

IN-DEPTH ANALYSIS

Requested by the ECON committee

Monetary Dialogue Papers, March 2023



# Quantitative tightening in homeopathic doses

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The ECB and the long shadow of the PSPP  
and the PEPP



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PE 741.482 - March 2023



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# Quantitative tightening in homeopathic doses

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## The ECB and the long shadow of the PSPP and the PEPP

### **Abstract**

The ECB is now planning to run down its vast bond holdings acquired under the asset purchase programme – a “quantitative tightening”. However, the ECB is not contemplating selling any bonds, only not reinvesting part of what is coming due. Under this approach, the continuing expansionary effect of keeping vast holdings remains large and is likely to complicate the fight against inflation. The ECB currently has two, fungible, policy instruments (policy rates and balance sheet operations), which make it impossible to determine the impact of quantitative tightening separately.

This document was provided by the Economic Governance and EMU Scrutiny Unit at the request of the Committee on Economic and Monetary Affairs (ECON) ahead of the Monetary Dialogue with the ECB President on 20 March 2023.

This document was requested by the European Parliament's Committee on Economic and Monetary Affairs.

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The authors wish to thank Cinzia Alcidi, Elena Carletti and Guido Tabellini, and staff members of the Economic Governance and EMU Scrutiny Unit for comments and suggestions.

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Original: EN

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Manuscript completed in March 2023

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This document was prepared as part of a series on 'Quantitative tightening in the euro area', available on the internet at:

<https://www.europarl.europa.eu/committees/en/econ/econ-policies/monetary-dialogue>

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## LIST OF ABBREVIATIONS

<b>APP</b>	Asset purchase programme
<b>AUD</b>	Australian dollar
<b>ECB</b>	European Central Bank
<b>GDP</b>	Gross domestic product
<b>NCBs</b>	National Central Banks
<b>OIS</b>	Overnight indexed swaps
<b>PEPP</b>	Pandemic emergency purchase programme
<b>PSPP</b>	Public sector purchase programme
<b>QE</b>	Quantitative easing
<b>QT</b>	Quantitative tightening
<b>TLTROs</b>	Targeted longer-term refinancing operations
<b>TPI</b>	Transmission Protection Instrument

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## EXECUTIVE SUMMARY

- **The time path announced by the European Central Bank (ECB) for reducing the bond holdings accumulated under the asset purchase programme does not amount to a real tightening.** “Easing of Quantitative Easing” might be more appropriate.
- **Given the aversion of the ECB to upsetting financial markets, it is only planning a soft ‘run-off’, which just means not reinvesting part of the bonds coming due, thus (implicitly) excluding outright sales from its large portfolio.**
- **The ECB is not alone taking a cautious approach.** But it is more cautious than most others, some of which are planning outright sales, including the Bank of England, the Reserve Bank of New Zealand and the Swedish Riksbank, all without major market reactions to the announcements or the sales that have taken place.
- **One reason why the ECB is not considering bond sales might be concerns about the stability of the bond markets for highly indebted countries.** This would mean that monetary policy is at least partially subject to “fiscal dominance”, i.e. the desire to provide governments with favourable financing conditions.
- The fear of market fragmentation does not apply to the private sector bonds acquired under the asset purchase programme (APP). The approximately EUR 650 billion of corporate and covered bonds could, and should, be sold quickly.
- **Without bond sales the Eurosystem can reduce its bond holdings only at a glacial speed, remaining above the pre-pandemic level until mid-2028, implying a continuing strong expansionary effect (because long-term interest rates would remain lower for longer).**
- **The stock effects of the future continuing holdings (in terms of keeping longer rates low) will be at least as substantial as those achieved in the past.** For example, the pandemic emergency purchase programme (PEPP) holdings were accumulated in 2 years, but a large share might remain on the balance sheet of the Eurosystem for another 4-5 years.
- **The ECB is thus effectively keeping one foot on the accelerator (retaining an extensive portfolio of bonds) while the other foot (increasing policy rates) is on the brake.** As long as the Eurosystem keeps large holdings of bonds on its balance sheet, the restrictive effect of higher interest rates will be muted.
- **Rough calculations suggest that the combination of the present public sector purchase programme (PSPP) and PEPP holdings with a policy interest rate of 3 % implies a stance equivalent to a policy rate of 1-2 % during the pre-quantitative easing (QE) period.**
- **When the ECB started its bond purchases, it emphasised the importance of the announcement effect and academic research also assumed that market participants would immediately price in the entire future path of purchases.** This time it is difficult to discern any announcement effect.
- **The reason why the announcement effect of the ECB’s time path for “quantitative tightening” (QT) has been so muted is simple: when the ECB started bond purchases, its policy rate could not be lowered any further.** QE was the only instrument left. Now the ECB has two instruments; any quicker quantitative tightening would simply mean less action on interest rates.
- **Since the ECB now has two instruments, it will look at their joint effect on markets and the economy.** Hence, one cannot disentangle the separate effect of QT on prices.



## 1. INTRODUCTION

Quantitative tightening (QT), also known as balance sheet normalisation, is an unconventional contractionary monetary policy through which central banks reduce their balance sheets. QT does not simply mean the end of bond purchases. One can speak of QT only if the bond holdings of the central bank decline. This can be achieved either by halting the reinvestment of maturing bonds and other assets on the balance sheet of the central bank, 'passive tightening', or by selling the assets, which is called 'active tightening'.

In assessing the effects of QT, one must thus be careful to distinguish between the (flow) effects of asset purchases or sales and the impact that large asset holdings can have on (long-term) interest rates and the term premium, i.e. the stock effect. Active QT, meaning asset sales by the central bank, should be equivalent to increases in the policy rate. However, merely keeping asset holdings constant maintains a constant downward pressure on long-term rates.

It is often argued that QT must be considered very differently than QE because it takes place under very different circumstances. The little available empirical evidence shows an asymmetry between the impact of balance sheet expansions and balance sheet normalisation, suggesting that QT does not simply reverse the effects of quantitative easing (QE) (see Smith and Valcarcel, 2023).

Schnabel (2023) deals with this issue and finds that the portfolio rebalancing effects of QT are similar to those of QE. This is what one would expect from the economic models of quantitative easing based on the idea that the impact of QE is determined by the amount of long-term bonds the central bank holds, thereby taking on duration risk. This effect, which European Central Bank (ECB) representatives have stressed over the last year, would imply that the QE and QT should be symmetric in their impact.

Schnabel (2023) also shows that the market reaction to the first steps towards QT has not always been what had been expected. She attributes some unexpected market reactions to contingent factors specific to 2022. We do not discuss the factors that might have affected markets in 2022. Instead, we adopt a more medium-run outlook for which the portfolio balance effects dominate and thus proceed under the assumption that QT is largely the negative of QE.

QE (asset purchases) was initiated when inflation was stable, and only less than one percentage point away from (below) the inflation target and the policy rate was at its lower bound. The need for QT arises now with highly volatile inflation that is much further away from the inflation target than during the entire QE period. Given these differences in inflation rates, one would thus expect QT (asset sales) to proceed much more quickly than asset purchases. However, this is not the case, certainly not for the ECB.

In the face of an inflation shortfall of less than 1 percentage point, the public sector purchase programme (PSPP) started with purchases of EUR 60 billion per month (from March 2015 to March 2016). After the COVID-19 crisis, bond purchases rapidly increased throughout 2021 and continued at close to an average of EUR 90 billion per month (the PSPP and pandemic emergency purchase programme (PEPP) together), at a time when inflation was already clearly above the target. By contrast, at present, the ECB is planning to reduce its asset holdings by only EUR 15 billion per month (six times less than the previous purchases) even though inflation remains very far from its target and is not projected to return to 2% over the forecast horizon.

At present, there is, of course, a large degree of uncertainty regarding the future evolution of inflation. However, as Schnabel (2022b) argues, such a situation requires a robust approach in order to avoid that inflationary expectations become unanchored.

The ECB did not tighten policy earlier when inflation was already clearly above target because its models indicated that inflation would return below the target within its forecast horizon, even given its very expansionary policy stance. Gros and Shamsfakhr (2022) show that this feature of inflation returning to below target (1.9% to be precise) was baked-in in these models because they assumed that inflation expectations would remain well anchored at that level.

Another asymmetry, or rather inconsistency, is that QE was initiated when the policy rate was at the lower bound and the ECB emphasised that bond purchases were needed because it could not stimulate the economy any further with interest rate cuts. This line of reasoning would suggest that the ECB should start selling bonds immediately once policy rates go above zero, thus obviating the need for asset purchases (or bond holdings) by the central bank. But the ECB has not followed this logic. Among major central banks, only the Bank of England announced asset sales as soon as its policy rate went above zero.

In the remainder of this paper, we first provide a brief overview of the global tightening cycle in terms of the shift from QE to QT. We then take a closer look at the very slow QT pace planned by the ECB and the implicit path of bond holdings. This is followed by a brief discussion of the trade-off between increases in the policy rate and running down bond holdings. The last section concludes.

## 2. CENTRAL BANKS TURN FROM QE TO QT AS INFLATION INCREASES

With inflation running far above its long-run target in 2022, major central banks started unwinding their accommodative monetary policy by lifting their policy rates and reducing their massive balance sheets (Table 1).

**Table 1:** Central Bank assets to GDP, selected advanced economies (2020)

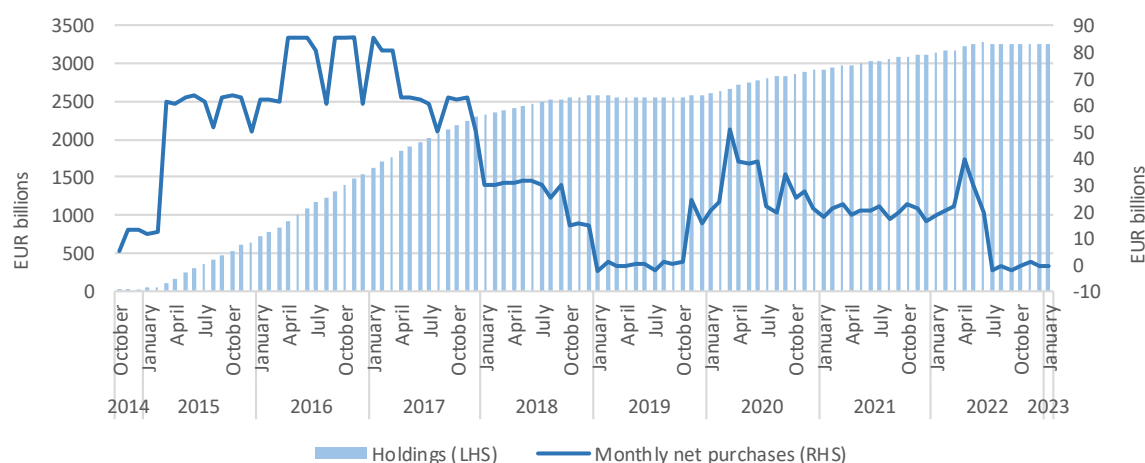
Euro Area	US	Australia	New Zealand	Canada
<a href="#">16.2%</a>	<a href="#">22.4%</a>	<a href="#">6.5%</a>	<a href="#">18.0%</a>	<a href="#">17.8%</a>

Source: World Bank, ECB.

It was only as of 1 July 2022 that the ECB decided to end the net purchases under the asset purchase programme (APP) but it continued the reinvestment of purchased maturing securities. At that time, euro area inflation was 8.9%, maintaining its upward trend. In October 2022, inflation peaked at 10.6%. At their last meeting of 2022, in December, the ECB Governing Council then announced that from the beginning of March 2023 it would passively diminish its APP holdings by an average of EUR 15 billion per month until the end of the second quarter of 2023. The pace of subsequent reductions has not yet been published (maybe not even been decided) but is widely expected to be larger.<sup>1</sup>

**Figure 1:** Evolution of purchases and the resulting stock under the APP and PEPP by the ECB

(2014-January 2023)



Source: Authors' elaboration based on data from the ECB.

The ECB has been more gradual than its peers, especially with respect to the Federal Reserve (Fed), both in the normalisation path of its policy rate and in terms of the timing and pace of QT.

A short survey of QT across major developed economies (below) confirms this.

<sup>1</sup> The February ECB Survey of Monetary Analysts referring to the period 16-19 January 2023

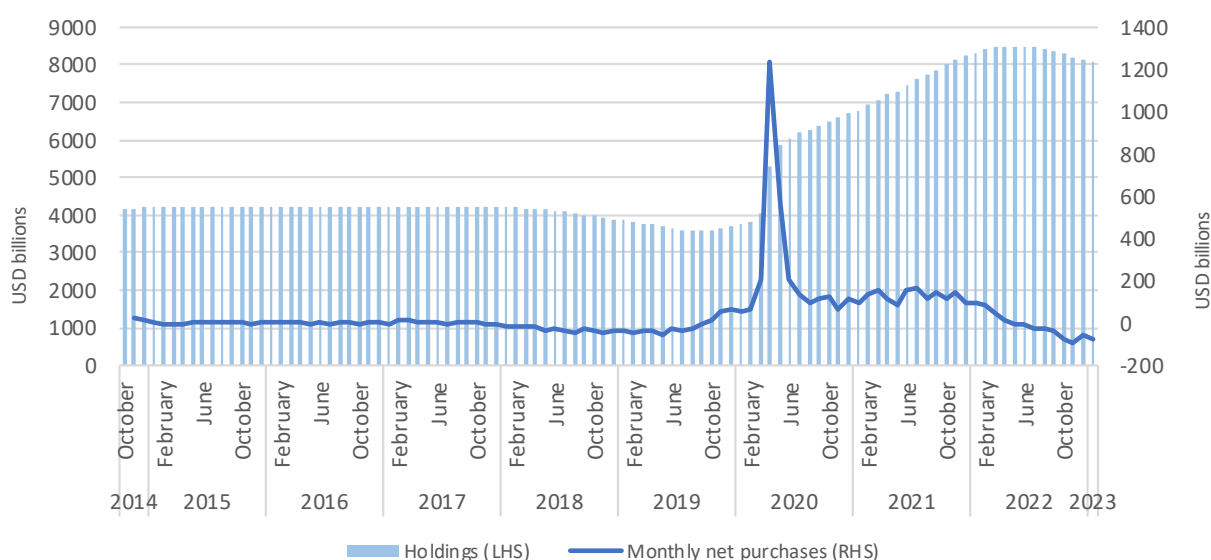
[https://www.ecb.europa.eu/stats/ecb\\_surveys/sma/shared/pdf/ecb.smar230206\\_february.en.pdf?de7bce0b65c618dfdb3a6ff376021206](https://www.ecb.europa.eu/stats/ecb_surveys/sma/shared/pdf/ecb.smar230206_february.en.pdf?de7bce0b65c618dfdb3a6ff376021206)

### The Federal Reserve

In May 2022, when the annual inflation rate in the US had reached 8.5%, more than 6 percentage points (pp) above the target inflation rate, the Fed ended its asset purchases, while still reinvesting maturing securities. Only a month later, in June 2022, it began a passive QT and stopped reinvesting up to USD 30 billion in maturing Treasuries and USD 17.5 billion in maturing mortgage-backed securities per month. Those caps were set to increase to USD 60 billion and USD 35 billion, respectively, after three months<sup>2</sup>. This implies that starting in September 2022, the Fed would reduce its asset holdings by up to USD 95 billion per month (compared with EUR 15 billion for the ECB), a much quicker pace even taking into account the difference in the size of the initial stock (which is about 60% larger for the Federal Reserve)<sup>3</sup>.

**Figure 2:** Evolution of purchases and the resulting stock under Treasury and mortgage-backed securities purchases by the Fed

(2014 to January 2023)



Source: Authors' elaboration based on Federal Reserve Economic Data.

It has been estimated that this pace of reduction would lead to a fall in asset holdings from over USD 8 000 billion to USD 5 000 billion by 2026, a fall of about 40% from the peak. The annual average reduction would amount to about USD 750 billion, more than USD 60 billion per month (Ennis and Kirk, 2022).

### Sweden

From January 2023, the Riksbank ended the purchases of government bonds that it had started in February 2015 with the aim of stimulating the Swedish economy and which it had enhanced during the COVID-19 crisis, between March 2020 and December 2021. By the end of 2022, the Riksbank's total holdings of purchased government bonds had reached SEK 338.4 billion (equivalent to EUR 30.4

<sup>2</sup> <https://www.federalreserve.gov/newsevents/pressreleases/monetary20220504b.htm>

<sup>3</sup> The actual amount can be somewhat smaller if the value of the maturing securities is lower than the cap. In particular, the upper limit on mortgage securities will be reached if only redemptions accelerate much beyond what was anticipated (Ennis and Kirk, 2022).

billion)<sup>4</sup>. In February 2023, the Riksbank announced that it would accelerate its asset holdings reduction by actively selling government bonds as of April 2023 in order to stabilise inflation around the target<sup>5</sup>.*Canada*

In October 2021, the Bank of Canada announced halting its quantitative easing, and at the end of April 2022 it started its QT by ending purchases of the government of Canada bonds in the primary or secondary markets, as well as ending the reinvestment of the maturing bonds<sup>6</sup>.

#### *Australia*

After ending its bond purchase programme in February 2022, the Reserve Bank of Australia decided to pursue a passive QT by not reinvesting any maturing bonds, starting from May 2022. This was predicted to reduce the total bond holdings by about AUD 4 billion and AUD 13 billion in 2022 and 2023, respectively<sup>7</sup>.

#### *New Zealand*

The Reserve Bank of New Zealand also announced the end of its purchases in 2022 and is now planning to start selling its portfolio of government securities with the aim of reducing its holdings of these bonds to zero by 2027<sup>8</sup>.

#### *Bank of England*

The Bank of England quit purchasing bonds at the end of 2021, much earlier than the Fed and the ECB, and it stopped reinvestments of maturing bonds as soon as February 2022. Moreover, by November 2022, it had already started active sales of its bonds.

The experience of the UK over the last year shows that even substantial bond sales by the central banks need not unsettle financial markets. Two episodes illustrate this.

First, the Monetary Policy Committee of the Bank of England announced in February 2022 that it would cease (totally) reinvestment of its bond portfolio as soon as its policy rate turned positive (BoE, 2022a; 2022b). It then also announced a plan to start sales of bonds in the near future, including substantial sales of government paper (gilts) in 2023 combined with a full sale of its (small) entire portfolio of corporate bonds by the end of 2023. These announcements did not cause any ructions in the market. The 10-year gilt rate remained around 1.5% at the time of the first announcement and later increased gradually over the subsequent months, in line with inflation and global rates. One of the reasons was that the average maturity of the gilt holdings of the Bank of England is so high (above ten years<sup>9</sup>,

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<sup>4</sup> Sveriges Riksbank, 'Purchases and sales of government bonds'.

<https://www.riksbank.se/en-gb/monetary-policy/monetary-policy-instruments/government-bonds/>

<sup>5</sup> See Riksbank's press release of 9 February 2023 <https://www.riksbank.se/en-gb/press-and-published/notices-and-press-releases/press-releases/2023/riksbank-raises-policy-rate-by-0.5-percentage-points-and-starting-in-april-will-begin-selling-government-bonds/>

<sup>6</sup> See Bank of Canada's press release of 13 April 2022 <https://www.bankofcanada.ca/2022/04/bank-of-canada-provides-operational-details-for-quantitative-tightening-and-announces-that-it-will-continue-to-implement-monetary-policy-using-a-floor-system/>

<sup>7</sup> See speech from Christopher Kent, Assistant Governor at the Reserve Bank of Australia, on 23 May 2022 <https://www.rba.gov.au/speeches/2022/sp-ag-2022-05-23.html>

<sup>8</sup> See Reserve Bank of New Zealand's press release of 9 June 2022 <https://www.rbnz.govt.nz/hub/domestic-markets-media-releases/reserve-bank-details-planned-sales-of-new-zealand-government-bonds>

<sup>9</sup> <https://obr.uk/box/debt-maturity-quantitative-easing-and-interest-rate-sensitivity/#:~:text=The%20Bank%20has%20not%20yet,gilt%20stock%20to%2011%20years.>

compared to about seven years for the PSPP<sup>10</sup>) that passive QT alone would have meant a very slow decline in holdings.

In September 2022, the gilt market came under considerable pressure due to a combination of government announcements of a very expansionary fiscal policy and the unwinding of specific investment positions of pension funds. The 10-year rates increased within a few weeks from below 3 to over 4%.

In response to these disorderly market moves, the Bank of England announced a targeted short-term bond purchase programme, stressing that it would resell these bonds as soon as market conditions normalised.

In January 2023, the Bank of England announced that it had unwound these purchases, amounting to over GBP 19 billion<sup>11</sup>. This unwinding had started only in late November and thus took just six weeks. The GBP 19 billion of gilt sold is equivalent to about 1% of the total outstanding, or 2.5% of the holdings of the Bank of England. For the euro area, this would be equivalent to bond sales of about EUR 100 billion<sup>12</sup>.

The Bank of England made a profit in this operation. Gilt prices were lower (yields were higher) when it bought them than when it sold them a few weeks later. This is the typical outcome one would expect from an operation designed to stabilise markets. By contrast, the continuing purchases during long periods of orderly market conditions under QE operations are now resulting in large losses for central banks (and ultimately taxpayers) (see Gros and Shamsfakhr, 2022). These losses arise because central banks have a large number of bonds on their balance sheets which yield little to nothing because they were bought during the period of low rates before 2022, while the refinancing costs (what central banks have to pay to commercial banks to induce them to hold large amounts of deposits) have increased to 3%. These losses are no accident. Economic theory predicts that QE works because the central banks take over the duration risk inherent in long-dated bonds and thereby reduce the price of duration risk. This risk has now materialised.

Overall, in comparison with other advanced countries, the ECB seems to be more cautious than its peers while inflation has been at least as high in the euro area as in some of its peers. To other knowledge, there is no other advanced country where the central bank did not switch already in 2022 to zero reinvestment, whereas the ECB is still reinvesting approximately one-half of its PSPP holdings and intends to continue fully reinvesting PEPP holdings, which account for one-third of the total.

The main explanation for the caution of the ECB might be a concern for the stability of the bond markets of some highly indebted countries. It is difficult to judge whether these concerns are well founded. In principle, the ECB has instruments to counter bond market turbulence, including the Transmission Protection Instrument (TPI) created only a year ago (Angeloni and Gros, 2022).

The experience of the UK (and that of Sweden) thus suggests that the ECB could be much more ambitious in the reduction of bond holdings. At the very least, it should go for zero reinvestment. Moreover, in the current high inflationary environment, there seems to be no reason for the Eurosystem to continue holding large amounts of covered bonds and commercial paper. The stock of about EUR 650 billion of private sector bonds acquired under the APP could and should be sold quickly,

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<sup>10</sup> <https://www.ecb.europa.eu/mopo/implement/app/html/index.en.html>

<sup>11</sup> See Bank of England's press release of 12 January 2023 <https://www.bankofengland.co.uk/news/2023/boe-completes-unwind-of-recent-financial-stability-gilt-purchases>

<sup>12</sup> Given total euro-area government debt in the form of bonds of EUR 10 trillion <https://ec.europa.eu/eurostat/documents/2995521/15131955/2-21102022-BP-EN.pdf/eeb714b8-83c4-cd8c-56b8-e9aa7c5798a8>

allowing for a quicker reduction in the balance sheet. The (in our view misguided) argument that outright sales create a fragmentation risk does not apply in this case.

Inflationary pressures have been rather similar in major advanced economies even if other conditions (energy dependency, exposure to supply chain shocks, fiscal policy) have been widely different<sup>13</sup>. Inflation, if entrenched, poses similar risks to these economies. This will have large consequences for countries with weaker fundamentals and financial conditions in the euro area.

More than a decade of monetary easing in the form of large-scale asset purchases undertaken by central banks in several developed economies has encouraged the emergence of a large body of literature, addressing the implications of this policy action for the economy and financial markets as well as analysing its transmission mechanism or channels. By contrast, the infrequent experience with QT is accompanied by a limited understanding of this policy and its potential impacts. Most existing literature focuses on the impact of the Fed's QT, as it was implemented in the past, from 2017 to 2019. One way to gauge the impact of QT is to look into it through some of the transmission channels of monetary policy that are commonly identified and discussed in the economic literature. That said, it is difficult to assess the impact of QT in isolation while central banks have already started deploying their traditional tool of interest rates, increasing the policy rate by a record level.

Here we focus on the signalling channel, as one of the widely examined transmission mechanisms of unconventional monetary policy by central banks, particularly at a time of much uncertainty.

## 2.1. Signalling channel

A signalling channel (Romer and Romer, 2000) refers to central banks' communication of their policy actions to the public and to market participants. It is assumed to have an impact on market expectations about the development of future policy rates and therefore the long-term interest rates. The response of the market to the signals central banks try to convey can determine the success of the monetary policy in stabilising inflation or at least inflation expectations.

The effect of the signalling channel can be asymmetric for contractionary versus expansionary monetary policy. Bullard (2019) posits a marginal signalling effect for the Fed's QT compared with that from QE. He argues that the signalling channel works well when the policy rate is near zero (or the effective lower bound) and the Fed signals a commitment to keep the policy rate near zero for an extended period. Similarly, the size of the balance sheet and the pace of its adjustment in the conduct of monetary policy and balance sheet actions change the effectiveness of the signalling channel. The signalling effects of QT can be far weaker, where the balance sheet is reduced gradually and predictably, compared with those of QE, when conducted in a more discrete and unexpected manner (Lane, 2022a).

The signalling or announcement effects of QE have been extensively examined through event studies (Altavilla et al., 2015). For a sceptical view, see Belke et al. (2021) and Greenlaw et al. (2018).

Using an event study methodology, Krishnamurthy and Vissing-Jorgensen (2011) find evidence of the signalling channel for the Fed's QE programmes during 2008-2011, which lowered long-term bond yields. They attribute it to the market's expectations of the Fed's commitment to lower future short-term interest rates rather than changes in the risk premiums. Similarly, Eggertsson and Woodford (2003) argue that the signalling of the central bank's credibility and its commitment to a future policy path is the key factor in reaching a desirable outcome in the conduct of monetary policy.

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<sup>13</sup> In January 2023, the annual inflation rate in the UK reached 10.1 %, in the euro area 8.6% and in the US 6.4%.



Applying the event study approach, Smith and Valcarcel (2023) do not find any evidence of a signalling effect for Fed balance sheet normalisation during 2017-2019. They attribute this effect to some extent to the predictability of QT announcements by the Fed. It is argued that the announcement effects of the ECB's QT will also be much weaker than for QE, as it provides the financial markets with much less information about the future path of interest rates (Hernández de Cos 2022).

**Table 2:** Changes in 10-year US Treasury yields and term premiums around QT announcements

Announcement dates	Yields	Term premium
22 May 2013	8.4	5.3
19 Jun 2013	21.3	13.4
21 May 2014	3.5	2.1
9 Jul 2014	-4.5	-2.7
20 Aug 2014	2.5	1.8
17 Sep 2014	5.1	3.1
12 Jan 2017	0.8	0.4
5 Apr 2017	-2.1	-1.8
24 May 2017	-3.0	-2.0
14 Jun 2017	-4.6	-3.1
20 Sept 2017	3.7	2.5
3 Nov 2021	-3.4	-2.0
26 Jan 2022	6.0	3.2
4 May 2022	3.1	2.9
Average change	2.6	1.6

Source: Authors' elaboration based on data from the Board of Governors of the Federal Reserve System, and Federal Reserve, *History of the FOMC's Policy Normalization Discussions and Communications*.

Note: The values indicate 2-day changes (in bps) around the announcement dates. All rates are in basis points.

To draw a conclusion about the possible effects from the Fed's QT announcements, one needs to isolate the impact of other events, at least those related to the macroeconomic environment. A simple analysis of changes in the 10-year Treasury bond yield and its estimated term premium around the Fed's announcements related to tapering and/or terminating the past asset purchases shows that the direction of the effect was in general the same, but in most cases of very modest size (less than 10 basis points).

The only instance of a strong market reaction can be observed on 19 June 2013, with a spike in yields and the term premium, which rose by more than 20 and 13 basis points, respectively. This is referred to as the 'Taper Tantrum' because the market moved strongly after Federal Reserve Chairman Ben Bernanke made a statement about a possible reduction in the monthly pace of purchases later that year<sup>14</sup> (see Table 2). Although Bernanke had already signalled a likely slowdown in the pace of USD 85

<sup>14</sup>See full Bernanke's statement at <https://www.federalreserve.gov/mediacenter/files/fomcpresconf20130619.pdf>



billion in monthly asset purchases 'in the next few meetings' in May, the reaction of the bond market was not that strong at that point in time.

Still, the Taper Tantrum is not representative of market reactions to QT announcements in general. The average change in Treasury yields after QT announcements is only 2.6 basis points and even less for the term premium, which is the variable that should be most affected by QE or QT.

Also in early 2022, when the Federal Open Market Committee released principles for reducing the Fed's balance sheet<sup>15</sup>, the increase in Treasury yields and the term premium was relatively moderate. Several QT announcements appear to have been associated with a fall in the yield and the term premium (Table 2).

Overall, the use of announcement dates to gauge the impact of QT is more difficult than during the period when QE was a novelty and not so widely anticipated. In the same vein, it is thus possible that the muted impact of ECB announcements on the term premium (the main gauge of the impact of QT) was so limited because these announcements contained little new information. However, one would have expected the term premium to increase over the last year as QT became more and more certain. Yet, this has not been the case.<sup>16</sup> Even more surprising is the fact that the difference between (overnight indexed swap) OIS (riskless) rates and the rate on German paper (Bunds) has increased over the last year as the ECB pivoted towards QT (see Lane, 2022c).

## 2.2. Stocks versus flows

The impact of central bank asset purchases is commonly considered in terms of stock and flow effects. The stock effect refers to the impact of (the market assessments of) the overall size as well as the composition of the bond portfolio held by the central bank over the lifetime of the programme. This is based on the idea that the asset holdings of the central bank can affect the yield curve through duration extraction as, *ceteris paribus*, private agents have to hold less duration risk.

By comparison, the flow effect arises as a response of prices to the ongoing purchases – a result of the improvements in market liquidity and functioning induced by the central bank purchases. These flow effects have generally been found to be small and temporary (D'Amico and King, 2013; De Santis and Holm-Hadulla, 2017).

From the start of the PSPP in 2015, the ECB has emphasised that its asset purchase programme would influence the market through the expected stock of (future) purchases (see for example Altavilla et al, 2015; De Santis and Holm-Hadulla, 2017). Altavilla et al. (2015) argue that most of the impact of ECB asset purchase programmes has been the stock effects at the announcements of the programme rather than flow effects from the actual purchases. Similarly, De Santis and Holm-Hadulla (2017) capture a larger impact of the PSPP on sovereign bond yields, attributable to stock effects, which emerged in anticipation and at the announcements, while the flow effect appeared to be only limited.

For the US, D'Amico and King (2013) find a relatively large stock effect for the Fed's USD 300 billion purchase of US Treasury securities between March and October 2009. It led to a persistent downward shift in yields of about 30 basis points throughout the programme as an outcome of changes in the outstanding amounts of Treasury securities. They also attribute a decline in yields of 3.5 basis points, caused by purchase operations, to the flow effect.

<sup>15</sup> See Fed's press release of 26 January 2022 <https://www.federalreserve.gov/newsevents/pressreleases/monetary20220126c.htm>

<sup>16</sup> The estimates of the 10-year term premium for the Euro Area (EUTERPE <https://www.unive.it/pag/39846#c443268>) currently available until October 2022 show a relatively strong upward movement over 2022. One however cannot certainly attribute this to the expectations about a possible QT. This trend is presumably more due to an increased risk of a recession and the deteriorating economic outlook.

More recently, some ECB representatives have again stressed the stock effect<sup>17,18</sup> (Cœuré, 2019; Schnabel, 2021a and b).

For example, Cœuré (2019) posits a relationship between the free float of bonds (bonds held by the private sector) and the Bund-OIS spread. This line of thought would suggest that the share of holdings of the ECB (and potentially other price-insensitive holders) is a key variable. According to the Bundesbank<sup>19</sup>, the free float of Bunds reached a record low of only 30% by end-2021. Consistent with this, the 10-year OIS swap rate is now (early 2023) 50 basis points above Bund rates.

Schnabel (2021b) stated explicitly that ‘the expected stock of cumulative purchases – the key transmission channel in many theoretical models of central bank asset purchases – is dominant in non-stressed market conditions’.

These views have important implications for the potential impact of QT. If the stock effect is paramount, one should not expect much from recent ECB decisions, since PEPP holdings will not be allowed to fall until end-2024 and the pace of decline for the APP announced so far is so slow (EUR 15 billion per month until summer 2023) that the stock will hardly be impacted if the ECB were to continue at this pace.

However, even if the ECB were to lower the proportion of reinvestments further, it would still have holdings above the pre-pandemic level for several years; that would be the case even if none of the redemptions was reinvested.

As Praet (2018) explained, ‘[t]he winding-down of net asset purchases is not tantamount to a withdrawal of monetary policy accommodation’.

By contrast, if the flow of net purchases were to be the main determinant, the switch from large net purchases to (small) net reductions in holdings implemented by the ECB over the course of 2022 should have had an important impact on yields. The data on 10-year term premium for the euro area during this period shows little evidence for such an effect.<sup>20</sup>

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<sup>17</sup> See speech of former ECB Executive Board Member Benoît Cœuré at the ECB’s Bond Market Contact Group meeting of 12 June 2019 [https://www.ecb.europa.eu/press/key/date/2019/html/ecb.sp190612\\_1~1a3bede969.en.html](https://www.ecb.europa.eu/press/key/date/2019/html/ecb.sp190612_1~1a3bede969.en.html)

<sup>18</sup> See speech of ECB Executive Board Member Isabel Schnabel of 1 October 2021 <https://www.ecb.europa.eu/press/key/date/2021/html/ecb.sp211001~ca589c6afcen.html>

<sup>19</sup> Deutsche Bundesbank, Monthly report May 2022, p. 43.

<sup>20</sup> See EUTERPE <https://www.unive.it/pag/39846#c443268>

### 3. THE CAUTIOUS APPROACH OF THE ECB

#### 3.1. How long will it take to unwind the APP and PEPP?

The ECB has so far only communicated that it will reinvest all of the redemptions under the PEPP until the end of 2024 and reduce its APP holdings (mainly under the PSPP) by EUR 15 billion per month until July 2023. After July, the pace of reduction will presumably accelerate, but at present it is not known by how much. At EUR 15 billion per month (EUR 180 billion per year) it would take almost 20 years to reduce the PSPP holdings to zero. This would mean a continual strong stimulus, which would clearly not be appropriate.

At the same time, the ECB has also implicitly ruled out any sales of bonds<sup>21</sup>, probably because it fears that the bond markets of some peripheral countries might come under stress. This puts a limit on the speed of reducing the ECB's holdings.

Figure 3 below shows the simulated time path of the Eurosystem's holdings of bonds (from the legacy of both the APP and PEPP) if one assumes no reinvestments of redemptions as of March 2023. This would be a more aggressive QT than the one the ECB is likely to follow given that it has so far announced only a reduction of EUR 15 billion per month on the APP.

The horizontal line shows the level of holdings at the end of 2019, when inflation was below the ECB's target, with inflation persistently above 2% central banks should hold much less. Even under the aggressive run-off path assumed here, the holdings of the Eurosystem would sink below the 2019 level only by end-2030<sup>22</sup>, i.e. eight years after inflation went above 2%. For this entire period, the Eurosystem's holdings would exert a strong expansionary effect while the ECB might at the same time be trying to lower inflation via increases in its main policy rate. This period would thus be characterised by keeping long-term rates (or at least the term premium) lower than they would be otherwise combined with higher short term rates.

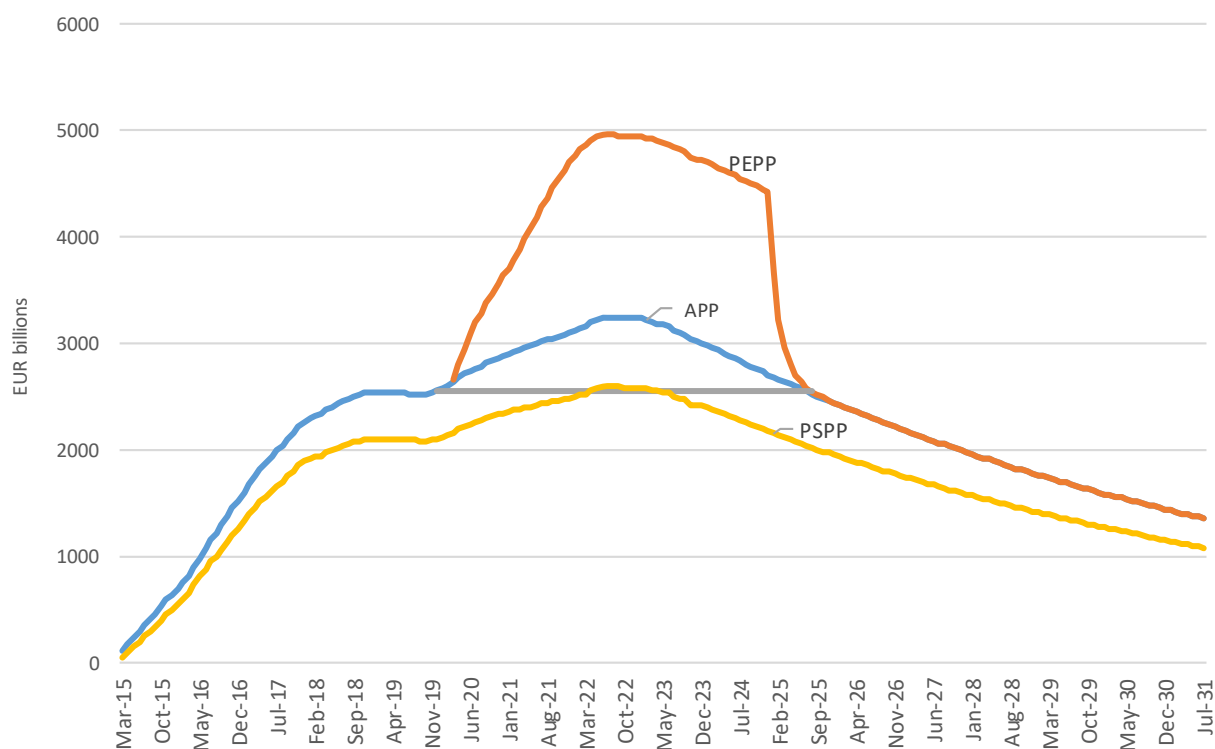
The chart shows also separately the two major components of the APP: the PSPP and private sector bonds (mainly covered and corporate bonds).

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<sup>21</sup> In June 2022, ECB decided to end net asset purchases under APP as of 1 July 2022. <https://www.ecb.europa.eu/press/pr/date/2022/html/ecb.mp220609~122666c272.en.html>

<sup>22</sup> With the assumption of no reinvestment of redemptions.

**Figure 3:** A simulation of ECB asset holdings by non-reinvestment of the APP and PEPP, respectively, as of June 2023 and January 2025

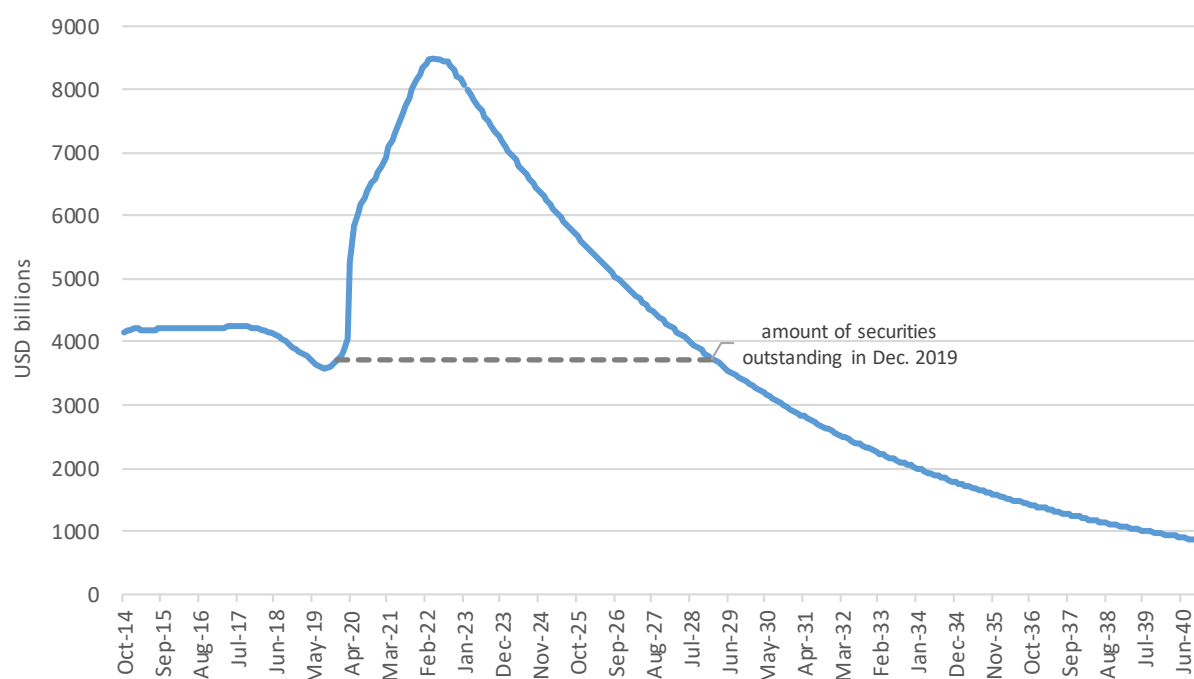


Source: Authors' elaboration based on data from the ECB.

Note: Simulations include redemptions. For 2023, we use the redemptions estimates from ECB, and for 2024 onwards we assume redemptions as a percentage of the holdings previous year (10%), under the assumption of a similar structure as for holdings (in terms of weighted average maturity and distribution over maturities).

The simulations also incorporate the EUR 15 billion APP reduction per month over the period March-June 2023, as announced by ECB on 15 December 2022. Based on the average PSPP redemptions over 2023, we assume that about 76%, of this asset reduction, equivalent to EUR 11.4 billion, is related to PSPP.

Using the same approach, we simulate the time path of the Fed's holdings of US Treasury and mortgage-backed securities, considering the non-reinvestment plan the Fed put into effect as of June 2022, with a maximum potential for the monthly balance sheet roll-off of USD 95 billion. We assume seven and ten years of average maturity for Treasury and mortgage-backed securities, respectively (see Figure 4). Under this scenario, the outstanding stock of Fed securities is expected to decline to the level of 2019 by the end of 2028, more than three years earlier than the ECB.

**Figure 4:** A simulation of the Fed's holdings of Treasury and mortgage-backed securities by non-reinvestment, as of June 2022

Source: Authors' elaboration based on Federal Reserve Economic Data.

Schnabel (2021a) argues that the stock of bond holdings at that time lowered long-term rates by 180 basis points and that, absent large asset sales, this effect would only slowly decline and still be around 120 basis points after four years. Our own rough simulations find a similar time path.

It is difficult to avoid the impression that the real reason why the ECB is not contemplating outright bond sales is that they would crystallise the losses the Eurosystem is now making on its stock of bonds. The market value of the bonds held by the ECB and National Central Banks (NCBs) in the Eurosystem is likely to have dropped by about 15-20% as yields have increased. For example, the price of Bund future (which is a contract on a notional German government bond of 8.5-10.5 years maturity)<sup>23</sup> has fallen by over 20% in 2022 as (long-term) interest rates have increased.<sup>24</sup>

It follows that if the Eurosystem were to mark its holdings to market (the Australian Reserve Bank has done this), it would have shown a loss of several hundreds of billions of euro. However, the bond holdings are held under amortised cost according to the rules of the Eurosystem. This means that the losses that arise because the 'refinancing rate' of the ECB (i.e. the deposit rate) is now much higher than the yield on the bonds acquired under the PSPP and PEPP will only gradually appear on the profit and loss accounts of the NCBs<sup>25</sup>.

### 3.2. Calibrating the continuing expansionary impact of ultra-slow QT

If the expansionary impact of QE depends on the size of the central bank's bond holdings, one can calculate the total overall expansionary impact by multiplying the amounts held by the Eurosystem by

<sup>23</sup> A contract on a notional German government bond of 8.5-10.5 years maturity <https://www.boerse-frankfurt.de/en/know-how/glossary/bund-future>

<sup>24</sup> See trend at <https://www.tradingview.com/symbols/EUREX-FGBL1%21/>

<sup>25</sup> For a detailed analysis of the fiscal cost of the ECB's bond purchases under the PSPP and PEPP, see Gros and Shamsfakhr (2022).

the years in months that these holdings remain on the balance sheets of the national central banks and the ECB.

We thus perform a simple exercise. We cumulate the monthly holdings under the APP and PEPP from early 2015 to end-2022, which we called the QE period. The resulting expansionary impact of the APP is equivalent to 18 ‘holding-years’, i.e. the equivalent of 18 years of holding EUR 1,000 billion of bonds (or holding EUR 18,000 billion worth of bonds for one year) (see Table 3 below).

We perform a similar calculation for the future holdings up to 2040 to gauge the cumulative expansionary impact of the slowly declining APP holdings over this period of ‘QT’, assuming that the ECB follows a policy of zero reinvestment. The expansionary impact of the remaining bond holdings falls over time for two reasons: holdings decline and the maturity of the remainder declines with the passage of time.

The result from this way of combining bond reductions and a shortening of the residual maturity is that the cumulative expansionary impact one can expect under the slow QT regime would be equal to EUR 26 trillion per year, even higher than that of the past<sup>26</sup>.

For the PEPP the comparison is even starker, since the PEPP was accumulated over a short period (i.e. April 2020 to February 2023), yielding an expansionary cumulative impact of EUR 3.6 trillion of holdings. Yet, the run-off of the PEPP holdings will take much longer than the build-up, and the cumulative impact of the time path of slowly declining PEPP holdings (which will be reduced only after 2024) is almost equal to the impact the PEPP has had so far.

**Table 3:** Outstanding stock of ECB Bonds

Unit: EUR trillion per year

	APP	PEPP	Total
QE period	18.0	3.6	12.7
QT period	25.6	3.5	29.1

Source: Authors’ elaboration based on data from the ECB.

Notes: Simulations include redemptions. For 2023, we use the redemptions estimates from ECB, and for 2024 onwards we assume redemptions as a percentage of the holdings previous year (10%), under the assumption of a similar structure as for holdings (in terms of weighted average maturity and distribution over maturities).

The simulations also incorporate the EUR 15 billion APP reduction over the period March-June 2023, as announced by ECB on 15 December 2022.

<sup>26</sup> This calculation considers only the amount of holdings. The duration extraction effect should decline more quickly as the duration of the remaining bonds declines over time.

## 4. INTEREST RATE HIKES VERSUS BOND SALES: REASONS FOR ULTRA-SLOW QT

The ECB was slow to normalise its policy, but once it started, it increased rates at an unprecedented speed as noted in a recent speech by an Executive Board Member of the ECB in Lane (2023).

### 4.1. Rate hikes versus QT

The ECB seems to focus at present on its policy rate as if QT does not matter much. The justification was given by Schnabel (2022), which is worth quoting in full:

*“The financing structure, in turn, has important implications for how strongly a given monetary impulse is transmitted to the real economy. Recent ECB staff analysis finds that when the share of bank loans in total external finance is high, like in the euro area, real GDP growth often shows only a weak response to changes in long-term interest rates (Slide 12, right-hand chart).*

*In other words, our key policy rates are best suited for influencing output and prices in the euro area during the normalisation process. Most of firms’ credit is either linked directly to short-term rates in financial markets, such as the EURIBOR, or has fixed maturities of short duration. Half of outstanding loans to euro area firms have a maturity of one year or less.*

*Long-term rates are not just less relevant for policy transmission, but also central banks have only indirect control over the part that is not related to the expected future path of short-term interest rates, i.e. the term premium.*

*The latter is affected by a host of factors, such as inflation uncertainty, global spillovers or demand by price-insensitive investors. The stock of bonds held by central banks is just one of these factors.*

*Balance sheet adjustments may thus not be well-suited as the main instrument for controlling the overall stance. This is also why our sequence foresees that policy lift-off will predate with some distance a reduction of our balance sheet.”*

The essence of the argument is that in a bank-based economy like the euro area, movements in the policy rate are a more potent instrument than bond purchases. Yet, it is not clear why this implies that asset holdings should not be reduced more quickly. The effect of stronger QT might not be large, but it would reinforce the tightening the ECB wants to achieve. Moreover, the limited effectiveness of bond purchases also applied in the past when the ECB started the PSPP or the PEPP although the ECB has consistently argued that its bond purchase programmes made a material difference to inflation via their impact on term premia and longer-term rates in general (Lane, 2022b).

### 4.2. Adjustment costs as determinants of the speed of QT

The only reason that could explain why the ECB did not decide to reverse the accumulated bond purchases more quickly (instead of maintaining holdings during a period of high inflation and a tightening cycle) must be that it fears turbulence in bond markets if it were to sell large amounts of bonds. The speed of QT is thus de facto limited by the perception of costs that would arise from bond sales.

These adjustment costs constitute the more important distinction between QT and rate hikes. Central banks can, and do, increase their policy rates by very large amounts within a short time, but they fear the consequences of sudden large bond sales.



The annex provides a simplified model of a central bank that wants to calibrate its monetary policy stance using two instruments, its policy rate and asset sales. These two instruments are not totally equivalent because the policy rate affects in the first instance the short-term end of the market whereas asset purchases affect mainly longer maturities (at least this was the aim of the PSPP and the PEPP). However, the central bank is in the end only interested in the aggregate monetary stance, which is influenced by both long and short rates. One can therefore view the two instruments as substitutable in terms of their impact on the overall monetary policy stance.

Substitutability in this context does not mean that one unit of asset holdings is equivalent to one unit of the policy rate. It only means that changes in asset holdings should be proportional in their impact on the monetary stance to changes in the policy rate. The factor of proportionality can be very different across countries, depending on the size of public debt and the nature of the financial system. As argued by Schnabel above, a more bank-based economy might react more to changes in the policy rate than to changes in the long-term rate induced by central bank asset holdings.

The key difference between the two instruments is that large asset sales might lead to costs. These costs might consist in the first instance of financial market disruptions. However, one could also hypothesise that large sales over a short period depress prices, thus increasing the fiscal cost of QT. Changing the stock of asset holdings quickly could lead to adjustment costs.

Taking into account these adjustment costs has major implications for the time path of policy. The annex provides a bare bones model of central bank policy settings in the presence of adjustment costs.

First of all, the model shows that policy rates will overshoot in the presence of adjustment costs. Upon impact, i.e. when a tighter monetary policy stance becomes available, policy rates are increased immediately. In this initial period, asset sales are minimal, providing little offset. After the initial impact has been absorbed mostly via rate hikes, the central bank starts asset sales. As its stock of holdings diminishes, the countervailing pressure it exerts diminishes and the central bank can lower policy rates.

The approach taken by the ECB – namely rate hikes first, QT later – implies an even more extreme overshooting, as during the first period of the revival of inflation the entire increase in the tightening has to be executed through rate hikes. Only later, as asset sales take place gradually, can the central bank again reduce rates (*ceteris paribus*, i.e. if it wants to maintain a constant restrictive stance).

The implication of the model, that policy rates will overshoot initially, is not due to its particular structure. It follows from common sense: if in the short run the ECB utilises only one instrument, rates, it has to move them by more than what is needed in the long run when QT has run its course. The main issue is how long this ‘long run’ will be.

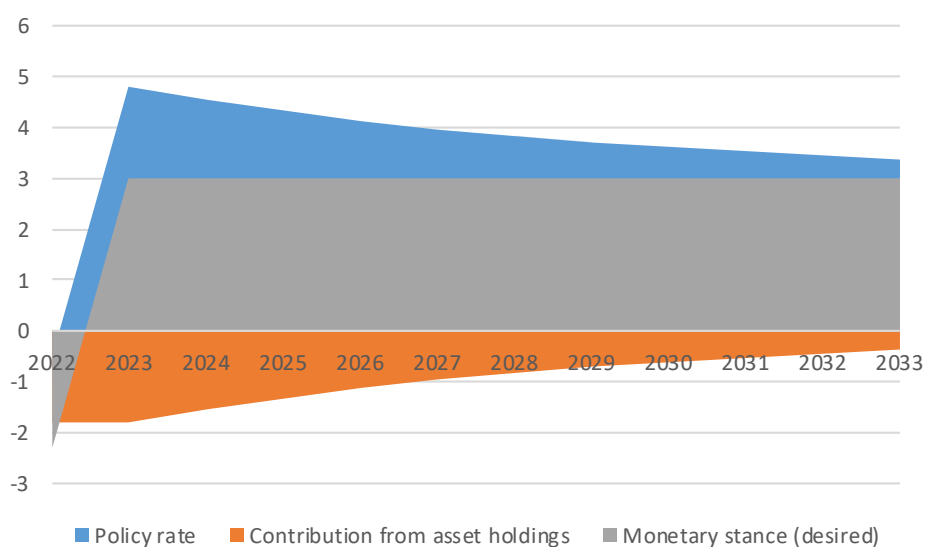
Figure 5 below illustrates the overshooting for a concrete case in which the desired monetary policy stance (delimited by the grey area) jumps in one year (2022) from somewhat below -2 to over 3% (and assuming it stays constant at this rate). However, the policy rate needs to jump from -0.5 to 4.8% in the first year because of the continuing expansionary effect of 180 basis points of the accumulated PSPP and PEPP holdings (Schnabel, 2021a). It is assumed here that bond holdings will start to decline only in 2024, allowing the ECB to ease gradually on the policy rate. However, the reduction in the policy rate made possible by the small reduction in holdings (i.e. without asset sales) is minimal, only 0.2 percentage points (per annum) because bond holdings diminish by only a tenth per annum (which would already require a reduction of over EUR 40 billion per month). At this pace of reduction, it will take ten years for the policy rate to return to 3% (the new long-term equilibrium value absent duration extraction by the ECB).

This is, of course, a stylised illustration of the framework in which the ECB determines its policy, where it is assumed that the 180 basis-point effect of the present PSPP and PEPP holdings persists and diminishes pro rata with asset sales. It is also assumed that this impact of bond holdings on the long



rate translates one-for-one into corresponding reductions in the policy rate.<sup>27</sup> A more detailed analysis would take into account the shortening of the remaining maturities even under constant holdings and other potential non-linearities in the impact of central bank asset holdings on the monetary stance.

**Figure 5:** Stylised overshooting under ECB policies



Source: Authors' calculations.

Notes: The figure illustrates the overshooting with a numerical example ( $MSQT=3$ ,  $MSQE=-2$ ,  $\gamma=0.4$ ,  $h^*=0$  assuming an arbitrary path for the reduction of asset holdings (1/5th each year). This path would be the outcome of the model if  $h^*=0$  and  $\frac{\alpha}{[\gamma^2+\beta+\alpha]} = 0.8$ .

The ECB has chosen a very slow path of asset reductions because it fears disruptive effects from bond sales. We do not share this fear of bond market disruptions. The experience of the Bank of England suggests that the market can absorb bond sales if their scale and purpose are announced sufficiently in advance. There is no reason to believe that in the euro area the impact on highly rated sovereign borrowers would be any different. It is possible that the rates for highly indebted euro area sovereigns would go up more. Yet, if this were the decisive concern for the ECB, it would show that it is now modulating its policy to lower the borrowing costs of some governments. This is not the task of the ECB.

In terms of the model presented in the annex, our own estimate of the adjustment cost parameter would thus be much lower than the ECB's estimate. However, the purpose of the model presented in the annex is mainly to provide a framework for thinking about a central bank which perceives high adjustment costs, not to be prescriptive of what the ECB is doing.

<sup>27</sup> See Wei (2022).

## 5. CONCLUSION

The time path for reducing the bond holdings of the Eurosystem is slow – much slower than the path along which these bonds were accumulated under the APP and PEPP. The balance sheet reduction is thus more like a glacier retreating under the impact of global warming than a decisive tightening of policy – with limited impact on markets and the broader economy.

Unlike the situation when the ECB started QE (under the APP/PSPP), it now has two policy instruments, namely its main policy rate (the deposit rate) and balance sheet reduction. The ECB will calibrate both instruments so that their joint effect on the economy is of the desired magnitude. This implies that one cannot determine the impact of QT on the economy in isolation. What matters is the combination of the speed of reducing bond holdings and the policy rate. A quicker reduction in bond holdings (more QT) could be offset by a lower policy rate.

The fact that these two policy instruments are determined together (and the fact that the balance sheet reduction will proceed only at a very slow pace) explains why the market reaction to announcements on QT, including those of the ECB, has been rather muted.

Economic theory (and speeches by ECB representatives) implies that the main impact of central bank bond purchases comes through the stock of bonds held by the central bank, not the amount bought or sold every period. Because of the slow pace in reducing the Eurosystem's bond holdings, the Eurosystem will continue to hold very large amounts of bonds, for a number of years. This implies a continuing easing effect on long-term rates, which will only gradually disappear. Preliminary calculations show that even under the quickest reduction in holdings that can be achieved through run-offs alone (i.e. without outright sales), the continuing easing impact would persist for several years, and in the case of the PEPP for much longer than the roughly 2-year period during which the holdings were accumulated.

The ECB is thus essentially keeping one foot on the accelerator through its large bond holdings while at the same time applying the brake by increasing its interest rates. This implies that the ECB will have to increase its policy rate by more than it would if it did not have these large bond holdings.

Estimates of the impact of the PSPP on inflation differ widely, but a survey (Beckmann et al. 2020) suggests that it increased inflation in the Harmonised Index of Consumer Prices (HICP) by about 1 percentage point. That stimulative effect was welcome in the past, but no longer today. By proceeding more quickly with asset sales, the ECB could materially diminish inflationary pressures (over and above the impact of higher policy rates). Lane (2022b) argues that the PEPP added another percentage point. This inflationary impact continues as long as the ECB maintains most of the PSPP and PEPP holdings on its balance sheet – which is clearly unwarranted with inflation so far above the target.

Another observation is that there is no substantial reason to differentiate between PSPP and PEPP holdings. They are totally fungible for market conditions (and the ECB has given no reason why they should be treated differently). It is true that the ECB had announced some time ago that it would not reduce PEPP holdings before 2025. However, the ECB has also changed abruptly the way it calculates the cost of the targeted longer term refinancing operations (TLTROs), which broke a previous announcement. The main reason might be that the ECB has reserved for itself the right to deviate from the capital key for the PEPP. However, the ECB has not acknowledged this motive.

Even granting this argument regarding forward guidance on the PEPP, it is difficult to understand why the ECB has started with such a slow pace in reducing APP holdings (EUR 15 billion per month).

The terms of reference for this paper did not include a request for policy recommendations. However, our analysis strongly suggests that the ECB is too timid in the pace at which it is reducing bond holdings.

At the very minimum there should be no reinvestment of maturing PSPP bonds after July of this year and the ECB should now announce the beginning of a programme of sales, of about one half of 1% of holdings every month (as the Bank of England has done). This policy should be extended to the PEPP from the end of 2024 onwards, as it would allow the ECB to reduce its asset holdings to the pre-pandemic level in a few years. The TPI could be used should this quicker QT lead to any turbulence in some bond markets.

The ECB should also announce a program to sell its holdings of private sector securities (corporate and covered bonds) over the next 12-18 months. There is no justification for keeping them on the balance of the Eurosystem as the market is working perfectly well.

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## ANNEX. A BARE BONES MODEL OF QT WITH ADJUSTMENT COSTS

### The model

The purpose of the following formal set-up is to describe the behaviour of a central bank that has to calibrate the impact of its asset holdings and its policy rate on the economy when changes in asset holdings are costly.

Formally, the first building block is a loss function that incorporates three elements:

$$Loss_t = (r_t - r^*)^2 + \beta(h_t - h^*)^2 + \alpha(h_t - h_{t-1})^2 \quad (1)$$

The first element on the right-hand side of this expression represents the assumption that the central bank would like to keep its policy rate,  $r_t$ , in each period close to the equilibrium rate,  $r^*$ . The second element represents the idea that the central bank would like to keep its asset holdings close to a certain target level,  $h^*$ , which could be zero (as before QE started), but it could change over time (e.g. the Federal Reserve has explicitly announced that in future it would like to keep a larger balance sheet than before the financial crisis). For the ECB, one might assume that  $h^*$  has not changed and remains close to zero. The parameter  $\beta$  indicates the relative importance of keeping asset holdings close to the target.

The decisive element, which can explain the gradual pace of asset sales adopted by all central banks is that there are costs to changing the asset holdings of the central bank very quickly. These costs reflect mainly potential market disruption that could arise if the central bank were to suddenly offload all of the holdings that might become excessive when inflation increases rapidly. The adjustment costs take the usual quadratic form and the parameter  $\alpha$  reflects the (at least perceived) strength of these costs. Given the concern of the ECB about market segmentation, one might surmise that the parameter  $\alpha$  is higher for the euro area than for the US or the UK (or other central banks). It is assumed here that the adjustment costs arise only from any change in holdings, there is no difference between outright sales and run-off via the non-investment of redemption.

Recapitulating the notation:  $r_t$  = policy rate,  $r^*$  = equilibrium rate,  $h_t$  = holdings of assets by the central bank,  $h^*$  = desired holdings,  $\beta$  = weight of excessive holdings in the loss function,  $\alpha$  = the weight of adjustment costs of quickly changing holdings in the loss function (which should be related to the fragility of the bond market).

The effective monetary stance is the sum of the policy rate and the impact of asset holdings on the monetary stance where the parameter  $\gamma > 0$  denotes how a unit of asset holdings translates into an equivalent of a lower policy rate. Central banks engaged in massive asset purchases when their policy rates reached zero (of an effective lower bound close to zero) because they believed that by extracting duration from the market they could stimulate the economy.

$$MS_t = r_t - \gamma h_t \text{ (For } r_t > 0 \text{)} \quad (2)$$

This formulation implies that it is the stock of asset holdings which determines the expansionary effect of QE, not the flow. (See Schnabel 2022 on this point.) Equation (2) implies that conventional and unconventional policy instruments are substitutable (see Sims et al., 2019). Substitutability does not mean that they have the same effect, only that both instruments have an impact on the overall monetary stance, which is the decisive point for a central bank that wants to achieve a certain stance.

### Central bank choices

In this set-up, the central bank can use two instruments (the policy rate,  $r_t$ , and (changes in) asset holdings,  $h_t$ ) to achieve its desired monetary policy stance. However, in view of the substitutability

between these two instruments given by equation (2), this boils down to choosing asset holdings so as to minimise the cost function (1) subject to (2).

Cost minimisation with respect to current asset holdings (taking those from the past as given) requires

$$\frac{dLoss_t}{dh_t} = 0 = \gamma((MS_t + \gamma h_t) - r^*) + \beta(h_t - h^*) + \alpha(h_t - h_{t-1}) \quad (3)$$

or

$$-h_t[\gamma^2 + \beta + \alpha] = \gamma(MS_t - r^*) - \beta h^* - \alpha h_{t-1} \quad (4)$$

which can be simplified to

$$h_t = \frac{\beta h^* - \gamma(MS_t - r^*)}{[\gamma^2 + \beta + \alpha]} + \frac{\alpha}{[\gamma^2 + \beta + \alpha]} h_{t-1} \quad (5)$$

Asset holdings thus follow a difference equation that is stable, since the coefficient on the lag is smaller than one.

One can also write the time path of asset holdings as:

$$h_t - h_{t-1} = \frac{\beta h^* - \gamma(MS_t - r^*)}{[\gamma^2 + \beta + \alpha]} - \frac{\gamma^2 + \beta}{[\gamma^2 + \beta + \alpha]} h_{t-1} \quad (6)$$

Given the holdings inherited from the past ( $h_{t-1}$ ), the stock declines as long as the adjustment cost effect (last term) is larger (in absolute value) than the effect coming from the fixed term, i.e. the combination of the desired asset holding ( $h^*$ ) and the difference between the monetary stance at that point in time and the equilibrium interest rate ( $r^*$ ).

The law of motion (6) also implies that the adjustment to any 'asset overhang' on the balance sheet of the central banks (e.g. the PSPP and PEPP holdings of the ECB as of end-2022) is only slowly wound down. The speed of adjustment depends on the adjustment cost parameter alpha. The higher the alpha, the slower is the adjustment.

If the target holdings are equal to zero ( $h^* = 0$ ) as before the QE period and the desired monetary policy stance is equal to the natural rate, holdings will decline over time asymptotically towards zero.

## Monetary policy regimes

In principle, the desired monetary stance could change each period, leading to a path of holdings that is irregular. In the following discussion it is more interesting to consider two different 'regimes' of monetary policy, each of which lasts a large number of periods, allowing the system to reach the steady state. One regime, which might be called secular stagnation, is characterised by an expansionary monetary stance, denoted by  $MS_{QE}$  and another regime, which might be called revival of inflation, requires a tighter stance, denoted by  $MS_{QT}$ .

In the more general case of desired asset holdings above zero, the steady state level of asset holdings can be calculated from the condition that the change in asset holdings is equal to zero:

$$0 = \frac{\beta h^* - \gamma(MS_{QE} - r^*)}{[\gamma^2 + \beta + \alpha]} - \frac{\gamma^2 + \beta}{[\gamma^2 + \beta + \alpha]} h_{ss, QE} \quad (7)$$

which can be solved to yield

$$h_{ss, QE} = \frac{\beta h^* - \gamma(MS_{QE} - r^*)}{\gamma^2 + \beta} \quad (8)$$

The asset holdings that would result from a long period of revival of inflation would be given by:



$$h_{ss,QT} = \frac{\beta h^* - \gamma(MS_{QT} - r^*)}{\gamma^2 + \beta} \quad (9)$$

The difference between the two, i.e. the fall in steady state asset holdings resulting from a shift in regime is given by (assuming no change in desired holdings,  $h^*$ , and the equilibrium rate,  $r^*$ ):

$$h_{ss,QE} - h_{ss,QT} = \frac{\gamma(MS_{QT} - MS_{QE})}{\gamma^2 + \beta} \quad (10)$$

The larger the difference between the desired monetary policy stances between the two regimes, the larger will be the difference in long-term asset holdings. If the central bank does not care much about its target asset holdings ( $\beta$  small), the difference in monetary policy stance will be magnified by a small value for  $\gamma$ . The intuition is that the central bank needs to buy more assets if QE does not have a strong impact on monetary conditions.

One can now imagine a sudden jump from one regime to the other. This would be a good description for the sudden emergence of inflation as a problem in 2022. Such a sudden jump, or step change, would lead to a jump in the steady state holdings, yet would not translate immediately into sales of a corresponding amount because this would involve adjustment costs.

## Gradual adjustment to regime change

The law of motion, equation (6), can be used to calculate the asset sales that would occur during the first period of a revival of inflation.

$$h_{t=1,QT} - h_{ss,QE} = \frac{\beta h^* - \gamma(MS_{QT} - r^*)}{[\gamma^2 + \beta + \alpha]} - \frac{\beta h^* - \gamma(MS_{QE} - r^*)}{[\gamma^2 + \beta + \alpha]} \quad (11)$$

This can be simplified to:

$$h_{t=1,QT} - h_{ss,QE} = \frac{-\gamma(MS_{QT} - MS_{QE})}{[\gamma^2 + \beta + \alpha]} \quad (12)$$

Comparing this to the difference in the steady state holdings, equation (10) establishes that only a fraction of the steady state difference will be eliminated through QT (reduction in asset holdings) during the first period of the revival of inflation. This fraction is smaller the higher the adjustment cost parameter,  $\alpha$ , as can be verified by substituting the equation (10) (the difference between steady state holdings) in equation (12) above:

$$h_{t=1,QT} - h_{ss,QE} = \frac{[\gamma^2 + \beta]}{[\gamma^2 + \beta + \alpha]} (h_{ss,QE} - h_{ss,QT}) \quad (13)$$

These results for asset holdings can then be used to investigate the time path for the policy rate using equation (2), which links holdings and rates via the desired monetary policy stance.

## Overshooting

For the first period after the revival of inflation, one needs to take into account the increase in the desired monetary stance.

$$r_t - r_{t-1} = MS_t + \gamma h_t - (MS_{t-1} + \gamma h_{t-1}) \quad (14)$$

In the concrete case considered here this translates into

$$r_{t=1,QT} - r_{ss,QE} = MS_{QT} - MS_{QE} + \gamma(h_{t=1,QT} + h_{ss,QE}) \quad (15)$$

Substituting out from equation (12) above yields:

$$r_{t=1,QT} - r_{ss,QE} = MS_{QT} - MS_{QE} - \gamma \left( \frac{\gamma(MS_{QT} - MS_{QE})}{[\gamma^2 + \beta + \alpha]} \right) \quad (16)$$

This can be simplified to:

$$r_{t=1,QT} - r_{ss,QE} = (MS_{QT} - MS_{QE}) \left( \frac{\beta + \alpha}{[\gamma^2 + \beta + \alpha]} \right) \quad (17)$$

The policy rate thus increases immediately, but not by the full amount of the increase in the desired monetary policy stance because some limited asset sales provide a partial offset. A higher (perceived) adjustment cost parameter (i.e. a higher  $\alpha$ ) leads to a larger jump in the policy rate because holdings fall by little and the expansionary effect of inherited asset holdings remains strong.

However, moving from the first to the second period (after the revival of inflation), one element of equation (17) disappears because the desired monetary stance does not change further. The change in the policy rate is then only a function of the change in asset holdings. As asset holdings fall, the policy rate can fall as the countervailing effect of large asset holdings declines slowly.

$$r_{t+1} - r_t = \gamma(h_{t+1} - h_t) \quad (18)$$

Since  $h_{t+1} < h_t$ , this establishes a central result: overshooting. Upon impact rates increase, but then fall.

In the parlance of financial markets, this overshooting corresponds to an inverted yield curve: the short-term rate is higher than the long-term rate because the average of future short rates is lower than the present one (and the still large bond holdings depress the term premium).

A much simpler case to analyse is what the ECB is planning: moving rates first and starting QT later. In terms of the model, this would be suboptimal, but this case is easy to analyse. Its implications are clear: on impact, the policy rate has to do all the work to increase the monetary stance given that asset holdings,  $h_t$ , remain constant.

$$r_{t=1,QT} - r_{ss,QE} = MS_{QT} - MS_{QE} \quad (19)$$

However, the ECB does plan to reduce asset holdings eventually. One must thus assume that from the first (or second?) period of the new regime, asset holdings decline. This decline reduces the downward impact of asset holdings and allows the ECB to lower rates. This policy of 'rates first, QT second' thus leads to an extreme overshooting. On impact of the revival of inflation, the policy rate has to be raised by much more than needed after asset holdings have adjusted. The price of the decision to go slow on one instrument (asset sales) is thus higher volatility of the other instrument (the policy rate).

Figure 5 in the main text illustrates the overshooting with a numerical example ( $MS_{QT} = 3$ ,  $MS_{QE} = -2$ ,  $\gamma = 0.4$ ,  $h^* = 0$  assuming an arbitrary path for the reduction of asset holdings ( $1/5^{\text{th}}$  each year). This path would be the outcome of the model if  $h^* = 0$  and  $\frac{\alpha}{[\gamma^2 + \beta + \alpha]} = 0.8$ .

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The ECB is now planning to run down its vast bond holdings acquired under the asset purchase programme—a “quantitative tightening”. However, the ECB is not contemplating selling any bonds, only not reinvesting part of what is coming due. Under this approach, the continuing expansionary effect of keeping vast holdings remains large and is likely to complicate the fight against inflation. The ECB currently has two, fungible, policy instruments (policy rates and balance sheet operations), which make it impossible to determine the impact of quantitative tightening separately.

This paper was provided by the Economic Governance and EMU Scrutiny Unit at the request of the Committee on Economic and Monetary Affairs (ECON) ahead of the Monetary Dialogue with the ECB President on 20 March 2023.

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PE 741.482

IP/A/ ECONMD/FWC/2020-002/C3

Print ISBN 978-92-848-0279-1 | doi:10.2861/825689 | QA-05-23-057-EN-C

PDF ISBN 978-92-848-0278-4 | doi:10.2861/517626 | QA-05-23-057-EN-N