). This political instability, accompanied by early elections and uncertainty over fiscal sustainability, led to a sharp rise in Italian bond spreads. The second episode involved French sovereign bond spreads reaching a twelve-year high at the end of 2022, following the threat of a no-confidence vote over the 2025 budget (Reuters, 2024). Despite the significant reaction of markets to these events, neither triggered the activation of the TPI. A plausible explanation for this restraint is that these developments, while they were destabilizing, were caused by domestic political turmoil and fiscal uncertainty, factors that are inherently linked to macroeconomic fundamentals. Consequently, it would be challenging for the ECB to justify categorizing the market reactions as “unwarranted”. Furthermore, while the general escape clause under the excessive deficit procedure was used during the COVID-19 pandemic, the European Council formally recognized excessive deficits in France and Italy in 2024 (European Council, 2025). Based on the eligibility criteria outlined by the ECB, this would disqualify these countries from TPI support.

Nevertheless, the ECB stated that these eligibility criteria serve as “an input into its broader decision-making” and may be dynamically adjusted in response to unfolding risks and conditions (ECB, 2022). Given the important economic weight of France and Italy in the euro area, financial fragmentation in these countries could have systemic implications, potentially triggering contagion across other member states through rising sovereign spreads. This situation highlights the earlier concerns regarding moral hazard, monetary financing, and the credibility of the ECB. If the rules for activation remain flexible and subject to reinterpretation, large member states might be incentivized to adopt permissive fiscal stances under the assumption that the ECB will intervene to prevent a collapse. Ultimately, this raises critical questions about the balance between safeguarding financial stability and maintaining market discipline within the euro area.

In this context, it becomes clear that safeguarding the cohesion of the monetary union cannot rest on monetary policy alone. Member states have the responsibility to follow the fiscal rules under the Stability and Growth Pact (*SGP*). Having a sustainable fiscal path is essential to prevent central bank intervention in the first place. Without fiscal discipline, the risk of fiscal dominance increases, threatening the ECB’s independence. Ultimately, the long-term stability and effectiveness of the euro project is dependent on the adherence to the fiscal rules.

3. Methodology

This section outlines the econometric framework and data employed to examine the effects of quantitative tightening policy announcements by the ECB on a range of financial variables. The methodology largely follows established approaches in the literature, including those of Du et al. (2024), Gagnon et al. (2011), Krishnamurthy and Vissing-Jorgensen (2011), Smith and Valcarcel (2023), and Altavilla et al. (2019).

To assess the impact of QT announcements, the analysis covers a broad set of financial variables. Table 1 details all variables included in the regression specified in equation (1). These variables are categorized into fixed-income instruments (sovereign yields, spreads, and corporate bonds), equity (broad Euro area stock indices), and foreign exchange rates. For sovereign yields, data for varying maturities across eight countries (Belgium, France, Germany, Italy, Greece, the Netherlands, Portugal and Spain) are incorporated. The dataset, sourced from the Refinitiv Datastream (LSEG) database, spans the period from January 2021 through May 2025.

The baseline specification for the event study is given by equation (1) and (2):

$$\Delta y_t = \alpha + \beta QT_t + \gamma CMPSurprise_t + \delta CESI_t + \varepsilon_t \quad (1)$$

$$\Delta y_{i,t} = \alpha_i + \beta QT_t + \gamma CMPSurprise_t + \delta CESI_t + \varepsilon_{i,t} \quad (2)$$

where

$$\Delta y_{(i),t} = y_{(i),t+1} - y_{(i),t-1} \quad (3)$$

represents the two-day change in the relevant financial variable, measured from the closing price one day prior to the QT event (*t*-1) through to the closing price the day after the event (*t*+1). This window is chosen to balance the need to reflect the announcement's impact while also allowing minor delays in market pricing for information processing. The distinction between specifications (1) and (2) lies in the structure of the data and the corresponding inclusion of fixed effects. Specification (1) is used for financial variables that do not vary across countries, such as stock indices or exchange rates at the euro area level. For these variables, there is no cross-country variation. In contrast, Specification (2) is applied to sovereign yield data, which vary both across countries and over time. As such, the model includes a country subscript *i* and incorporates country fixed effects, denoted by α_i . These control for time-invariant characteristics of euro area member states, such as market liquidity, that may influence changes in bond yields. The inclusion of these fixed effects removes between-country variation, thereby isolating within-country variation essential for identifying the effect of QT announcements on financial markets.

The variable QT_t is a binary indicator equal to one on dates of QT announcements and zero otherwise. The coefficient β, associated with QT_t , is the primary parameter of interest in this analysis. It captures the average change in the financial variable attributable to a QT announcement, after controlling for other macroeconomic news that might influence the dependent variable. A comprehensive list of the nine QT events is included in appendix table A1.

Variable	Indicator	Category	Description
30-year sovereign bond yield	*Sovereign30Y*	Fixed-income	Sovereign 30-year bond yield of eight euro area economies: Belgium (*BE*), France (*FR*), Germany (*DE*), Greece (*GK*), Italy (*IT*), Netherlands (*NL*), Portugal (*PT*) and Spain (*ES*)
10-year sovereign bond yield	*Sovereign10Y*	Fixed-income	Sovereign 10-year bond yield of eight euro area economies (BE, FR, DE, GK, IT, NL, PT, and ES)
5-year sovereign bond yield	*Sovereign5Y*	Fixed-income	Sovereign 5-year bond yield of eight euro area economies (BE, FR, DE, GK, IT, NL, PT, and ES)
2-year sovereign bond yield	*Sovereign2Y*	Fixed-income	Sovereign 2-year bond yield of eight euro area economies (BE, FR, DE, GK, IT, NL, PT, and ES)
12-month sovereign bond yield	*Sovereign1Y*	Fixed-income	Sovereign 12-month bond yield of eight euro area economies (BE, FR, DE, GK, IT, NL, PT, and ES)
Sovereign spread	*SovereignSpread*	Fixed-income	Sovereign spread of country 10-year bond yield with German 10-year yield (BE, FR, GK, IT, NL, PT, and ES)
iBoxx EUR Corporates Index	*iBoxxcorp*	Fixed-income	Index that tracks the performance of euro-denominated investment-grade corporate bonds issued by euro area corporations.
Bund-OIS spread	*BundOISspread*	Fixed-income	The difference between the German sovereign 10-year spread and the 10-year overnight index swap. This is a measurement of the convenience yield (see section 2.3.3).
Overnight index swap	*OIS*	Fixed-income	The OIS reflects the market expectations of short-term interest rates over the maturity (3 month, 6 month and 1 year), with minimal credit risk.
Euro Stoxx 50 price index	*STOXX50price*	Equity	Stock market index that tracks the performance of 50 of the largest corporations in the euro area.
Euro Stoxx 50 gross return index	*STOXX50return*	Equity	Stock market index that tracks the performance of 50 of the largest corporations in the euro area, but where dividends are reinvested.
STOXX Europe 600 price index	*STOXX600price*	Equity	Stock market index that tracks the performance of 600 of large, mid-, and small-cap European companies.
STOXX Europe 600 gross return index	*STOXX600return*	Equity	Stock market index that tracks the performance of 600 of large, mid-, and small-cap European companies, but where dividends are reinvested.

Table 1 - Description of the dependent variables used in the event study (*continued on next page*)
Source: Refinitiv Datastream

Variable	Indicator	Category	Description
STOXX Europe 600 Banks Index EUR	*STOXXbanks*	Equity	Stock market index that tracks the corporations classified within the banking sector of the STOXX Europe 600 index
USD/EUR	*USDEUR*	Foreign exchange	Exchange rate of the U.S. dollar (*USD*), expressed as the amount of euros needed to buy one dollar. An increase means a depreciation of the euro.
GBP/EUR	*GBPEUR*	Foreign exchange	Exchange rate of the pound sterling (*GBP*), expressed as the amount of euros needed to buy one dollar. An increase means a depreciation of the euro.
CHF/EUR	*CHFEUR*	Foreign exchange	Exchange rate of the Swiss franc (*CHF*), expressed as the amount of euros needed to buy one dollar. An increase means a depreciation of the euro.
5-year inflation-linked swap	*ILS 5Y*	Inflation expectations	Proxy for inflation expectations over a five year period.

Table 1 - Description of the dependent variables used in the event study (*continued*)
Source: Refinitiv Datastream

To obtain an unbiased estimate of the effect of QT announcements, several assumptions must hold (Bauer and Swanson, 2023). The first and most fundamental assumption for this analysis is the efficient market hypothesis (Frömmel, 2016). According to Fama (1991), this hypothesis holds that security prices fully reflect all available information. In the context of this event study, this implies that the impact of QT announcements on financial variables will be entirely and immediately priced in by market participants upon the release of the announcement. This assumption is crucial for the implementation of an event study, since it ensures that any observed changes in asset prices within the defined event window can be causally attributed to the QT announcement.

The second assumption is the absence of reverse causality, meaning that the two-day change in the financial variable (Δy_t) does not affect the occurrence or timing of the QT announcement. In other words, the QT announcement must be exogenous with respect to financial market price movements. Otherwise, endogeneity could lead to biased estimates. This assumption is generally reasonable, as decisions by the Governing Council regarding QT are typically planned well in advance and communicated according to a predetermined strategy (Du et al., 2024). However, it is important to acknowledge that the exogeneity assumption could be violated if short-term financial market developments influence either the timing or the content of QT announcements. For instance, as discussed in section 2.3.1, the Bank of England suspended its plans to sell long-term government bonds following a sharp selloff in global bond markets. As this did not really affect the QT announcement, it demonstrates how central banks could halt some of its plans as a result of short run financial market dynamics (and thus $\varepsilon_{i,t}$). Such behavior would

violate the strict exogeneity condition, where past or current financial shocks (e.g. $\varepsilon_{i,s}$) are correlated with the policy decision at time *t*. Formally expressed:

$$E[\varepsilon_{i,s} \mid QT_t] = 0 \qquad \text{(strict exogeneity assumption)}$$

However, in the context of fixed effects estimation, this assumption can be somewhat relaxed. For consistent estimation as $T \to \infty$ (here $T = 1122$), it is sufficient that the regressor is weakly exogenous, i.e.

$$E[\varepsilon_{i,t} \mid QT_t] = 0 \qquad \text{(weak exogeneity assumption)}$$

which allows for some impact from past shocks as long as current shocks are uncorrelated with the independent variable. Although there is limited evidence of reverse causality in the euro area as of now, one possible concern is the activation of the anti-fragmentation instrument TPI in response to widening sovereign spread. If financial market stress influences QT-related decisions through this channel, the exogeneity assumption may be compromised.

A third assumption is that QT announcements do not contain "information effects". Information effects arise when central bank announcements convey signals not only about the policy action itself but also about the central bank's private assessment of the economic outlook (Romer and Romer, 2000). In this context, a QT announcement could be interpreted by market participants as indicative of a more hawkish stance, such as a reassessment of inflation risks being higher than previously anticipated, thereby triggering a stronger financial market response than the announcement alone would imply. Such effects would confound the interpretation of the estimated QT coefficient, as it would reflect both the policy impact and the market's reaction to the newly revealed macroeconomic information. While Bauer and Swanson (2023) find that information effects are relatively minor in the context of U.S. monetary policy announcements, Kerssenfischer (2019) documents more pronounced effects for the euro area. However, it is unknown whether the information effects would exist for quantitative tightening announcements.

A fourth assumption is that QT announcements constitute a surprise to financial markets. If market participants fully anticipate the announcement, its impact will already be incorporated into asset prices, leading to an underestimation of the QT policy effect in the specification. Ideally to get the full effects of QT, the policy announcements should be completely unanticipated. This assumption is particularly relevant in the context of the ECB, which emphasizes predictability in its communication strategy to minimize market volatility (as discussed in section 2.3.1). Consequently, any forward guidance regarding the balance sheet normalisation leads to adjustments in asset prices, which would weaken the estimated effect of the QT dummy variable, creating a bias in the coefficient. One approach to address this issue is to expand the event window to capture the earliest moment when QT-related expectations begin to influence market pricing. However, this introduces the risk of being impacted from other contemporaneous events. Du et al. (2024) address this concern by identifying which QT announcements in their (global)

sample were unanticipated ex ante[16]. Out of 39 events, they classified 12 as surprises and found that the impact on financial markets, particularly bond yields, was generally larger, albeit more variable and often statistically insignificant. Effects on other financial variables were found to be minimal.

A fifth and final assumption is that all relevant confounding factors that are correlated with QT announcements and influence asset prices are appropriately controlled for. As noted by Greenlaw et al. (2018), standard event study methodologies are affected by omitted variable bias if contemporaneous macroeconomic developments are not accounted for. This is particularly pertinent here, as all QT announcements in the sample coincide with scheduled monetary policy decision meetings, during which conventional interest rate decisions are also announced, especially during the post-2022 tightening cycle. Failing to control for such policy surprises may result in attributing conventional monetary policy effects to the QT dummy, thus biasing the coefficient. To account for this, the baseline regressions (1) and (2) include a control variable, $CMPSurprise_t$, which captures the monetary policy rate surprise. A crucial identifying condition is that markets incorporate expected policy rate changes prior to the meeting. Only unanticipated changes should affect asset prices on the event day. The conventional monetary policy surprise variable is measured as the change in the 1-month overnight index swap (*OIS*) rate between the day before and the day of the policy announcement. A positive value of this variable implies that the actual policy stance was more contractionary than markets had priced in. The appendix additionally assesses the robustness of the results for sovereign bond yields by incorporating an alternative control variable that accounts for expectations surrounding monetary policy decisions. Specifically, I include a measure $POLSURPRISE_t$ that captures the difference between the actual policy rate change and the policy rate change anticipated by market participants, as reported by Bloomberg (Bloomberg, n.d.). This variable serves to isolate the unexpected component of conventional monetary policy announcements. The objective is to evaluate whether controlling for this alternative measure of policy rate expectations has a significant impact on the estimated effects of QT announcements.

In addition, to control for the influence of macroeconomic data surprises, the specification includes the Citigroup Economic Surprise Index for Europe ($CESI_t$), which captures the extent to which recent economic releases deviate from market expectations. A positive value reflects stronger-than-expected economic data (e.g. for inflation, GDP, or labor market indicators), while a negative value indicates weaker performance relative to forecasts. Importantly, CESI does not measure actual economic conditions, but rather deviations from expectations. As with the dependent variables, the two-day change in CESI is used in the regression to maintain consistency in the event window.

[16] One could interpret this surprise in a broad way, like surprise in magnitude, start date, type of securities, etc. For the euro area, the researchers classify the QT announcements of 15/12/2022 and 04/05/2023 as the surprise events (Du et al., 2024).

To identify transmission mechanisms through which QT affects financial markets, this study identifies the effect of QT announcements on four primary transmission channels, discussed in section 2. These channels are: (i) the signaling channel, (ii) portfolio rebalancing channel, (iii) duration risk channel and (iv) the inflation channel. The first one, also referred to as forward guidance, captures the extent to which QT announcements convey information about the expected future path of policy rates, thereby influencing short- to medium-term interest rate expectations. In the analysis, this will be tested by examining the changes in the OIS rates with maturities up to one year around QT events. If the QT event variable has a positive sign, then the balance sheet normalisation could be seen as strengthening the central bank's commitment to bring down inflation, and therefore increases bond yields. On the other hand, as discussed in section 2.1, QT could also reduce expectations for increases in the policy rate if QT is seen as a substitute for raising the policy rate. The portfolio rebalancing channel reflects the idea that reductions in asset holdings alter the relative supply of securities, prompting investors to shift their portfolios, which should negatively affect equities and corporate bonds. To assess this channel, the empirical analysis includes responses in broad equity and corporate bond indices (Du et al., 2024). Thirdly, the duration channel considers how QT affects term premia or the slope of the yield curve, as discussed in section 2.2.1. This will be captured using the spread between long- and short-term government bond yields. Specifically, the difference between 10-year and 2-year sovereign yield (Du et al., 2024). Finally, the inflation channel will be proxied by the 5-year inflation-linked swaps (Du et al., 2024). Similar to the preceding analysis, this analysis uses an event study methodology using a two-day window, ranging from the closing price of the variable the day prior to the QT announcement to the closing price on the day after the event. The regression analysis applies specifications (1) and (2), incorporating the same set of control variables as previously described.

To have more grip over specific events, I extend the analysis by estimating the individual effects of each QT event. This is captured by equation (4), where the variables of interest are denoted by $QT_{n,t}$. Each $QT_{n,t}$ is a dummy variable that takes the value of one if QT event *n* occurs on date *t*. All *n* events are listed in table A1 of the appendix.

Furthermore, building on specification (4), I examine the heterogeneous effects of different types of QT announcements. These events are categorized into four distinct types: (i) quantitative easing tapering ($TAPER_t$), (ii) full reinvestment (FR_t), (iii) partial reinvestment (PR_t) and (iv) the cessation of full reinvestment ($RUNOFF_t$).). The classification of each event is shown in the second row of Table A1 in the appendix. These event types are incorporated as dummy variables in equation (5), where $QT_{C,t}$ denotes the vector containing each of the four categories. It should be noted, however, that the limited number of events poses a constraint on the analysis, as only nine observations are available. Consequently, the results should be interpreted with caution due to the small sample size. The objective of this specification is to assess whether different forms of QT announcements elicit differing reactions in financial markets.

$$\Delta y_{i,t} = \alpha_i + \sum_N \beta_n QT_{n,t} + \gamma CMPSurprise_t + \delta CESI_t + \varepsilon_{i,t} \qquad n = 1, \ldots, N \tag{4}$$

$$\Delta y_{i,t} = \alpha_i + \sum_C \beta_C QT_{C,t} + \gamma CMPSurprise_t + \delta CESI_t + \varepsilon_{i,t} \tag{5}$$

with $C = \{ TAPER_t, FR_t, PR_t, RUNOFF_t \}$

In line with the discussion in section 2.3.4, I also explore whether QT announcements influence fragmentation risks in the euro area, with particular attention to their effect on sovereign spreads relative to Germany. To investigate this, I first test whether QT announcements are associated with a widening of sovereign spreads. In a second step, I construct two subsamples based on countries' fiscal strength. Specifically, countries are classified using Standard & Poor's credit ratings as of 31 January 2025 (S&P Global, 2025). Table A2 in the appendix reports the sovereign credit ratings for each country in the sample. Countries rated A+ or below, i.e. not classified as "high grade", are grouped into a "lower-rated" subsample, while all others are assigned to the "higher-rated" group. This stratification allows for an analysis of whether less creditworthy countries are more susceptible to fragmentation risks following QT announcements.

As mentioned earlier, the baseline estimations in this research relies on a two-day change in the dependent variables to capture the immediate market response to QT announcements. To assess the robustness of the results to the choice of the event window, I include additional tests using alternative windows. These will be incorporated within the appendix. First, I will test whether the effects on bond yields are affected by a smaller window size, specifically a one-day change, i.e. the difference between the closing price on the event day and the day before the event day. The advantage of a smaller window is that it minimises the likelihood of capturing other macroeconomic effects that may impact yields, while making the trade-off with the possibility of not incorporating the total price change. Conversely, I will also test the effect on a three-day window, i.e. the difference between the closing price two trading days after the event and the closing price the day before the event. Since all the mentioned announcements are done on Thursdays, market participants will get the weekend to further price the QT announcement on yields. The trade-off here is that other events that happened over the weekend could be incorporated in the price, which biases the results.

To ensure reliable inference, all regressions are estimated using Newey-West heteroskedasticity- and autocorrelation-consistent standard errors with 10 lags. The lag length is chosen based on the rule of thumb $L = T^{1/3}$ rule of thumb, with approximately 1100 observations. This approach ensures that the standard errors are robust to autocorrelation and heteroskedasticity, thereby enhancing the reliability of the hypothesis testing and improving the robustness of the estimated effects of QT announcements.

4. Results

I begin by examining the overall pooled impact of QT announcements on sovereign bond yields across different maturities, using a two-day event window around each announcement. The results of regression (2) for sovereign yields can be found in table 2. This table shows that QT announcements are associated with statistically significant increases in sovereign yields across all maturities. The effects are most pronounced at the two-year, five-year, and ten-year maturities, with an average impact of 6.6, 7 and 4.8 respectively. These coefficients can be interpreted as an average increase of two-year bond yields by 6.6 basis points as a result of the QT event. The results suggest that the effects of QT announcements are the strongest for the median and longer-term maturities, in line with the results of Du et al. (2024). However, the impact on 30-year bond yields appears most muted. While it is still statistically significant at the 5% level, the effect is only about half of the size of that observed for two- and five-year maturities. A possible explanation is that 30-year bond yields are less affected by QT because the ECB has not announced active bond sales, and these long-term securities mature very slowly. As a result, the pace at which they roll off the central bank's balance sheet is limited, reducing the immediate impact on their supply. This dampens the portfolio rebalancing effect and, consequently, the upward pressure on the very long term yields. Backing this point, Du et al. (2024) finds that active QT announcements in other economies are associated with a steepening of the yield curve, i.e. a more pronounced effect on the long end of the curve.

The consequence is thus that the yield curve does not steepen as might be expected via the increase in the term premium. Table 2 rather reveals a reverse-U relationship, with the smallest impact of a QT announcement on the shortest and longest end of the curve. Nonetheless, caution is warranted when interpreting the short-end results, as the 1-year and 2-year yields may reflect confounding macroeconomic developments during the event window, which can't be easily controlled for. Nevertheless, these findings indicate that QT tightens financial conditions, either by signaling a more restrictive future policy stance or by requiring the private sector to absorb more duration risk (portfolio rebalance channel). The control variables have the anticipated effects. An unanticipated higher policy rate (*CMPSurprise*) significantly affects short-term yields, particularly at the one- and two-year horizon, with its impact diminishing with maturity. Likewise, positive macroeconomic surprises (*CESI*) are associated with increases in yields across the curve.

In general, these announcement effects of QT are smaller than those reported under QE (see section 2.1). This indicates that the symmetry hypothesis of balance sheet policies does not hold in reality. However, as discussed in section 2.2.1, this can be attributed to five factors, which is written extensively in that section. These are: (i) the presence of non-QT related events, (ii) communication in advance, (iii) different market conditions, (iv) a weaker signaling channel and (v) the gradual approach.

To check whether these results are robust, I perform several sensitivity analyses. For instance, using a narrower one-day event window, as shown in table A3 in the appendix, results in smaller and mostly insignificant coefficients, possibly indicating that markets take time to incorporate QT news. In contrast, a broader three-day window (table A4) yields larger effects, especially at shorter maturities, though these may be confounded by non-QT events over the weekend.

Changing the measure of monetary policy surprises (table A9) or omitting control variables altogether (table A12) does not alter the estimated QT effects notably, although statistical significance at longer maturities weakens slightly. Finally, estimates using random effects instead of the fixed effects estimator (table A13) confirm the robustness of the results, reinforcing the interpretation that QT announcements consistently tighten financial conditions.

	Sovereign yield				
	1 year (1)	2 year (2)	5 year (3)	10 year (4)	30 year (5)
QT event	0.034*** (0.012)	0.066*** (0.020)	0.070*** (0.021)	0.048*** (0.018)	0.033** (0.014)
CMPSurprise	0.405*** (0.062)	0.394*** (0.091)	0.154 (0.114)	0.111 (0.130)	0.092 (0.123)
CESI	0.001*** (0.0001)	0.001*** (0.0001)	0.001*** (0.0002)	0.001*** (0.0003)	0.001*** (0.0003)
Number of observations	8976	8976	8976	8976	8976
R-squared	0.007	0.01	0.007	0.003	0.001
Adjusted R-squared	0.006	0.009	0.006	0.002	0

Table 2 - Announcement effects of QT on sovereign yields (in percentage points)
Note: The p-values are denoted as follows: $p < 0.10$ (*); $p < 0.05$ (**); $p < 0.01$ (***).
Source: Refinitiv Datastream

Next, I examine the effects of individual QT announcements on sovereign yields, as detailed in specification (4). Table 3 and figure 16 present these results, which analyze each of the nine QT events separately to assess the fixed-income market's reaction to each. Overall, the majority of events exhibit yield movements in a consistent direction across all maturities, with exceptions noted for events 1, 6, and 7. Notably, events 5 and 8 produce counterintuitive outcomes, showing a downward impact of the QT announcement on yields across the maturity spectrum. This pattern may indicate that markets had already anticipated portions of these QT announcements, and when the actual announcements proved less severe than expected, yields adjusted downward accordingly. Event 6 shows mixed directional effects across maturities. Among these, the significant yield changes occur at the longer maturities (10- and 30-year), which move upward, while the negative one- and two-year maturities are not significant at the 5% level. The early QT events, particularly events 2 through 4, generated the strongest yield responses across all maturities, likely reflecting the newness of QT at that time and the market's limited ability to price it in advance. Conversely, subsequent events displayed markedly smaller impacts, with some, such as events 5 and 8, even resulting in negative yield changes.

Aggregating the cumulative effect across all nine events reveals that QT announcements collectively raised two- and five-year yields by approximately 60 basis points, while the 10-year yields increased by about 43 basis points. The effects on 1-year and 30-year maturities were more modest, with cumulative increases near 30 basis points. However it is important to note that this cumulative change should be interpreted with caution, as it sums up coefficients that aren't

always significant. Nevertheless, these findings demonstrate that QT announcements have a significant impact on sovereign bond yields across maturities.

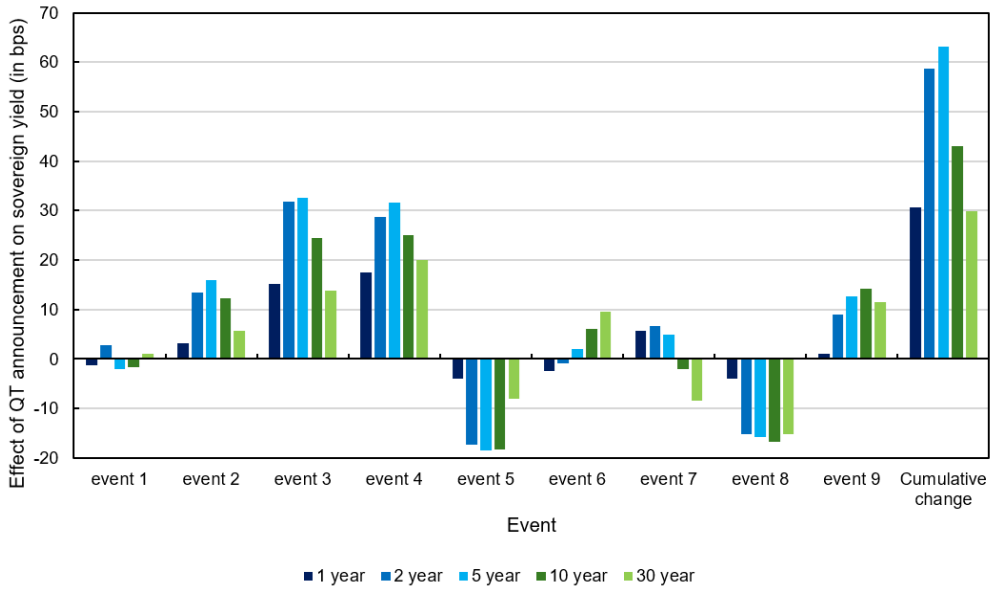

Figure 16 - Announcement effects of QT on sovereign yields: by event and cumulative change (in bps)

Note: This graphic illustrates the findings reported in table 3. For information about each event, see table A1 in the appendix.

To further explore the effects of QT announcements, I categorised events into four distinct groups. As mentioned in section 3, these are QE tapering, full reinvestment, partial reinvestment, and the end of reinvestment. Using the regression specification (5), the results presented in table 4 and figure 17 reveal that, with the exception of partial reinvestment, all categories exhibit positive and statistically significant coefficients at the 1% level. Notably, announcements related to QE tapering and the start of full reinvestment (i.e. the end of net purchases) exert the largest impact on sovereign yields. This may reflect, as mentioned earlier, that market participants had limited prior knowledge about the specific details of the balance sheet normalization process, which led to a stronger upward reaction when the announcement was made. Specifically, many analysts expected that the post-pandemic normalization by central banks would be a slow process, with no balance sheet reductions for several years, similar to the Federal Reserve's approach to quantitative tightening before the pandemic. In that previous cycle, the Fed waited three years after ending its quantitative easing program before starting to reduce its balance sheet (Du et al., 2024). However, in the current cycle, the Federal Reserve and other central banks shortened this period to just three months. The European Central Bank's process was somewhat slower but still took less than a year. Markets may have anticipated a longer delay for the Eurosystem's normalization as well, which could explain why the initial reaction was stronger when the process began, but responses were more subdued once it was underway.

The partial reinvestment events show a small negative coefficient. However these are not significant, suggesting negligible influence on bond yields. The announcement effects of sovereign yields to the decision to end reinvestments are smaller than the other announcements, maybe revealing that this might have been partially priced in. Overall, these findings show that

the earlier announcements have the largest effects on sovereign yields across different maturities.

	Sovereign yield				
	1 year (1)	2 year (2)	5 year (3)	10 year (4)	30 year (5)
QT event 1	-0.014*** (0.005)	0.027 (0.043)	-0.020*** (0.005)	-0.017*** (0.003)	0.010** (0.004)
QT event 2	0.031*** (0.008)	0.134*** (0.008)	0.159*** (0.009)	0.123*** (0.017)	0.057*** (0.020)
QT event 3	0.152*** (0.048)	0.318*** (0.024)	0.326*** (0.027)	0.244*** (0.024)	0.138*** (0.033)
QT event 4	0.175*** (0.049)	0.287*** (0.015)	0.316*** (0.020)	0.250*** (0.023)	0.199*** (0.017)
QT event 5	-0.040*** (0.012)	-0.173*** (0.021)	-0.185*** (0.018)	-0.183*** (0.026)	-0.080*** (0.020)
QT event 6	-0.024* (0.013)	-0.009 (0.008)	0.020 (0.012)	0.061*** (0.013)	0.096*** (0.016)
QT event 7	0.057*** (0.015)	0.066*** (0.023)	0.048*** (0.007)	-0.020** (0.009)	-0.084*** (0.013)
QT event 8	-0.041** (0.018)	-0.152*** (0.023)	-0.159*** (0.008)	-0.168** (0.010)	-0.152*** (0.009)
QT event 9	0.010 (0.016)	0.089*** (0.014)	0.126*** (0.007)	0.141*** (0.008)	0.114*** (0.009)
CMPSurprise	0.411*** (0.016)	0.422*** (0.092)	0.187 (0.115)	0.145 (0.132)	0.117 (0.125)
CESI	0.001*** (0.0001)	0.001*** (0.0002)	0.001*** (0.0002)	0.001*** (0.0003)	0.0005* (0.0003)
Number of observations	8976	8976	8976	8976	8976
R-squared	0.01	0.019	0.016	0.007	0.003
Adjusted R-squared	0.008	0.017	0.014	0.005	0.001

Table 3 - Announcement effects of QT on sovereign yields: event-by-event analysis (in percentage points)

Note: For information about each event, see table A1 in the appendix. The p-values are denoted as follows: $p < 0.10$ (*); $p < 0.05$ (**); $p < 0.01$ (***).

Source: Refinitiv Datastream

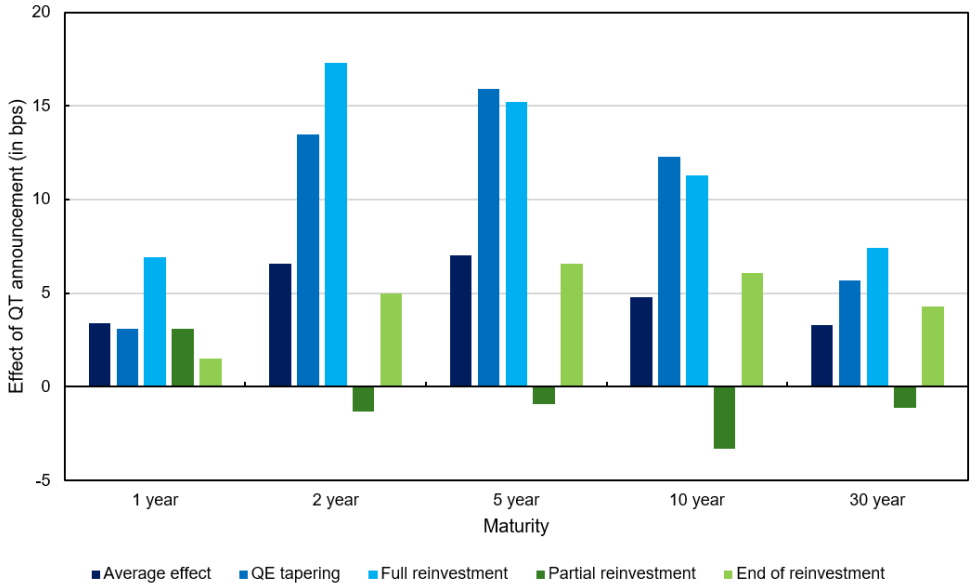

Figure 17 - Announcement effects of QT on sovereign yields: by category and overall effect (in bps)

Note: This graphic illustrates the findings reported in table 2 and 4. The categorisation of the nine events can be found in Table A1 in the appendix.

	Sovereign yield				
	1 year (1)	2 year (2)	5 year (3)	10 year (4)	30 year (5)
TAPER	0.031*** (0.008)	0.135*** (0.008)	0.159*** (0.009)	0.123*** (0.017)	0.057*** (0.020)
FULL REINVESTMENT	0.069*** (0.032)	0.173*** (0.044)	0.152*** (0.045)	0.113*** (0.035)	0.074*** (0.023)
PARTIAL REINVESTMENT	0.031 (0.027)	-0.013 (0.044)	-0.009 (0.047)	-0.033 (0.042)	-0.011 (0.032)
RUNOFF	0.015 (0.011)	0.050*** (0.013)	0.066*** (0.010)	0.061*** (0.015)	0.043** (0.020)
CMPSurprise	0.407*** (0.062)	0.407*** (0.091)	0.166 (0.114)	0.121 (0.130)	0.097 (0.124)
CESI	0.001*** (0.0001)	0.001*** (0.0002)	0.001*** (0.0002)	0.001*** (0.0003)	0.001* (0.0003)
Number of observations	8976	8976	8976	8976	8976
R-squared	0.007	0.012	0.009	0.003	0.001
Adjusted R-squared	0.006	0.01	0.007	0.002	0

Table 4 - Announcement effects of QT on sovereign yields: event category analysis (in percentage points)

Note: The categorisation of the nine events can be found in Table A1 in the appendix. The *TAPER* variable results are practically the same as those of the second event in table 3, as this was the sole ECB announcement explicitly signaling QE tapering. The p-values are denoted as follows: $p < 0.10$ (*); $p < 0.05$ (**); $p < 0.01$ (***).

To examine how quantitative tightening affects sovereign yields in the euro area, I analyse its impact through four key channels identified earlier in section 2.1: the signaling channel (i.e. forward guidance about interest rates), the portfolio rebalancing channel (rebalancing the portfolio towards other assets), the duration risk (here proxied as the term spread of 10-year sovereign yields and 2-year sovereign spreads) and the inflation channel (Krishnamurthy and Vissing-Jorgensen, 2011). The results of this analysis are presented in table 5.

The first three columns of table 5 examine the relationship between QT announcements and changes in short-term interest rate expectations, as measured by OIS rates with maturities of 3 months, 6 months, and 1 year. The coefficients on the QT event dummy are generally positive but statistically insignificant across all maturities, indicating that markets do not interpret QT announcements as conveying new or decisive information about the near-term policy rate trajectory. From an economic perspective, the positive sign of the coefficients suggests that QT may be perceived as reinforcing the ECB's commitment to tightening monetary policy and addressing inflationary pressures. The control variables behave as expected and are statistically significant: positive macroeconomic surprises are associated with increases in yields, and unexpected changes in the policy rate lead to upward shifts in OIS rates.

Columns 4 and 5 assess the presence of a portfolio rebalancing channel, using the EURO STOXX 50 index and the iBoxx corporate bond index as proxies for equity and corporate bond markets, respectively. The QT dummy coefficients for both asset classes exhibit the anticipated negative sign, implying a shift away from riskier assets in response to QT announcements, which aligns with theoretical expectations. However, these effects are not statistically significant, offering limited empirical support for the hypothesis that QT induces broad-based portfolio reallocation in the euro area.

Even in the absence of strong forward guidance or portfolio rebalancing effects, QT may still influence asset prices through the pricing of duration risk. Column 6 of table 5 explores this channel by examining the term spread, defined as the difference between 10-year and 2-year sovereign bond yields. The QT dummy is negative and statistically insignificant, suggesting that QT announcements have not materially affected the term premium in the euro area. This finding is consistent with earlier empirical evidence pointing to a reverse-U shaped relationship between QT and sovereign yields. As shown by Du et al. (2024), active QT is typically associated with a steepening of the yield curve, whereas passive QT tends to exert upward pressure on the short-end of yields, thereby flattening the curve. Given the absence of active QT in the euro area until now, these results are consistent with the work of Du et al. (2024).

The results of the last channel, the inflation channel, can be found in the seventh column of table 5. The coefficient shows that QT announcements have a counterintuitive positive, but negligible impact on inflation expectations. Therefore, we can't conclude that QT has an impact on inflation expectations.

These empirical findings suggest that it is unclear how quantitative tightening has upward pressure on bond yields. Even though most coefficients have the expected sign, these aren't significant and therefore we can't conclude which channel is the most relevant in putting upward pressure on sovereign yields.

	Channels of quantitative tightening						
	Signaling channel			Rebalancing channel		Duration	Inflation
	OIS 3M (1)	OIS 6M (2)	OIS 1Y (3)	STOXX50 (4)	iBoxxcorp (5)	Term spread (6)	ILS 5Y (7)
QT event	-0.004	0.017	0.009	-34.951	-0.046	-0.021	0.010
	(0.005)	(0.013)	(0.033)	(28.733)	(0.607)	(0.022)	(0.025)
CMPsurprise	0.699***	0.745***	0.663***	240.371**	23.244	-0.250***	0.069
	(0.061)	(0.093)	(0.184)	(114.317)	(22.720)	(0.077)	(0.196)
CESI	0.0001**	0.0005***	0.001***	-0.263	-0.015***	-0.0002	0.0001
	(0.0001)	(0.0001)	(0.0002)	(0.216)	(0.006)	(0.0002)	(0.000)
Constant	0.003***	0.003*	0.001	2.891	-0.494		-0.004
	(0.001)	(0.001)	(0.001)	(2.588)	(0.457)		(0.004)
Observations	1122	1122	1122	1122	1122	1122	795
R-squared	0.237	0.142	0.093	0.008	0.002	0.012	0
Adjusted R-squared	0.235	0.14	0.09	0.006	0	0.009	0

Table 5 - Announcement effects on the channels of QT

Note: The p-values are denoted as follows: $p < 0.10$ (*); $p < 0.05$ (**); $p < 0.01$ (***).

Source: Refinitiv Datastream

Next, to assess whether QT announcements changes markets' perception of fragmentation risks, like discussed in section 2.3.4, I examine the impact of the QT announcements on sovereign spreads. Table 6 presents the results, showing that the coefficient on QT announcements is positive, indicating an increase in sovereign spreads. This suggests that markets may perceive fiscal strength as less robust due to QT, leading to a rise in the risk premia. However, the magnitude of this effect is small, approximately 1 basis point, and importantly, it is statistically insignificant, indicating limited evidence that QT materially alters risk sentiment at the aggregate level.

To explore heterogeneity across credit quality, the sample is divided into lower- and higher-rated economies based on their S&P credit ratings as of early 2025 (with lower-rated countries defined as those rated A+ or below; see table A2). The analysis reveals that lower-rated economies experienced a slightly larger increase in sovereign spreads following QT announcements, about 1.3 basis points, compared to just 0.5 basis points for higher-rated countries. This pattern may reflect greater market concern over the fiscal outlook of lower-rated countries amid QT. Nevertheless, consistent with the pooled estimates, the coefficients for both subgroups remain statistically insignificant, suggesting that any differential impact across credit quality is modest. Furthermore, as shown in tables A4 and A5, while the impact on spreads remains largely unchanged in the 1-day window specification, it turns negative when using a 3-day window. This suggests that the estimated effects on spreads may lack robustness.

	Sovereign spreads with Germany		
	Full Sample (1)	Lower rated economies (2)	Higher rated economies (3)
QT event	0.010	0.013	0.005
	(0.009)	(0.016)	(0.005)
CMPSurprise	-0.075	-0.099	-0.043*
	(0.115)	(0.229)	(0.022)
CESI	-0.0003	-0.0001	-0.00002
	(0.0002)	(0.0004)	(0.00004)
Number of observations	7854	4488	3366
R-squared	0	0.001	0.002
Adjusted R-squared	0	0	0

Table 6 - Announcement effects of QT on sovereign spreads: full and subsample analysis (in percentage points)

Note: Specification (1) uses the full sample, specification (2) includes only lower rated countries (Greece, Italy, Portugal and Spain), and specification (3) includes higher rated economies (Belgium, France and the Netherlands) (see table A2). Sovereign spreads are defined as the difference between the country's 10-year bond yield and the German 10-year yield. The p-values are denoted as follows: $p < 0.10$ (*); $p < 0.05$ (**); $p < 0.01$ (***).

Source: Refinitiv Datastream

To assess whether QT announcements influence broader financial markets beyond sovereign yields, I also examine their impact on a range of equity indices. The results are presented in table 7 and indicate that, as expected, the coefficients for all equity variables are negative. This suggests that QT may tighten financial conditions by lowering investor confidence and reducing risk appetite, although the effects are statistically insignificant. The impact on the STOXX Europe 600 Banks Index shows a negative impact as well. This reveals that markets expect that tighter liquidity conditions are worse for banks. As mentioned in section 2.2.4, the balance sheet normalisation results in banks looking for short-term funding elsewhere, specifically the repo market. Here, funding costs have risen because of QT. On top of this, QT could further slow the economy down, resulting in less lending activity. All of this could hinder bank's profitability, resulting in lower bank stock prices. Robustness checks using different event window lengths, as shown in Tables A6 and A7, confirm that the direction of the estimated effects does not change. For wider windows, some effects become more pronounced, particularly for the Euro STOXX 50 price and gross return indices, which become significant at the 10% level. These relatively muted and statistically insignificant reactions contrast with the experience during the balance sheet expansion, when central bank asset purchases had a more pronounced effect not only on sovereign bond yields but also on asset prices through portfolio rebalancing (see section 2.1). The limited response to QT may reflect the more gradual and anticipated nature of balance sheet normalisation. However, as discussed earlier, the pace of the balance sheet normalisation proceeded more rapidly than initially by market participants. As a result, the early announcements, particularly those related to QE tapering and the transition to full reinvestment, were likely to have a more pronounced impact on equity markets. Table 8 confirms this expectation: the announcement of QE tapering had a statistically significant negative effect

across all equity indices considered. While the announcement of full reinvestment did not yield statistically significant results, the estimated coefficients remain economically meaningful and negative in direction. By contrast, the later stages of QT showed much smaller or even slightly positive effects, suggesting that the initial surprise element diminished over time. This pattern is consistent with the sovereign bond yield results, where early QT announcements generated stronger market reactions than subsequent ones. Changing the event windows (tables A6 and A7) doesn't seem to have a major impact on the results: the coefficients remain negative and mostly insignificant.

For foreign exchange markets, the results are mixed. In theory, tighter monetary policy through balance sheet normalisation should lead to an appreciation of the euro, reflected in a depreciation of foreign currencies and thus negative coefficients. This expected relationship is observed for the British pound (*GBP*) and Swiss franc (*CHF*) in table 9, although the coefficients are not statistically significant. In contrast, the effect on the U.S. dollar (*USD*) does the opposite: the coefficient is positive and even significant at the 5% level, indicating a counterintuitive market reaction. This suggests other dynamics that may have influenced the euro-dollar exchange around the QT events affecting the results. Examining the effects by individual event categories, as shown in table 10, reveals that announcements related to QE tapering and the start of full reinvestment were associated with a significant depreciation of the euro (i.e. a positive coefficient). This is a counterintuitive outcome given that the balance sheet normalisation tightens financial conditions. For the later stages of the balance sheet normalisation process, the estimated effects generally align with expectations, showing negative coefficients. However, these are largely insignificant, with the exception of the Swiss franc (CHF), where the response is more pronounced.

	Equity variables				
	STOXX50 price (1)	STOXX600 price (2)	STOXX50 return (3)	STOXX600 return (4)	STOXX600 banks (5)
QT event	-34.951	-2.909	-15.145	-6.626	-1.304
	(28.733)	(2.769)	(13.055)	(6.404)	(0.999)
CMPSurprise	240.371**	21.321*	103.826*	48.189*	11.676*
	(114.317)	(11.054)	(53.187)	(26.147)	(6.337)
CESI	-0.263	-0.039*	-0.120	-0.091*	0.009
	(0.216)	(0.021)	(0.098)	(0.048)	(0.011)
Constant	2.891	0.223	1.864	0.759	0.287*
	(2.588)	(0.244)	(1.201)	(0.578)	(0.155)
Number of observations	1122	1122	1122	1122	1122
R-squared	0.008	0.01	0.007	0.009	0.005
Adjusted R-squared	0.006	0.007	0.005	0.007	0.003

Table 7 - Announcement effects of QT on equity (in euros)

Note: The p-values are denoted as follows: $p < 0.10$ (*); $p < 0.05$ (**); $p < 0.01$ (***).

Source: Refinitiv Datastream

	Equity variables				
	STOXX50 price (1)	STOXX600 price (2)	STOXX50 return (3)	STOXX600 return (4)	STOXX600 banks (5)
TAPER	-81.161***	-3.474***	-35.327***	-7.171***	-2.533***
	(3.098)	(0.297)	(1.449)	(0.709)	(0.193)
FULL REINVESTMENT	-95.599	-7.336	-43.272	-17.030	-3.676
	(66.031)	(7.177)	(29.490)	(16.376)	(3.300)
PARTIAL REINVESTMENT	-27.532	-2.458	-12.774	-5.768	-1.345
	(59.818)	(6.096)	(26.926)	(14.107)	(0.885)
RUNOFF	13.568**	-0.215	8.014*	-0.351	0.732
	(5.764)	(1.473)	(4.183)	(3.752)	(0.655)
CMPSurprise	235.924**	21.092*	101.879*	47.689*	11.544*
	(113.796)	(11.015)	(52.972)	(26.065)	(6.328)
CESI	-0.251	-0.038*	-0.114	-0.089*	0.009
	(0.214)	(0.021)	(0.096)	(0.047)	(0.011)
Constant	2.905	0.224	1.870	0.760	0.288*
	(2.587)	(0.244)	(1.201)	(0.577)	(0.155)
Number of observations	1122	1122	1122	1122	1122
R-squared	0.012	0.011	0.011	0.011	0.007
Adjusted R-squared	0.007	0.006	0.006	0.006	0.002

Table 8 - Announcement effects of QT on equity: event category analysis (in euros)
Note: The categorisation of the nine events can be found in Table A1 in the appendix. The p-values are denoted as follows: $p < 0.10$ (*); $p < 0.05$ (**); $p < 0.01$ (***).

To conclude, I examine the impact of QT announcements on foreign exchange markets and a selection of other financial indicators, including the iBoxx Corporates index (capturing investment-grade corporate bond performance) and the Bund-OIS spread, which as discussed in section 2.3.3, serves as a proxy for the convenience yield on safe and liquid assets. The results of the regressions can be found in tables 7 and 8.

The estimated coefficient of the iBoxx Corporates Index is negative but statistically insignificant. This is in line with expectations, as QT has an upward impact on yields, which has a downward effect on bond prices because existing bonds pay less than newly-issued ones. On top of this, the index could decline because credit risk for these corporations increased. Across the separate event categories, three out of four display coefficients with the expected negative sign, while the fourth (partial reinvestment) shows a positive sign. This is consistent with earlier findings that partial reinvestment was associated with a reduction in sovereign yields. Nonetheless, all of these estimates remain statistically insignificant. The Bund-OIS spread shows a positive, though insignificant coefficient. This is consistent with the idea that QT raises the convenience yield (i.e. Bund-OIS spread) by reducing the availability of safe assets such as Bunds. While these two indicators aren't statistically significant, the sign aligns directionally with the narrative that QT tightens financial conditions across asset classes. Contrary to the corporate bond index, the

Bund-OIS spread exhibits a significant increase of nearly 5 basis points following the QE tapering episode, and a more modest but significant 1 basis point rise during the full reinvestment announcements. This suggests that as the central bank is releasing part of its asset holdings, market participants value “convenience services” less than they did before, resulting in a decline of the convenience yield, particularly during the initial phases of the balance normalisation.

	Foreign exchange and other variables				
	USDEUR (1)	GBPEUR (2)	CHFEUR (3)	iBoxxcorp (4)	BundOISspread (5)
QT event	0.006**	-0.002	-0.0002	-0.046	0.007
	(0.003)	(0.003)	(0.002)	(0.607)	(0.007)
CMPSurprise	-0.002	0.002	-0.004	23.244	0.105
	(0.013)	(0.010)	(0.011)	(22.720)	(0.069)
CESI	0.00000	-0.00003	-0.00001	-0.015***	0.0002***
	(0.00002)	(0.00002)	(0.00002)	(0.006)	(0.0001)
Constant	0.0001	0.0001	0.0003	-0.494	0.0004
	(0.0002)	(0.0002)	(0.0002)	(0.457)	(0.001)
Number of observations	1122	1122	1122	1122	1122
R-squared	0.006	0.003	0.001	0.002	0.011
Adjusted R-squared	0.004	0	-0.002	0	0.008

Table 9 - Announcement effects of QT on foreign exchange and other financial indicators
Note: The p-values are denoted as follows: p < 0.10 (*); p < 0.05 (**); p < 0.01 (***).
Source: Refinitiv Datastream

In conclusion, the overall findings show that QT announcements generally tighten financial conditions, with the clearest effects observed in sovereign bond markets, especially at median and long maturities. While the effects on these bonds are significant, the channel through which it has this effect remains unknown, since all of the four transmission channels have insignificant coefficients. While some reactions in equity and foreign exchange markets align with expectations, most are statistically insignificant. Notably, the impact of QT appears strongest during the earlier stages of the process, when announcements likely contained the most informational value for market participants. Over time, as QT became more predictable due to good communication by the Governing Council, market reactions to announcements diminished. Overall, these results suggest that quantitative tightening does not trigger abrupt market reactions. This is an outcome that, as discussed in section 2.2.1, may have been precisely what the ECB intended to achieve.

	Foreign exchange and other variables				
	USDEUR (1)	GBPEUR (2)	CHFEUR (3)	iBoxxcorp (4)	BundOISspread (5)
TAPER	0.014***	0.005***	0.005***	-0.522	0.048***
	(0.0003)	(0.0003)	(0.0002)	(0.624)	(0.001)
FULL REINVESTMENT	0.011**	0.002***	0.007***	-0.706	0.012***
	(0.005)	(0.001)	(0.002)	(1.080)	(0.003)
PARTIAL REINVESTMENT	0.008*	-0.007*	-0.001***	0.721	-0.003
	(0.004)	(0.004)	(0.003)	(1.149)	(0.009)
RUNOFF	-0.002	-0.001	-0.006***	-0.213	0.001
	(0.003)	(0.006)	(0.002)	(0.458)	(0.008)
CMPSurprise	-0.001	0.002	-0.003	23.147	0.107
	(0.013)	(0.010)	(0.011)	(22.745)	(0.069)
CESI	0.00000	-0.00003	-0.00001	-0.015***	0.0002***
	(0.00002)	(0.00002)	(0.00002)	(0.006)	(0.0001)
Constant	0.0001	0.0001	0.0003	-0.494	0.0004
	(0.0002)	(0.0002)	(0.0002)	(0.457)	(0.001)
Number of observations	1121	1121	1121	1122	1122
R-squared	0.013	0.006	0.009	0.002	0.013
Adjusted R-squared	0.008	0	0.004	0	0.008

Table 10 - Announcement effects of QT on foreign exchange and other financial indicators: event category analysis

Note: The categorisation of the nine events can be found in Table A1 in the appendix. The p-values are denoted as follows: $p < 0.10$ (*); $p < 0.05$ (**); $p < 0.01$ (***).

Source: Refinitiv Datastream

5. Conclusion

Following a prolonged period of unconventional monetary policy through large-scale asset purchase programmes, the ECB's decision to reverse course and initiate a reduction of its asset holdings marks for the first time in its history marks an important shift in monetary policy. Given the limited global experience with balance sheet normalisations, the potential macroeconomic and financial implications remained largely uncertain. This master's dissertation set out to examine the rationale, implementation, and challenges associated with the post-pandemic balance sheet normalisation of the Eurosystem. By offering both a theoretical and empirical analysis of this unprecedented process, the study aimed to get a deeper understanding of the ECB's evolving policy toolkit and its implications for monetary transmission and financial stability.

From a theoretical perspective, this dissertation presented several justifications for normalising the balance sheet. Quantitative tightening can be warranted in order to reduce residual monetary accommodation in an environment it is no longer required. Moreover, QT may facilitate the proper functioning of financial markets, particularly the repo market, which has been distorted by the scarcity of high-quality collateral. A leaner balance sheet is also important for restoring monetary policy space, especially as balance sheet tools are likely to remain a permanent feature of the ECB's toolkit. In this context, reducing the size of the balance sheet strengthens the readiness for future crises. Furthermore, returning to a leaner balance sheet enhances central bank credibility and independence by demonstrating that these policy measures are temporary and reversible.

While the rationales for a balance sheet normalisation are robust, this thesis also recognises the potential challenges it presents. Among these, the risk for financial market disruption is the most important concern. As a result, the execution should be communicated well in advance and approached with caution. Additionally, determining the optimal size of the portfolio remains inherently uncertain and is largely dependent on the varying demand for liquidity. Furthermore, the euro area's unique institutional structure further complicates normalisation, as heterogeneous financial and economic conditions across member states may result in asymmetric transmission.

Empirically, the study applied an event study methodology to assess the immediate effects of QT announcements on a range of financial variables. The findings suggest only a modest market response, with limited statistical significance across most financial indicators. Notably, sovereign bond yields exhibited upward pressure, suggesting QT does influence risk premia. However, the muted overall response compared to the effects typically associated with quantitative easing indicates that the "symmetry hypothesis" of balance sheet policies does not fully hold, at least not in these market conditions. In this respect, the results strongly affirm Janet Yellen's analogy that balance sheet normalisation is akin to "watching paint dry". Rather than representing an important part of the ECB's monetary policy stance like QE, QT appears as a background adjustment.

Nevertheless, the limited market reaction should not be interpreted as a sign of irrelevance. On the contrary, the ECB's ability to initiate QT without triggering market instability reflects the effectiveness of its communication strategy and the cautious pace of implementation. The ECB's gradualist approach has thus far proven successful in maintaining financial stability while beginning to rebuild policy space for the future.

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7. Appendix

7.1. Data Description and Variable Overview

Date	Dummy	Description
16/12/2021	QT_t (1) $QT_{1,t}$ (4) FR_t (5)	Discontinue net asset purchases of PEPP at the end of March 2022. Reinvestment of the PEPP portfolio would last at least until the end of 2024.
10/03/2022	QT_t (1) $QT_{2,t}$ (4) $Taper_t$ (5)	Downward adjustment in QE tapering of net asset purchases under APP to €40 billion in April, €30 billion in May, and €20 billion in June (instead of €40 billion in the second quarter).
09/06/2022	QT_t (1) $QT_{3,t}$ (4) FR_t (5)	Announcement that net asset purchases under APP will end as of July 2022.
15/12/2022	QT_t (1) $QT_{4,t}$ (4) PR_t (5)	Announcement of partial reinvestment of €15 billion per month of APP portfolio until the end of June 2023.
02/02/2023	QT_t (1) $QT_{5,t}$ (3) PR_t (4)	Operational clarification of reduction APP portfolio starting March 2023.
04/05/2023	QT_t (1) $QT_{6,t}$ (4) $RUNOFF_t$ (5)	Expectation to discontinue reinvestment as of July 2023.
15/06/2023	QT_t (1) $QT_{7,t}$ (4) $RUNOFF_t$ (5)	Announcement of discontinuation of APP reinvestments as of July 2023 (equivalent to reducing reinvestments by €25-30 billion per month in next 12 months).
14/12/2023	QT_t (1) $QT_{8,t}$ (4) PR_t (5)	Announcement of partial reinvestment of €7.5 billion per month of PEPP portfolio from the second half of 2024 onwards.
12/12/2024	QT_t (1) $QT_{9,t}$ (4) $RUNOFF_t$ (5)	Announcement that the ECB will end reinvestment of maturing PEPP assets as of start 2025.

Table A1 - Description of the quantitative tightening announcement events of the ECB

Source: European Central Bank. (n.d.). *Monetary policy decisions.*

Note: The numbers in parentheses in the second column indicate which specification the dummy variable belongs to. The monetary policy decision of 16 December 2021 doesn't include a Taper dummy, as it involved an upward adjustment of net purchases under the APP portfolio, increasing to €40 billion in the second quarter of 2022, €30 billion in the third quarter, and mean reverting to €20 billion in the fourth quarter (before this announcement it was €20 billion). As such, no actual appearing of APP purchases was announced.

Country	Code	S&P rating	Rating
Belgium	BE	AA	High
France	FR	AA-	High
Germany	DE	AAA	Reference country
Greece	GK	BBB-	Low
Italy	IT	BBB	Low
Netherlands	NL	AAA	High
Portugal	PT	A-	Low
Spain	ES	A	Low

Table A2 - Countries in sample by credit rating and risk category

Note: Countries are classified as lower-rated if their credit rating falls below “high grade”, defined as a rating of A+ or lower. Germany is excluded from classification, because it is used as the reference country for calculating sovereign yield spreads.

Source: Standard & Poor’s Global. (2025, February 19). *Sovereign Ratings List.*

7.2. Robustness check: different window sizes

	Sovereign yield (1-day event window)					
	1 year (1)	2 year (2)	5 year (3)	10 year (4)	30 year (5)	spreads (6)
QT event	0.013	0.031*	0.031*	0.020	0.016	0.007
	(0.009)	(0.016)	(0.018)	(0.016)	(0.011)	(0.007)
CMPSurprise	0.372***	0.551***	0.352***	0.210*	0.184*	-0.103
	(0.057)	(0.094)	(0.100)	(0.110)	(0.107)	(0.111)
CESI	0.0004***	0.001***	0.001***	0.0005***	0.0003*	-0.0002
	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0002)
Number of observations	8976	8976	8976	8976	8976	7854
R-squared	0.006	0.007	0.004	0.001	0.001	0
Adjusted R-squared	0.005	0.006	0.003	0	0	0

Table A3 - Robustness check : 1-day event windows for sovereign yields

Note: Event windows span from the closing price on the day prior to the event (*t*-1) to the closing price on the event day (*t*). The p-values are denoted as follows: p < 0.10 (*); p < 0.05 (**); p < 0.01 (***).
Source: Refinitiv Datastream

	Sovereign yield (3-day event window)					
	1 year (1)	2 year (2)	5 year (3)	10 year (4)	30 year (5)	spreads (6)
QT event	0.047***	0.090***	0.084*	0.056	0.024	-0.043
	(0.014)	(0.032)	(0.047)	(0.058)	(0.064)	(0.066)
CMPSurprise	0.526***	0.568***	0.267**	0.140	0.137	-0.074
	(0.079)	(0.105)	(0.121)	(0.130)	(0.127)	(0.117)
CESI	0.001***	0.001***	0.001***	0.001***	0.001***	-0.0001
	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Number of observations	8968	8968	8968	8968	8968	7847
R-squared	0.008	0.011	0.008	0.003	0.001	0
Adjusted R-squared	0.006	0.01	0.007	0.002	0	0

Table A4 - Robustness check : 3-day event windows for sovereign yields

Note: Event windows span from the closing price on the day prior to the event (*t*-1) to the closing price two trading days after the event (*t*+2). The p-values are denoted as follows: p < 0.10 (*); p < 0.05 (**); p < 0.01 (***).
Source: Refinitiv Datastream

	Equity variables (1-day event window)				
	STOXX50 price (1)	STOXX600 price (2)	STOXX50 return (3)	STOXX600 return (4)	STOXX600 banks (5)
QT event	-27.418 (21.220)	-1.692 (1.934)	-12.106 (9.415)	-3.788 (4.409)	-1.056 (0.699)
CMPSurprise	224.659** (106.412)	17.454* (9.153)	98.706** (48.836)	40.142* (21.679)	12.136** (5.469)
CESI	-0.108 (0.136)	-0.016 (0.013)	-0.050 (0.061)	-0.037 (0.031)	0.006 (0.007)
Constant	1.328 (1.401)	0.101 (0.132)	0.882 (0.649)	0.354 (0.311)	0.135 (0.084)
Number of observations	1122	1122	1122	1122	1122
R-squared	0.011	0.008	0.01	0.008	0.01
Adjusted R-squared	0.008	0.005	0.007	0.005	0.008

Table A5 - Robustness check : 1-day event windows for equity indicators (in euros)

Note: Event windows span from the closing price on the day prior to the event (*t*-1) to the closing price on the event day (*t*). The p-values are denoted as follows: p < 0.10 (*); p < 0.05 (**); p < 0.01 (***).

Source: Refinitiv Datastream

	Equity variables (3-day event window)				
	STOXX50 price (1)	STOXX600 price (2)	STOXX50 return (3)	STOXX600 return (4)	STOXX600 banks (5)
QT event	-61.235* (31.443)	-5.237 (3.199)	-26.964* (14.459)	-12.069 (7.423)	-1.470 (1.328)
CMPSurprise	275.181* (155.009)	24.236* (14.598)	114.987 (71.837)	53.304 (34.443)	12.208 (8.274)
CESI	-0.453* (0.275)	-0.062** (0.027)	-0.207* (0.123)	-0.143** (0.062)	0.002 (0.014)
Constant	4.608 (3.704)	0.360 (0.349	2.930* (1.721)	1.201 (0.827)	0.433* (0.223)
Number of observations	1121	1121	1121	1121	1121
R-squared	0.012	0.014	0.01	0.013	0.004
Adjusted R-squared	0.009	0.011	0.008	0.01	0.001

Table A6 - Robustness check : 3-day event windows for equity indicators (in euros)

Note: Event windows span from the closing price on the day prior to the event (*t*-1) to the closing price two trading days after the event (*t*+2). The p-values are denoted as follows: p < 0.10 (*); p < 0.05 (**); p < 0.01 (***).

Source: Refinitiv Datastream

	Foreign exchange and other variables (1-day event window)				
	USDEUR (1)	GBPEUR (2)	CHFEUR (3)	iBoxxcorp (4)	BundOISspread (5)
QT event	0.001	-0.002	0.0004	0.175	0.008
	(0.002)	(0.002)	(0.001)	(0.475)	(0.008)
CMPSurprise	-0.005	-0.002	-0.006	3.186	0.104
	(0.010)	(0.008)	(0.007)	(5.980)	(0.094)
CESI	-0.0000	-0.00002	-0.00001	-0.009**	0.0001**
	(0.00001)	(0.00001)	(0.00001)	(0.004)	(0.0001)
Constant	0.0001	0.0001	0.0001	-0.229	0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.226)	(0.001)
Number of observations	1122	1122	1122	1122	1122
R-squared	0.001	0.003	0.001	0	0.009
Adjusted R-squared	-0.002	0.001	0	0	0.007

Table A7 - Robustness check : 1-day event windows for foreign exchange and other variables

Note: Event windows span from the closing price on the day prior to the event (*t*-1) to the closing price on the event day (*t*). The p-values are denoted as follows: p < 0.10 (*); p < 0.05 (**); p < 0.01 (***).

Source: Refinitiv Datastream

	Foreign exchange and other variables (3-day event window)				
	USDEUR (1)	GBPEUR (2)	CHFEUR (3)	iBoxxcorp (4)	BundOISspread (5)
QT event	0.007*	-0.004*	-0.0003	-0.377	0.002
	(0.004)	(0.002)	(0.002)	(0.841)	(0.009)
CMPSurprise	-0.009	-0.001	-0.013	24.625	0.135*
	(0.017)	(0.013)	(0.014)	(24.402)	(0.074)
CESI	0.00003)	-0.00002	-0.00001	-0.015**	0.0002**
	(0.00002)	(0.00003)	(0.00002)	(0.006)	(0.0001)
Constant	0.0002	0.0002	0.0004	-0.715	0.001
	(0.0004)	(0.0003)	(0.0003)	(0.647)	(0.001)
Number of observations	1121	1121	1121	1118	1121
R-squared	0.008	0.003	0.002	0.001	0.009
Adjusted R-squared	0.005	0	-0.001	0	0.007

Table A8 - Robustness check : 3-day event windows for foreign exchange and other variables

Note: Event windows span from the closing price on the day prior to the event (*t*-1) to the closing price two trading days after the event (*t*+2). The p-values are denoted as follows: p < 0.10 (*); p < 0.05 (**); p < 0.01 (***).

Source: Refinitiv Datastream

7.3. Robustness check: different control variables

	Sovereign yield (policy surprise control variable)					
	1 year (1)	2 year (2)	5 year (3)	10 year (4)	30 year (5)	spreads (6)
QT event	0.035***	0.066***	0.070***	0.048***	0.033**	0.010
	(0.012)	(0.020)	(0.020)	(0.018)	(0.014)	(0.009)
POLsurprise	0.182	0.193	-0.077	-0.048	0.005	0.096
	(0.122)	(0.125)	(0.117)	(0.103)	(0.086)	(0.086)
CESI	0.001***	0.001***	0.001***	0.001***	0.001*	-0.0003
	(0.0001)	(0.0002)	(0.0002)	(0.0003)	(0.0003)	(0.0003)
Number of observations	8976	8976	8976	8976	8976	7854
R-squared	0.003	0.008	0.007	0.003	0.001	0
Adjusted R-squared	0.002	0.007	0.006	0.001	0	0

Table A9 - Robustness check : policy surprise control variable for sovereign yield (in percentage points)

Note: The policy surprise control variable takes a positive value when the actual DFR exceeds market expectations, as reported by Bloomberg (n.d.). The p-values are denoted as follows: $p < 0.10$ (*); $p < 0.05$ (**); $p < 0.01$ (***).
Source: Refinitiv Datastream

	Equity variables (policy surprise control variable)				
	STOXX50 price (1)	STOXX600 price (2)	STOXX50 return (3)	STOXX600 return (4)	STOXX600 banks (5)
QT event	-34.562	-2.868	-14.975	-6.533	-1.285
	(29.392)	(2.822)	(13.321)	(6.520)	(1.006)
POLsurprise	178.532**	23.641***	79.158**	54.190***	8.837
	(73.617)	(6.830)	(33.753)	(16.051)	(6.285)
CESI	-0.242	-0.037*	-0.111	-0.086*	0.010
	(0.216)	(0.021)	(0.098)	(0.048)	(0.011)
Constant	3.329	0.257	2.051*	0.086*	0.308**
	(2.500)	(0.235)	(1.156)	(0.048)	(0.147)
Number of observations	1122	1122	1122	1122	1122
R-squared	0.005	0.008	0.005	0.008	0.003
Adjusted R-squared	0.002	0.006	0.002	0.005	0

Table A10 - Robustness check : policy surprise control variable for equity indicators (in euros)

Note: The policy surprise control variable takes a positive value when the actual DFR exceeds market expectations, as reported by Bloomberg (n.d.). The p-values are denoted as follows: $p < 0.10$ (*); $p < 0.05$ (**); $p < 0.01$ (***).
Source: Refinitiv Datastream

	Foreign exchange and other variables (policy surprise control variable)				
	USDEUR (1)	GBPEUR (2)	CHFEUR (3)	iBoxxcorp (4)	BundOISspread (5)
QT event	0.006** (0.003)	-0.002 (0.003)	-0.0002 (0.002)	-0.018 (0.663)	0.007 (0.006)
POLsurprise	-0.001 (0.011)	-0.003 (0.004)	0.030*** (0.011)	4.819 (3.181)	-0.054) (0.112)
CESI	0.00000 (0.00002)	-0.00003 (0.00002)	-0.00001 (0.00002)	-0.014*** (0.005)	0.0002*** (0.0001)
Constant	0.0001 (0.0002)	0.0002 (0.0002)	0.0002 (0.0002)	-0.443 (0.409)	0.001 (0.001)
Number of observations	1122	1122	1122	1122	1122
R-squared	0.006	0.003	0.006	0	0.007
Adjusted R-squared	0.004	0	0.003	0	0.005

Table A11 - Robustness check : policy surprise control variable for foreign exchange and other variables

Note: The policy surprise control variable takes a positive value when the actual DFR exceeds market expectations, as reported by Bloomberg (n.d.). The p-values are denoted as follows: $p < 0.10$ (*); $p < 0.05$ (**); $p < 0.01$ (***).

Source: Refinitiv Datastream

7.4. Robustness check: other specifications

	Sovereign yield (without control variables)				
	1 year (1)	2 year (2)	5 year (3)	10 year (4)	30 year (5)
QT event	0.033*** (0.013)	0.063*** (0.021)	0.067*** (0.022)	0.046** (0.019)	0.032** (0.014)
Number of observations	8976	8976	8976	8977	8976
R-squared	0.001	0.001	0.001	0	0
Adjusted R-squared	0	0.001	0	0	0

Table A12 - Announcement effects of QT on sovereign yields without controls (in percentage points)
Note: The p-values are denoted as follows: $p < 0.10$ (*); $p < 0.05$ (**); $p < 0.01$ (***).
Source: Refinitiv Datastream

	Sovereign yield (random effects estimator)				
	1 year (1)	2 year (2)	5 year (3)	10 year (4)	30 year (5)
QT event	0.034*** (0.012)	0.066*** (0.020)	0.070*** (0.021)	0.048*** (0.018)	0.033** (0.014)
CMPSurprise	0.405*** (0.062)	0.394*** (0.091)	0.154 (0.114)	0.111 (0.130)	0.092 (0.123)
CESI	0.001*** (0.0001)	0.001*** (0.0001)	0.001*** (0.0002)	0.001*** (0.0003)	0.001* (0.0003)
Constant	0.002* (0.001)	0.003** (0.001)	0.005*** (0.001)	0.005*** (0.002)	0.006*** (0.002)
Number of observations	8976	8976	8976	8976	8976
R-squared	0.007	0.01	0.007	0.003	0.001
Adjusted R-squared	0.006	0.009	0.007	0.002	0.001

Table A13 - Announcement effects of QT on sovereign yields with the random effects estimator (in percentage points)
Note: The p-values are denoted as follows: $p < 0.10$ (*); $p < 0.05$ (**); $p < 0.01$ (***).
Source: Refinitiv Datastream