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ABSTRACT

In response to the Global Financial Crisis, central banks engaged in large-scale asset purchases funded by the issuance of reserves. These "unconventional" policies continued during the pandemic, so that by 2022 central banks' balance sheets had grown up to ten-fold. As a result of rapidly increasing interest rates, these massive portfolios began producing substantial losses. We interpret these losses as fiscal policy consequences of quantitative easing and stress that they must be balanced against the prior benefits of implementing purchase policies. Importantly, losses differ qualitatively depending on whether the central bank chooses to buy domestic or foreign assets, thus resulting in transfers either within or between countries. Effects of losses may differ due to accounting rules (when losses are realized) and when the fiscal authority compensates for losses (the structure of indemnification agreements). Data from the Federal Reserve, the Eurosystem, and the Bank of England show that maximum annual losses are between 0.3 and 1.5 percent of GDP. By contrast, the Swiss National Bank is sustaining losses up to 17 percent of GDP.

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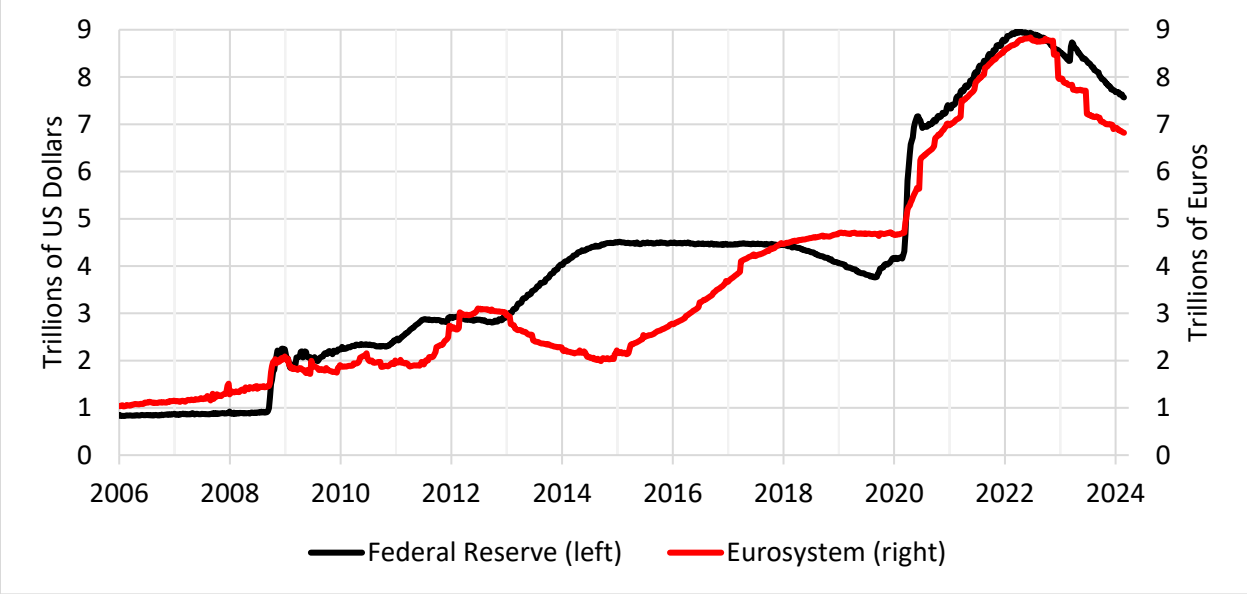
"*As the sole issuer of euro-denominated central bank money, the euro system will always be able to generate additional liquidity as needed. So, by definition, it will neither go bankrupt nor run out of money. And in addition to that, any financial losses, should they occur, will not impair our ability to seek and maintain price stability*." ECB President Christine Lagarde, Committee on Economic and Monetary Affairs Monetary Dialogue," 19 November 2020.

"A negative equity does not affect the Riksbank's ability to conduct monetary policy in the short term." Sveriges Riksbank Governor Erik Thedéen, Riksdag Committee on Finance, 24 October 2023.

1. Introduction

During and after the Global Financial Crisis of 2008-09, central banks around the world engaged in large-scale asset purchase programs significantly increasing the size of their balance sheets. Purchases continued during the pandemic in the early 2020s. This pattern is evident in Figure 1 where we plot the consolidated assets of the Federal Reserve System and the Eurosystem.[1] In both of these cases, total assets peaked at nearly 10 times their level in 2008.

Figure 1: Total Assets of the Federal Reserve and Eurosystem Jan 2006 to Mar 2024, weekly



Source: FRED

Importantly, central banks purchased bonds when short and long-term rates were low. So, when interest rates rose in 2022 and 2023, their holdings started to generate losses.[2] This sparked a

[1] The Federal Reserve System's balance sheet consolidates the balance sheets for the 12 Federal Reserve banks while the Eurosystem's combines that of the European Central Bank and the (currently) 20 National Central Banks in the euro area.

[2] In their survey of pandemic-related policies in 40 jurisdictions, Cantú et al. (2021) catalogue 21 cases in which central banks purchased domestic government bonds and 13 in which they purchased private assets. The latter

debate both over whether it was prudent to amass these portfolios in the first place, and over whether the mounting losses would undermine the ability of central banks to meet their price stability objectives. Indeed, some observers argue that it is important to focus on both central bank capital and profitability, concepts that were previously of limited interest to researchers and policymakers. The idea seems to be that the valuation effects and implications for net interest margins – i.e. losses associated with large asset purchases – are of sufficient size to have welfare implications for society. In contrast, the above quotes suggest that central banks themselves are much less concerned. And, as both President Lagarde and Governor Thedéen indicate, the idea that they might 'run out of money' seems novel.[3]

In this paper, we strive to provide a framework for understanding the medium- and long-run implications of the losses arising from central banks' large-scale asset purchases. Specifically, we suggest that they are best viewed as a form of fiscal policy.

To understand this conclusion, we start by showing how losses resulting from central bank policy are most easily understood if one consolidates the balance sheets of the central bank and the finance ministry. This change in accounting immediately clarifies how the ultimate economic effect of central banks' bond purchase programs and resulting potential losses arise from the fact that purchases change the maturity structure (and in some cases the gross quantity) of outstanding domestic sovereign debt.

When policymakers initially purchase the bonds, their objective is to reduce longer-term interest rates, compressing some combination of sovereign term spreads and risk premia on private sector bonds. If successful, these policies stimulate aggregate demand, stabilizing inflation, growth and employment, and the financial system. Ideally, this reduces the length and severity of recessions, thereby increasing aggregate welfare. To the extent that policies are enacted when term spreads are especially large, asset purchases also may generate large cash-flow gains from the fact that bond coupon payments exceed funding costs. However, as time passes and interest rates rise to their longer-run steady state level, funding costs will rise and the central bank will begin to suffers losses. If interest rates even rise further, for example due to policies designed to combat higher-than-expected inflation, these losses will increase. As a result, remittances from the central bank to the fiscal authority shrink. Depending on the structure of the indemnity agreement with the finance ministry, as well as the accounting rules that are in place, central bank losses (negative payments) may trigger an explicit fiscal expenditure either immediately or at some time in the future. It is in this sense that central bank balance sheet policies have direct fiscal consequences.

Our main focus in this paper is to analyze how central banks' balance sheet policies can result in losses and transfers. First and foremost, these depend on what it is that the central bank

included the Federal Reserve, the Eurosystem, the Bank of Japan, the Bank of England, the Bank of Canada, and the Sveriges Riksbank.

[3] As we discuss shortly, we assume that central banks have fiscal support and do not consider the case where central bank actions could become inflationary due to large operational costs and no fiscal support.

chooses to purchase: domestic sovereign bonds, domestic private sector bonds, or securities issued by a foreign entity. We show that purchases of domestic sovereign bonds change the maturity structure of privately-held government debt, implying no direct ex ante transfer of wealth, though there may be transfers ex post. Similarly, purchasing private-sector bonds can create ex post transfers. But since owners of the bonds' issuing companies are domestic, this is a within-country transfer. In contrast, purchases of foreign securities, regardless of whether the issuer is a sovereign or private entity, result in transfers to foreigners.

In addition, the central bank's governance structure and its specific policy objectives have implications. For example, an inflation-targeting central bank's jurisdiction may coincide with national boundaries, and asset purchases may be limited to primarily domestic securities. This describes the case of both the Federal Reserve and the Bank of England. Alternatively, a small open economy central bank targeting the exchange rate may purchase primarily foreign securities. As an example, consider the Swiss National Bank. Finally, as in the case of the Eurosystem, a monetary union with a set of national central banks and a common central bank at the center will have a set of rules regarding who holds which securities as well as how losses are distributed across member countries. We consider this case as well.

Before turning to a detailed analysis of the structure of central bank balance sheets and the implication of various types of losses, we should mention the issue of central bank solvency. As a technical matter, central banks have very little capital, so they are highly leveraged. For example, the Eurosystem as a whole has capital equal to €120 bn supporting total assets of €8.8 trillion in October 2022 – a leverage ratio of roughly 75. Similarly, the Federal Reserve System has $43 billion of capital with peak assets of $9.0 trillion, implying leverage of over 200. As a result, even very modest losses can lead to technical insolvency.

Reis (2015) provides an excellent summary of the various ways in which a central bank can become insolvent. The bottom line is that failure to remain solvent in the absence of fiscal support will result in the central bank being forced to issue additional reserves to finance its liabilities, potentially putting price stability at risk.[4] Importantly, with the appropriate fiscal support, solvency will never be an issue. Buiter (2008) explains how recapitalization of a central bank is in essence a trivial transaction within the government in which the fiscal authority can simply exchange government bonds for central bank equity. As we will see below, this has no impact at all on the consolidated balance sheet of the government. But if one separates the two balance sheets, it does recapitalize the central bank. We also assume that the central bank will always have sufficient funds to run its operations and pursue its mandates. We thus exclude the possibility that the central bank may have to 'fend for itself' and pay its own bills (salaries, rent

[4] Wessels and Broeder (2022b) also argue that solvency is essential if a central bank is to meet its policy objectives and retain credibility. They proceed to provide guidelines for determining the appropriate level of central bank capital.

etc.). That is, we assume the appropriate level of support from a fiscal authority that is running a sustainable policy.

The form and timing of the fiscal support is important. There are two aspects that are relevant: when the central bank realizes losses and when the fiscal authority transfers funds to make the central bank whole again. If the central bank realizes losses when securities are sold or mature, then the timing of sales becomes relevant. This is the case for the Bank of England. At the same time, if the central bank uses fair value accounting, i.e. if the central bank uses mark-to-market valuation of its portfolio, then losses are generated as soon as interest rates increase. This is what the Sveriges Riksbank does. Turning to when these losses trigger payments from the fiscal authority, there are two possibilities. One is that losses are paid for as they arise (e.g. Bank of England), while the second is that payments are delayed in some way (Federal Reserve). As we discuss the cases of different central banks, we also consider the impact of these institutional differences.

We should also note the very legitimate view that insolvency could be a signal that politicians are treating the central bank as a source of funds. This obviously leads to concerns about fiscal dominance that could drive up sovereign risk premia and expected inflation.[5] However, these are rather curious concerns, especially given the relatively modest size of realized losses.

While we do not examine the benefits of central banks' large-scale asset purchases in any detail, it is important to balance them against the losses. Gagnon (2016) provides an overview of the literature studying the effects on quantitative easing (QE), citing 'overwhelming evidence' that asset purchases eased financial conditions.[6] It is therefore likely that QE had a significant impact on aggregate demand, stabilizing growth and employment. This, in turn, generated direct fiscal benefits in the form of increased tax revenue. If the costs are in fact small, then they are most likely smaller than these benefits, even if the exact size of those benefits is uncertain.[7] Importantly, however, costs and benefits need to be compared from an ex-ante perspective and include the benefits that arose from the large portfolios prior to interest rate increases. That

[5] A number of papers discuss the relationship between the strength of central bank balance sheets and monetary policy, including inflation outcomes. These include Perera, Ralston and Wickramanayake (2013), who find that countries whose central banks have weak balance sheets experience higher inflation; Pinter (2018) who concludes that fiscal support is critical in determining the inflation outcome in these circumstances; Adler, Castro and Tovar (2018) who examine the impact of foreign exchange intervention on domestic monetary policy; Del Negro and Sims (2015) who discuss how losses can lead central banks to increase total government debt at a rate that is not sustainable, resulting in an explosive price path; and Nordström and Vredin (2022) and Wessels and Broeders (2022a) who both discuss the importance of having sufficient revenue to cover its operational costs if a central bank is to meet its monetary policy objectives.

[6] In contrast, in their extensive study of the impact of central bank balance sheet shrinkage (quantitative tightening) in seven jurisdictions, Du, Forbes and Luzzetti (2024) conclude that the economic and financial impact is modest.

[7] Greenlaw, Hamilton, Harris and West (2018) summarize the extensive debate over the impact of the purchases during and in the aftermath of the 2007-08 financial crisis. For a comprehensive discussion of the impact of large-scale asset purchases during the COVID-19 pandemic, the experiences in 19 jurisdictions, see Committee on the Global Financial System (2023).

comparison is beyond the scope of our analysis. Instead, we take the realized losses as one indicator of costs, exploring their size and implications.

The remainder of this paper is organized as follows. In Section 2 we present balance sheets for all the various economic actors: central bank, fiscal authority, commercial banks, households, and nonfinancial firms. We then merge the fiscal authority and central bank balance sheets to describe the consolidated government balance sheet.

Using this balance sheet framework, in Section 3 we turn to the simple closed economy case and discuss the case where a central bank purchases solely domestic sovereign debt, as well the case where they also purchase private sector debt. We explain how purchases of long-term government bonds shorten the average maturity of outstanding government debt. The addition of more short-term liquid government bonds reduces the expected size of interest expenses but increases its variability.[8] Indeed, the realized path of interest rates resulted in higher interest costs. The impact on ex ante welfare derived from a change in the maturity structure depends on the relative importance of these two effects – the benefits of liquidity services relative to the deadweight loss from taxation.[9]

We next consider purchases of private sector debt in which the central bank exchanges risky long-term private bonds for overnight reserves. This transaction increases gross government debt and reduces its average maturity. Since the purchase of private sector debt is a simple intermediation transaction, it supplies liquid assets but creates duration risk for the public sector as well as exposing it to potential ex post losses in the event of a bond's default. In turn, this risk is compensated by the central bank receiving the associated credit spread of the debt. As with purchases of domestic sovereign debt, the net welfare effect is ambiguous.

We illustrate this analysis with a description of transfers to their respective fiscal authorities of the Bank of England and the Federal Reserve.[10] Both hold primarily domestic bonds. But the specific holdings, size and treatment of losses are different. First, the Bank of England holds almost exclusively UK gilts, while the Fed holds a mix of Treasuries and government-insured mortgage backed securities (MBS). Second, the UK has indemnification rules which mean that any realized losses translate almost immediately into a fiscal expenditure. In the case of the Fed, the losses simply postpone the date when transfers to the US Treasury will restart (they are currently on hold). Finally, the undiscounted sum of the Bank of England's losses appears to be larger than that of the Fed – 7.87% versus 0.82% of nominal GDP – and could stretch out for decades as opposed to lasting for only a few years.

In Section 4 we turn to the open economy case where the central bank purchases foreign securities. Here, the transfers are between domestic residents and foreigners. Assuming that a

[8] See Greenwood, Hanson, and Stein (2015).
[9] For discussions of the costs of taxation, see Barro (1974), Lucas and Stokey (1983), Bohn (1990).
[10] For a comprehensive examination of how central bank and fiscal authorities handle transfers associated with profits and losses, see Chaboud and Leahy (2013).

country's government places different welfare weights on domestic and foreign residents, transfers are qualitatively different in terms of their welfare implications. We consider the case of the Swiss National Bank, which might be characterized as a small open economy. In stark contrast to the Fed and the Bank of England, the size of central bank losses, which are mainly transfers to foreigners, is quite large, net income varying from +8% to –17% of GDP in a year.

Finally, in Section 5 we examine the case of a monetary union in which there is a common central bank as well as national central banks. This is the structure of the Eurosystem. The national Central Banks all have balance sheets and share both income and risk. The result is that there are transfers among countries that depend on the relative sizes and movements of interest rates. But those transfers appear to be small and the overall consolidated losses look to be even smaller than in the United States.

Section 6 concludes.

2. Balance Sheets: Structure and Implications

The most straightforward way to understand the impact of central bank asset purchases is to see how they change various balance sheets. To do this, we start by presenting some stylized balance sheets for four sectors of a closed economy. These are the fiscal authority, the central bank, the private financial system, and private nonfinancial firms and households. Taken together, these provide a comprehensive summary of the wealth of an economy.

2.1. Public and Private Sector Balance Sheets

Table 1 provides four stylized balance sheets. For the time being we ignore two potentially important financial exposures. First, some entities may own assets issued by foreign entities, possibly in foreign currency. For example, entities may hold foreign currency, referred to as reserves in the case of the central bank, or foreign assets, e.g. the holdings of a sovereign wealth fund. We introduce this in Section 4 below. Second, there may be off-balance sheet exposures in the form of contingent assets and liabilities, e.g. deposit insurance. Including these exposures can be done in principle, but since they are not needed for us to make our main points, we ignore them throughout.[11]

It is worth discussing each of these balance sheets very briefly. Starting with the fiscal authority, the main asset is the present value of future tax revenue. In addition, there is the account at the central bank; and, since they own the central bank, the central bank's net worth is an asset of the fiscal authority as well. Real assets owned by the government are reflected in "Other Assets." Turning to liabilities, the fiscal authority issues government bonds. Its liabilities include

[11] Off-balance sheet exposures generally shift risk among and within the various groups we consider. One of our goals is to improve our understanding of how central bank balance sheet actions change that allocation of risk, so we take as given the initial distribution and simply go on from there.

the present value of future social insurance payments (Social Security and Medicare in the U.S.), which we include in "Other Liabilities."

Table 1: Stylized Balanced Sheets

A. Fiscal Authority

Assets	Liabilities
PV of Future Tax Revenue	Government Bonds
Account at Central Bank	Other Liabilities
Central Bank Net Worth	
Other Assets	
	Fiscal Net Worth

B. Central Bank

Assets	Liabilities
Government Bonds	Currency
Private Bonds	Commercial Bank Reserves
Loans to Banks	Fiscal Authority's Account
PV of Future Seigniorage	Other Liabilities
Other Assets	
	Central Bank Net Worth

C. Private Financial System

Assets	Liabilities
Commercial Bank Reserves	Public Customer Deposits
Government Bonds	Central Bank Borrowing
Private Bonds	Other Liabilities
Other Assets	
	Banking System Net Worth

D. Private Nonfinancial Firms and Households

Assets	Liabilities
Currency	PV of Future Tax Payments
Deposits at Commercial banks	PV of Future Seigniorage
Government Bonds	Private Bonds
Banking System Net Worth	Other Liabilities
Fiscal Net Worth	
Real Assets	Private Nonfin Net Worth

Panel B of Table 1 is a standard central bank balance sheet. The central bank owns government and private bonds, as well as making loans to banks. The present value (PV) of future seigniorage is also an asset. The central bank issues currency, reserve accounts, and provides an account to the fiscal authority.

Looking at the domestic financial system, again this is a standard balance sheet. Note that this is the balance sheet of the entire private financial system. So, in addition to banks, this includes insurance companies, pension funds, mutual funds, and other types of financial organizations.

Finally, we have the private nonfinancial sector balance sheet. Here, we are consolidating assets and liabilities within each of these sectors. For example, a household may make a loan to a firm or to another household. Furthermore, the firms are owned by the households.

2.2. Consolidating the Public and Private Sector Balance Sheets

An important contribution of our paper is to examine the consequence of central bank policy from the perspective of the consolidated government balance sheet. We therefore now use the balance sheets in Table 1 to examine the consequences of consolidating the domestic fiscal authority (Table 1.A) and the central bank (Table 1.B) into what we will label the government's balance sheet. Table 2 presents the result.

Table 2: Consolidated Balance Sheet of the Public Sector

Assets	Liabilities
PV of Future Tax Revenue	Govt Bonds held by private sector
PV of Future Seigniorage	Currency
Private Bonds held by the Central Bank	Commercial Bank Reserves
Central Bank Loans to Banks	Other Liabilities
Other Assets	
	Fiscal Authority Net Worth

Several implications of this consolidation are noteworthy. Looking at Table 2 we see that since three items are liabilities of one and assets of the other, they disappear. These are the fiscal authority's account at the central bank, the net worth of the central bank, and the domestic government bonds held at the central bank. In addition, the government bonds held by the central bank net out, so all that is left is government bonds held by the private sector – the combination of banks (and other financial institutions), firms, and households. This is an important point, and it is worth restating. Government bonds held by the central bank disappear from the public sector balance sheet. When this quantity changes, the government is simply lending more or less to itself. So, once we consolidate the fiscal authority and the central bank, the only bonds left are privately-held government bonds and the private sector bonds held by the public sector (a central bank asset).

This point is stronger than what is made by Barro (1974) when he noted the equivalence in present value between current and future taxation. In our case, a bond that is issued by one part of the government (fiscal authority) and then bought by another part of the government (central bank) does not enter the consolidated balance sheet. All future payments associated with such a bond appear as both assets and liabilities on the same balance sheet and therefore net out.

Turning to the private sector, consolidating the balance sheets of the financial and nonfinancial sector yields the balance sheet in Table 3. Note that the only private bonds (a liability) remaining are those held at the central bank.

Table 3: Consolidated Balance Sheet of the Private Sector

Assets	Liabilities
Currency	PV of Future Tax Payments
Reserves	PV of Future Seigniorage
Government Bonds	Private Bonds held by the Central Bank
Fiscal Authority Net Worth	Central Bank Loans to Banks
Real Assets	
	Private Nonfinancial Net Worth

3. The Impact of Central Bank Purchases of Domestic Securities

Using the consolidated balance sheets from Section 2, we can examine two central bank actions: the purchase of a domestic government bond and the purchase of a private sector bond. Importantly, we use the framework to examine the implications of central bank losses. Since central bank actions affect seigniorage and the maturity structure of sovereign debt, we also discuss the optimal maturity structure of government debt and determinants of seigniorage revenue.

In the final part of this section, we examine two cases that engage in primarily domestic bond purchases: The Bank of England and the Federal Reserve. We describe the size and the institutional treatment of the losses that are accruing. In the following sections, when discussing the open economy case, we consider the impact of asset purchases on the balance sheets of the Swiss National Bank and the Eurosystem.

3.1 Purchases of Domestic Sovereign Securities

When the central bank purchases a government bond in the secondary market, it changes the composition of government liabilities but not their level.[12] The standard case is that the central bank creates reserves to purchase long-term government bonds. The result is a shortening of the maturity structure of outstanding government liabilities leaving the total size unchanged.

The overall effect of a shortening of the maturity structure of government debt on cash flows is ambiguous. Longer term bonds have, on average, higher interest costs due to the term spread. At the same time, fixed-rate long-term bonds have fixed funding costs, while short-maturity debt has variable funding cost. A shorter maturity structure therefore results in more variable government debt funding costs. Since shortfalls have to be covered by higher taxes, and since costs of taxation likely increase more rapidly as the tax rate rises (the costs are convex), a shortening of the maturity structure may create a deadweight loss. At the same time, a shorter maturity structure may result in lower interest costs. This tradeoff was present prior to central bank asset purchases and one might assume the maturity structure was ex-ante optimal before the policy was enacted. In this case, large-scale asset purchases may have had a small expected cost associated with a move away from this optimum.

If the purchases also reduce the long-term interest rate (possibly by compressing the term premium), this might act as an offset to the deadweight loss from taxation. Importantly, however, this is only relevant for long-term bonds issued by the fiscal authority and sold to the

[12] The central bank purchase of a government bond directly from the fiscal authority (in the primary market) creates new reserves, so it is the issuance of new government debt. That is, it increases the size of the public sector consolidated balance sheet, something that must be accompanied by an increase in the size of some asset, which could be either a real asset or a rise in the present value of future tax revenue.

private sector during the period over which large scale asset purchases were being made. But such an action by the debt manager runs counter to the objectives of the central bank. Assuming some degree of coordination, the size of such issuance is likely to be small.[13]

It is also possible to consider ex post costs of a shorter maturity structure. We discuss this below.

3.2 Purchases of Domestic Private Securities

When the central bank purchases a private bond, it changes the overall size of the consolidated government balance sheet, increasing both assets and liabilities.[14] Again, the central bank is creating reserves. But now it is using them to purchase private bonds. In essence, this transforms risky private sector debt into safe government debt. Importantly, since the private debt can be used to repay the reserves, *net* government debt does not increase and there is little if any need for additional future taxation. But again, there are consequences from the central bank financing long-term bonds by issuing short-term debt. In this case, there is a transfer of interest rate risk from private investors to future tax payers. Rather than holding private fixed-rate debt, the private sector now holds variable-rate reserves.

If the long-term interest rates increase (as has been the case), it is the central bank that faces the risk of mark-to-market losses on the private bonds. The government (through the central bank) is compensated for this risk through the term spread. But that was likely low when the central bank bought the bonds. In addition, the purchase shifts risk of default on private debt from the private sector to the government. However, the fact that the central bank reaps the risk premium from the private bonds reduces the size of the loss (unless there are larger-than-expected defaults).[15] Furthermore, to the extent that there is a liquidity spread on private bonds, the government may be compensated for holding illiquid securities.

Taken together, it seems unlikely that the government faces more than a very modest ex ante expected cost from purchasing private sector debt. That said, the ex post losses accruing from interest rate increases – both the negative carry and the losses at maturity – are the same as those associated with the purchase of domestic sovereign bonds. In addition, there may be ex post costs that arise from private sector bonds defaulting at a higher-than-anticipated rate. The

[13] See Greenwood, Hanson, Rudolph and Summers (2015) for a discussion of this issue in the United States.
[14] As we note earlier, at least 13 central banks purchased private sector domestic assets during the pandemic. Quantities varied widely. For example, the Bank of Canada purchased only CA$218 million, while the Eurosystem purchased (and at this writing still holds) €344 billion.
[15] When the central bank purchases private securities, it has to decide which ones to buy. As Cecchetti and Tucker (2021) discuss, this choice creates an opportunity to subsidize favored sectors. This is one reason that central banks were reluctant to purchase corporate bonds. This practice changed during the pandemic. See Buiter et al. (2023).

central bank balance sheets we consider either had very small holdings of private sector debt or were not hit by a lot of defaults, so we will not pursue this any further.

3.3 Central Bank Losses

We next consider the consequences of ex post central bank losses.[16] We can think of these losses as either declines in the value of the bonds the central bank holds or a negative cash flow. Valuation losses arise when interest rates rise, driving down the mark-to-market (or fair value) of both government and private bonds on the central bank's balance sheet. Cash flow losses come from two sources. The first is the negative net interest margin (or negative carry) and the second is the realized loss at maturity.

We first reiterate our earlier point about the consolidated government balance sheet. When the central bank uses reserves to purchase government bonds, losses from mark-to-market declines in the value of its government bond holdings do not appear on the consolidated balance sheet of the government. The losses of the central bank are the gains of the fiscal authority, so they are an internal government transfer. Using Table 1 as a guide, mark-to-market losses decrease central bank net worth as a result of the decline in the bond's value. But neither the holdings of government bonds by the central bank nor central bank net worth appear on the consolidated balance sheet (see Table 2).

However, the shortening of the maturity structure does have an effect. It shows up as negative carry. When the central bank purchased the government bonds, it replaced long-term bonds with reserves (which we think of having zero maturity). As a result, when the interest rate rises, the government's interest costs go up with it.

As we suggested earlier, in the absence of convex costs of taxation, these losses have no impact on welfare. What has changed is the overall interest cost of the debt relative to the no-large-scale-purchase counterfactual. There can, however, be distributional consequences to the extent that holders of debt and taxpayers are different. But if higher tax rates generate proportionally larger deadweight losses, then the shortening of the maturity structure of the government debt will reduce aggregate welfare. The reason is that the losses destabilize the tax rate needed to collect the revenue necessary to meeting the now variable interest payments on short-term debt. This reasoning does lead us to ask whether the impact of the central bank actions on the maturity structure of the government debt is good or bad – a question we return to shortly.[17]

The consequences of these losses are different for central bank holdings of private bonds. Here, both the valuation losses and the negative carry represent losses to the government (and gains

[16] For an in-depth discussion of central bank losses, see Archer and Moser-Boehm (2013).
[17] Since this is a government, we ignore the possibility that short-term debt may be difficult and costly to roll over.

to the private sector). Put slightly differently, when the central bank buys a bond issued by the private sector, it is as if they are making a loan to the issuing firm. The loan is funded by reserves. As the interest rate rises two things happen: the market value of the private domestic bond falls and the interest expense of the reserves rises. The first of these represents a loss in the net worth of the government and the second creates a net interest cost. Note that these two effects are not additive. Rather, they represent two ways of describing the same thing. The valuation loss is equal to the present value of the negative carry over the life of the bond plus the loss at maturity. Again, there may be distributional consequences. Relative to the no-purchase counterfactual, the government's net interest costs are higher. This reflects the fact that the private investors from whom the bonds were purchased are receiving higher interest rates on short term deposits compared to the coupon payments on the bond.

To help understand the mechanics of these losses, consider a simple example where the central bank holds a 3% annual coupon bond with 10 years remaining to maturity. Assume that the bond has a face value of 100 and that the central bank accounts for the purchase at historical cost. If the yield to maturity (when purchased) is 2%, then the purchase price for this bond is 109. Now, assume that the interest rate rises to 4%, so the price of the bond falls to 91.9. Immediate sale of the bond generates a capital loss of (*109 – 91.9) = 17.1*. The alternative to selling the bond is to finance the purchase of 109 at the current interest rate (4%), receive the coupon payments (3%), and then receive 100 at maturity. This results in an annual loss of *(0.04) x (109) – 3 = 4.36 – 3 = 1.36*, plus a realized loss at maturity of 109 – 100 = 9. The present value of these losses is the same as the loss that would be incurred from selling the bond immediately.

As this example makes clear, when the central bank uses historical cost (held-to-maturity) accounting, the decision to sell the bond, or hold it to maturity, has implications for the timing of losses but not their present value. Selling brings losses forward and makes them certain, while holding the debt both pushes the losses into the future and makes them uncertain. Depending on the indemnity agreement between the central bank and the fiscal authority, this could have implications for the temporal pattern of government taxation. We return to this point when we discuss the case of the Bank of England.

Importantly, note that when using fair value accounting, the central bank will realize the losses as they occur. Here, the difference between the two cases, one where the bond is sold and the other where it is held to maturity, is that the central bank will reap gains as the price returns to the face value (100 in the example) as it matures, as well as if interest rates were to fall.

The Sveriges Riksbank and the Bank of Canada are prime examples where the use of fair value accounting gave rise to large losses as interest rates rose. The Sveriges Riksbank reported a loss

of SEK 80 billion (roughly 5% of GDP) in 2022, while the Bank of Canada's loss that year was CAD 30 billion (1% of GDP).[18]

Before continuing, it is worth restating that the welfare impact of the central bank's losses (which is largely distributional) should be compared to the macroeconomic stabilization gains from the implementation of the asset purchase policies. These benefits come in the form of higher growth and employment and inflation closer to target. Not only does this increase social welfare, it also raises the net present value of government tax revenue. That is, if we look back at the consolidated balance sheet of the government in Table 2, we can see that this has an unambiguously positive impact as it raises the value of government assets without changing the value of government liabilities, so government net worth rises. Yet another benefit is the positive cash flow resulting from holding the large debt portfolios prior to interest rates increasing. We will discuss this effect in more detail below.

3.4 Two Digressions

Before continuing, we will digress and discuss two topics related to central bank balance sheet management: the optimal maturity structure of government debt and the role of seigniorage.

3.4.1 On the Optimal Maturity Structure of Government Debt

As we noted earlier, central bank purchases of long-term domestic sovereign bonds will shorten the maturity of government debt without changing its overall size. This effect can be large. For example, in the case of the United States, Mitra and Sack (2022) estimate that by mid-2022 the Federal Reserve's purchase of U.S. Treasury securities reduced the average weighted duration of publicly held government debt from 5.1 to 3.6 years. If the initial maturity structure was roughly optimal – and the debt manager does not take actions to reverse the impact of the central bank's actions – this will have social costs.

How large are they? Answering this question is beyond the scope of this paper. Instead, we will simply note the issuance of short- versus long-term government debt involves a tradeoff. As Greenwood, Hanson, Rudolph, and Summers (2015) discuss in detail, determining the optimal maturity structure of government debt requires balancing the benefits of the liquidity services against the deadweight costs of tax rate volatility. The former is the mirror image of the term premium that is evident in long-term debt, while the latter arises from the fact that costs of taxation are convex.

[18] See the Riksbank's Annual Report for 2022 and Bank of Canada's Annual Report for 2022. Similar to the case of the Federal Reserve discussed below, both of these central banks have agreements with their respective governments to retain profits for as long as it takes to return capital to an agreed upon level.

The point at which these benefits and costs balance depends on a host of national characteristics.[19] For example, Greenwood, Hanson and Stein (2015) argue that there are likely negative externalities associated with the private sector issuance of short-term liquid liabilities. Examples include the possibilities of runs and fire-sales. To reduce these externalities, the government (including the central bank) should issue more short-term liabilities. Another result that does emerge from several studies is that the higher the government debt to GDP ratio, the longer term the average maturity should be.[20]

3.4.2 The Role of Seigniorage

Seigniorage is the ability of the government to finance its activities through an increase in central bank liabilities – commonly known as "printing money." In our context, seigniorage is important because it is added to potential losses when determining central bank overall net income. In addition, it will be present in the future, after the effects of asset purchase policies have ceased, and so it can make up for today's losses. From this intertemporal perspective, we should consider the net present value of future seigniorage as an asset of the central bank. We include it as part of the central bank and the consolidated government balance sheet; we also note that it may be substantial.

So, when does seigniorage arise? The answer depends on several factors. What did the central bank purchase, government or private bonds? What did the central bank issue to make the purchase, currency or interest-bearing reserves?

When the central bank issues non-interest-bearing currency to purchase government bonds – the textbook case – the seigniorage is the growth rate of currency. But the revenue is far lower in all other cases. When the central bank issues interest-bearing reserves to purchase government securities, there is no seigniorage at all. And when the central bank uses interest-bearing reserves to purchase private securities, the seigniorage is the carry – which could be negative. So, as the amount of currency in circulation falls, as it has in some jurisdictions, the overall interest margin will fall affecting the amount of seigniorage revenue. In the case where the net interest margin fluctuates around a positive steady state so the net interest margin and the monetary base (currency plus reserves) is roughly proportional to nominal GDP, the level of seigniorage will be proportional to nominal GDP growth.

[19] See Belton et. al. (2018) for an empirical model that delivers the optimal maturity structure of U.S. government debt.

[20] See Greenwood, Hanson, Rudolph, and Summers (2015); Bandari, Evans, Golosov and Sargent (2017); and Mitra and Sack (2022).

3.5 The Case of the Bank of England

We now turn to two examples. The first is the Bank of England, which purchased primarily UK gilts.[21] The second is the Federal Reserve, which holds large amounts of both US Treasury securities and government-guaranteed mortgage-backed securities. In both cases, we focus on the flows between the central bank and their respective fiscal authority.

In a letter from 29 January 2009, Chancellor of the Exchequer Alistair Darling set out the terms of the Asset Purchase Facility (APF), a subsidiary of the Bank of England.[22] The letter describes the size of the facility, originally £50 billion; the eligible securities, including corporate bonds, commercial paper, syndicated loans, and certain asset backed securities; that the facility is financed by borrowing from the Bank of England; and, importantly, that the Government indemnifies the Bank of England, so it bears the risk.

The mechanics of this arrangement are as follows. The Bank of England lends funds to the APF, which uses the proceeds to purchase UK gilts. The facility receives interest income in the form of coupon payments on the gilts and pays interest at the cash rate (the overnight policy rate) to the Bank of England. The UK Treasury receives any surplus and must make up any shortfall.

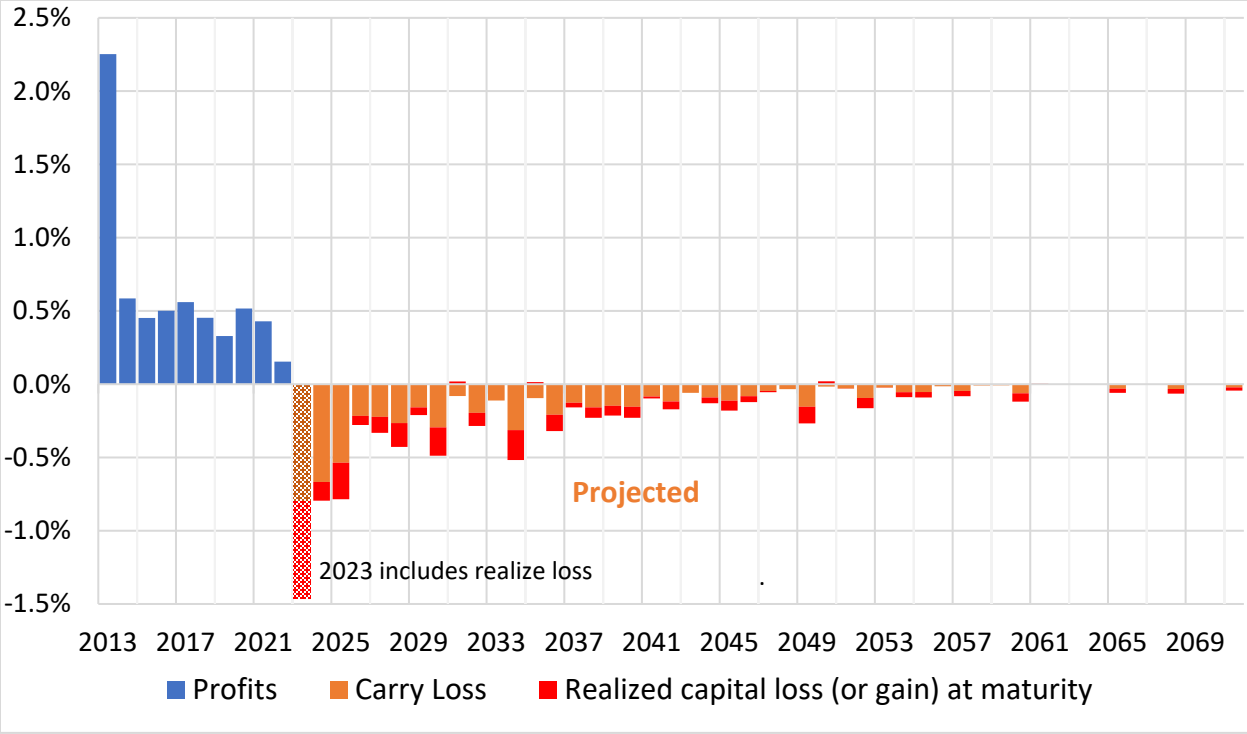
The consequences of this arrangement are straightforward. During the period of very low policy rates, the facility generated a positive cash flow for the fiscal authority. But, as policy rates rose over the last few years, the flow turned negative. To give a sense of the size of this swing, we can do a simple calculation for 2024. Start with the fact that the nominal holdings at the beginning of 2024 are £639 billion with £46 billion maturing during the year. These holdings yield coupon interest income of £15.2 billion. Next, note that the cost of these bonds, some of which were purchased at a substantial premium, is £744 billion of which £49.6 billion will mature. Using the OIS forward curve from January 2024 – 5.06% at 6 months and 4.23% at 12 months – this implies an interest cost of £33.6 billion. So, the net interest expense (the negative carry) of the APF is £18.4 billion. In addition, during the course of the year, £46 billion will mature and generate a realized loss (the purchase price minus the par value) of £3.5 billion. Adding these together, we see that the total loss is £21.9 billion, or roughly 0.8% of UK GDP.

Figure 2 shows the actual and projected transfers between the Bank of England and HM Treasury from 2013 to 2071 as a fraction of UK nominal GDP implied by current holdings assuming no active sales, so all bonds are held to maturity. From 2013 to 2022, the Bank of England made positive transfers that sum to 6.23% of UK GDP. In fact, the average for 2014 to 2022 (ignoring the large positive value in 2013) is 0.44% of UK GDP per year. Looking at the

[21] The Bank of England did purchase some private bonds. The maximum amount was roughly £20 billion out of a peak level of £890 billion. Furthermore, at this writing, all but £300 million remained. So, we ignore these.
[22] See here.

losses, we divide these into the negative carry (in orange) and the capital loss realized at maturity (in red). For 2023, we have actual numbers. This includes the losses realized on the sale of £46 billion worth of bonds that had not matured. The total loss of –1.43% of GDP is quite large. Our estimate suggests that roughly half of this is from realized losses associated with selling long-term securities purchased at a premium that were sold at a discount.[23] We also note that the sum of the (undiscounted) losses through 2071 is about –7.8% of GDP. This should be balanced against the combination of profits over the past decade (+6.2 percent of GDP) and the stabilization benefits from accommodative monetary policy.

Figure 2: Bank of England Asset Purchase Facility Net Profits and Losses, 2013 to 2071



Note: Data through 2023 are the net transfers from the Bank of England to HM Treasury as reported by the UK Office of National Statistics. For 2023, the division between the carry loss and the capital loss is the authors' estimate. Data for 2024 to 2071 are authors' estimates based on the information on the holdings of the Bank of England's Asset Purchase Facility, combined with a forward interest curve as published by the Bank of England, assuming that all bonds in the APF are held to maturity. Data for GDP through 2028 are from the IMF. From 2028 on, nominal GDP is assumed to grow at a 3.6% constant rate consistent with assumptions in the Office of Budget Responsibility (2023)
Source: UK Office of National Statistics, Bank of England, IMF World Economic Outlook Database, and authors' calculations.

[23] Since we do not know the exact purchase price of the lots sold, we compute the realized capital loss using the average purchase premium bond by bond and subtract this from the total published by the Office of National Statistics.

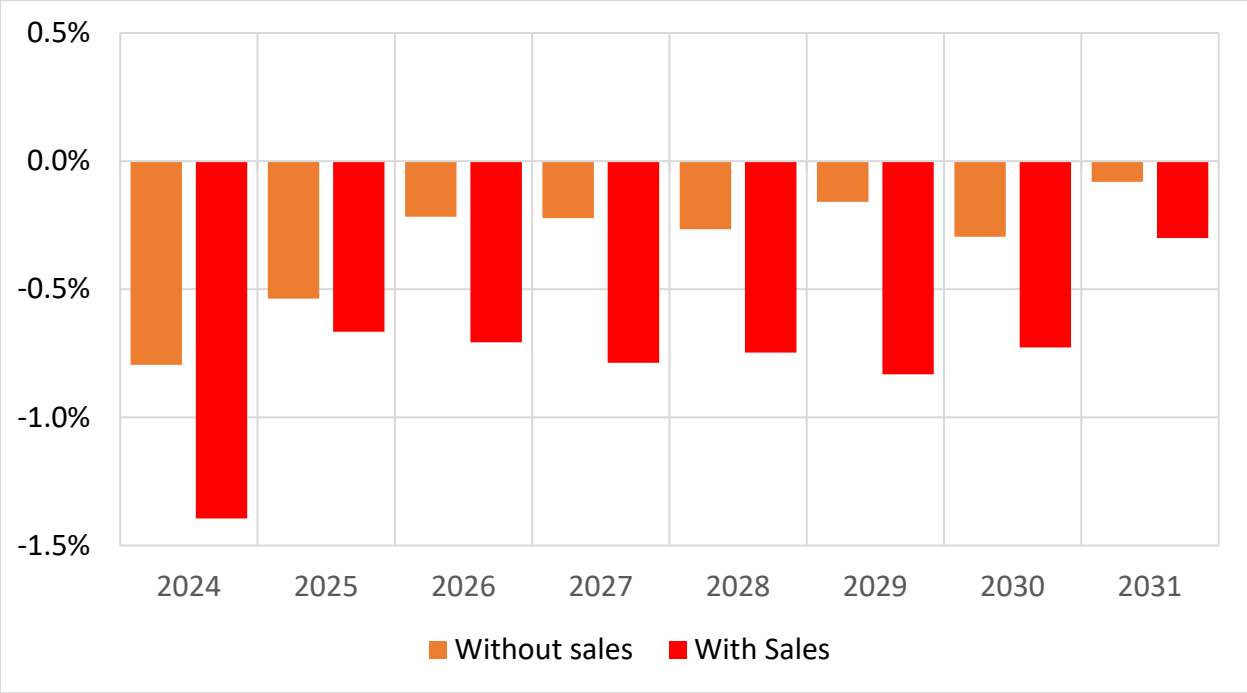
The financing arrangements for the APF mean that HM Treasury must make transfers to the Bank of England in compensation for the losses in the Asset Purchase Facility. These payments create a fiscal expenditure – both the negative cash flow and the realized capital losses. At one level, this is purely bookkeeping, as the amounts are exactly what the UK debt manager would have to pay if they had issued debt with the maturity structure of the consolidated balance sheet of the government. This means that the only true economic cost comes from the fact that the debt may be too short term relative to what would have been optimal ex ante.[24] But from a political perspective, there may be a problem as the APF's losses show up as an explicit budget expenditure for the government.

It is worth emphasizing that the estimates in Figure 2 represent the slowest possible path for the runoff of the APF. Because the Bank of England is choosing to sell bonds before they mature, the losses are being realized more quickly. The end-of-2023 Asset Purchase Facility Quarterly Report suggests a base case in which the combined maturities plus sales will be roughly £100 billion face value per year until nothing is left.[25] These sales can result in the realization of fairly large losses. To see how large, we note that the bonds currently in the APF were purchased at an average premium of roughly 15%. Sales in 2022 and 2023 were at a discount of 25%. That is, on average, bonds purchased at £115 are being sold for £75.

To understand the overall implications of this, we compare projected measures of the losses with and without sales in Figure 3. Over the 2024 to 2031 period, undiscounted losses without sales average £9.7 billion per year. By comparison, with sales, the average is £23.8 billion per year. As a percent of GDP, the path with sales averages 0.78% of GDP per year, while the path without sales implies average losses of 0.35% of GDP.[26] Two things explain the difference. First, the slower path averages the losses over a far longer period, and second it pushes some of the losses into years when nominal GDP is higher.[27] The smoother path clearly puts less short-run pressure on fiscal finances and may involve smaller deadweight losses of taxation.

[24] We note that this economic cost – the expected cost of a suboptimal maturity structure – is different from the ex post cost that we report in Figure 2.
[25] See https://www.bankofengland.co.uk/asset-purchase-facility/2023/2023-q4.
[26] Since UK government spending is roughly 45% of GDP, these numbers represent rough 0.8% and 1.7% of total fiscal expenditure.
[27] We note that a smaller level of nominal GDP growth may result in slightly larger future burdens when measured as a percentage of GDP.

Figure 3: Bank of England Asset Purchase Facility Net Losses with and without sales, 2024 to 2031



Note: We assume that the APF sells £100bn each year. The total is a combination of bonds that mature, paying the face value, and sales. We assume that the APF sells bonds across the board and measure the total size of sales using the average purchase price. Losses then have three components: negative carry, capital losses from maturing bonds, and capital losses from sales. We assume that the bank sells only bonds with maturities of 2032 and beyond since the other bonds will naturally mature within the time span it takes to unwind the APF. Projected sale prices are calculated by discounting bond cash flows using the forward gilt curve published by the Bank of England. Cost of carry is based on the forward OIS rates. Nominal GDP projections are based on a 3.6% annual growth rate. Source: Bank of England and authors' calculations.

To summarize, at the beginning of 2024, the UK's APF has large holdings with significant unrealized losses. The institutional arrangement between the Band of England and HM Treasury means that APF losses are covered by HM Treasury as they occur. The apparent current schedule of bond sales, together with this institutional setup, implies substantial deficits for the fiscal authority.

Indeed, the UK government is well aware of these implications:

> *"When the Bank of England voted to implement quantitative tightening in September 2022, it put the UK economy in uncharted territory — particularly in terms of the decision to actively sell gilts back to the market.*
>
> *No major central bank has pursued [quantitative tightening (QT)] in this way. Both the Federal Reserve and the European Central Bank have opted only for the passive method of allowing their bonds to mature without replacement."*
>
> *Harriett Baldwin, chair of the House of Commons Treasury select committee,* 7 February 2024.

It is possible that active quantitative tightening, as appears to be pursued by the Bank of England, is a deliberate choice in setting monetary policy so as to ensure price stability. This view is suggested by Bank of England Governor Bailey's letter to Harriett Baldwin from December 18, 2023. He states that the "scale and pace of the reduction in the stock of assets in the APF as part of QT are chosen solely to meet the MPC's policy objectives." We note that this choice of policy instrument stands in contrast to other central banks combating high inflation (Fed, ECB) who have chosen to rely primarily on increases in the policy rate.

One potential response by HM Treasury could be to simply roll over the shortfall by issuing new debt. However, this path will increase headline public sector borrowing, which could influence borrowing costs. The result may be that, on top of the quantitative tightening that results from the APF selling bonds there may be concurrent fiscal tightening in response to the APF's realized losses and resulting costs for HM Treasury.

3.6 The Case of the Federal Reserve

Turning to the Federal Reserve, institutional arrangements are quite different.[28] When the Federal Reserve System's revenues exceed its operational costs, the Fed transfers the excess to the US Treasury. This was the case in virtually every year until 2023. When losses accrue, however, these are treated as a deferred asset with the agreement that there will be no further transfers to the Treasury until that deferred asset is extinguished.[29] Put slightly different, the Fed keeps track of the losses and then retains earnings until they are completely gone.[30]

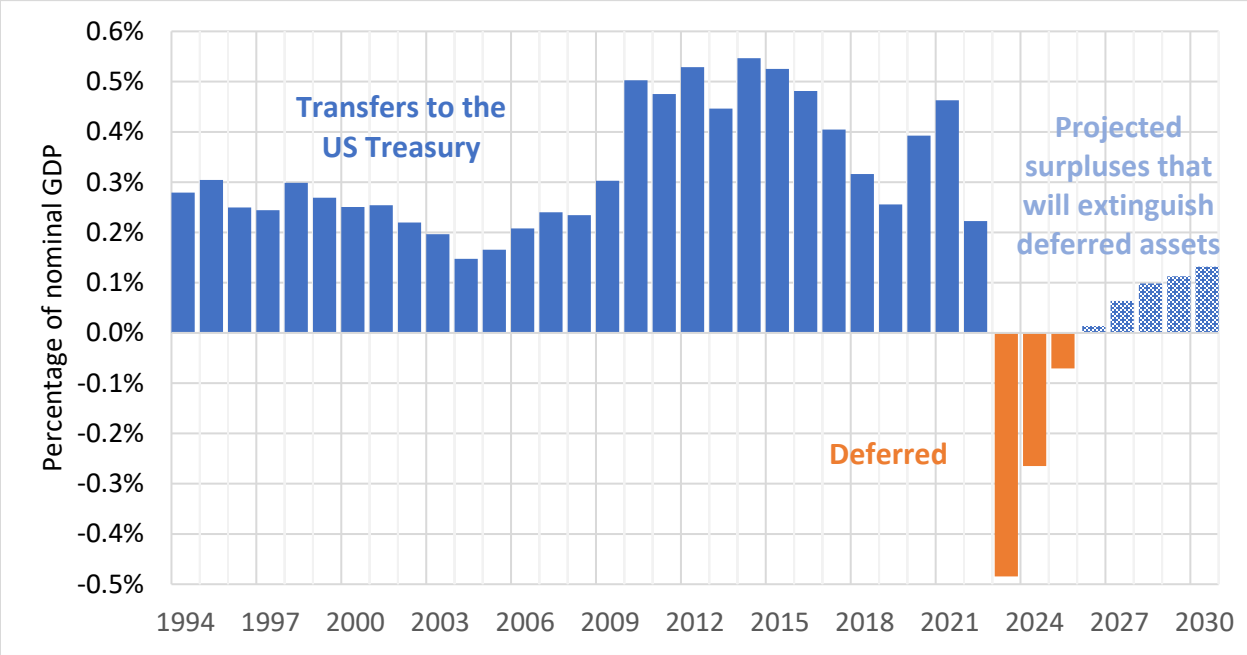
Figure 4 plots the Fed's transfers to the US Treasury in blue and its deferred assets in orange.[31] We note that from 2010 to 2021 the average annual transfer to the Treasury was roughly 0.45% of GDP, or USD 84 billion. Levin and Skinner (2023) report projections suggesting that the cumulative deferred assets of the Federal Reserve will still be in the range of USD 100 billion by the end of this decade. That is, the profits from 2026 to 2030 will not be sufficient to balance the losses over the 2023 to 2025 period.

Importantly, however, these numbers appear small. Peak losses are less than one-half of one percent of GDP. If, as we suspect is the case, the asset purchase programs helped to avert a

[28] See Carpenter, Ihrig, Klee, Quinn and Boote (2015) for a detailed discussion of the mechanics and accounting of the Federal Reserve's balance sheet.
[29] Note that there is a separate arrangement associated with the risks associated with the possibility of losses that may arise from the purchase of private securities. Since the Federal Reserve can only purchase and hold assets that are fully government guaranteed, purchases of corporate bonds, commercial paper, and the like can only occur through special purchase vehicles. These facilities require US Treasury indemnification, so that the Federal Reserve cannot sustain any losses. We do not concern ourselves with these types of instruments here.
[30] The Riksbank and the Bank of Canada appear to have similar arrangements where they withhold profits to rebuild their capital. See Riksbank (2024) and Bank of Canada (2020).
[31] Note that these are published weekly in Table 6 of the Federal Reserve's H.4.1 release. They are a liability labeled "Earnings remittances due to the U.S. Treasury."

severe recession both following the financial crisis and the pandemic, then the benefits almost surely outweighed the costs.[32]

Figure 4: Federal Reserve Transfers to the US Treasury, 1994 to 2030



Source: Federal Reserve Board H.4.1, Table 6; and Figure 3, Levin and Skinner (2024). We thank Andrew Levin and Christina Paragon Skinner for sharing their data.

To summarize, the large asset purchases by the Fed, resulting in the Fed balance sheet peaking at approximately USD 9 trillion, are producing losses in response to higher interest rates. Similar to the case of the UK, there are fiscal implications since transfers from the Fed to the Treasury have now been halted for likely close to ten years. However, foregone transfers are small as a percentage of GDP and small, measured relative to GDP, when compare to the UK's APF losses. Most likely, the difference is due to the longer-maturity bonds purchased by the APF.

In both cases – Bank of England and Fed – we calculate *ex post* losses resulting from a shortening of the maturity structure of public debt. Because of the timing of our study, we are focusing on losses and have not balanced these against the previous gains. When the large-scale asset purchase programs were initiated, the carry was positive. Funding the purchases at a close-to-zero interest rate was low cost, while the coupons provided interest income. We therefore emphasize that focusing on current losses misses three important counterbalancing considerations. First, losses were preceded by gains and it may therefore make sense to consider net rather than gross losses. Second, what matters from the perspective of optimal policy is *ex ante* expected gains and losses rather than *ex post* losses. For example, one might

[32] Benefits of different rounds of QE may have been different. For example, Levin, Lu, and Nelson (2022) point out that the first round of pandemic-related QE in March/April 2020 was most likely cost effective, while the second round from May 2020 to March 2022 may not have been.

argue that interest rates are higher-than-expected today because of high energy costs (due to the Russian invasion of Ukraine) and larger-than-expected supply chain disruptions (due to COVID).[33] Third, as pointed out already, large asset purchase programs most likely reduced the length and severity of two recessions. In addition, higher borrowing costs translate directly into higher returns for the holders of government debt. They are therefore a transfer rather than a direct cost. Correspondingly, we need to consider deadweight costs of taxation, as well as distributional consequences, rather than treating losses directly as reductions of welfare due to cross-border wealth transfers. This last piece is something that changes when foreigners hold the assets.

4. The Impact of Central Bank Purchases of Foreign Securities

We now turn to the case of an open economy with cross-border capital flows. That is, the public and private sector can hold assets issued by foreigners denominated in foreign currency, and foreigners can hold domestic assets issued in domestic currency. Our interest is in valuation changes that create cross-border wealth transfers.

To focus the discussion, we make the following simplifying assumptions: (1) private sector cross-border investment positions exactly balance in both quantity and duration and (2) the foreign government owns no domestic assets. This allows us to focus on the impact of exchange rate and interest rates changes on the central bank's holdings of foreign assets net of both foreign public sector's holding and the (net) private sector investment position. Adjusting the balance sheet in Panel B of Table 1, we now have the following:

Table 4: Stylized Balance Sheet of the Domestic Central Bank in an Open Economy

Assets	Liabilities
Domestic Government Bonds	Domestic Currency
Domestic Private Bonds	Commercial Bank Reserves held by domestic residents
Loans to Banks	**Commercial Bank Reserves held by foreigners**
PV of Future Seigniorage	Fiscal Authority's Account
Other Assets	Other Liabilities
Foreign Assets	
	Central Bank Net Worth

There are two additions – the items in red. First, we add "Foreign Assets." These could be of any type. These are government bonds, private bonds, equity, and real assets. Second, since the central bank purchased these assets from foreigners and paid for them by creating reserves, we now include commercial bank reserves held by foreigners as a central bank liability. (This is an

[33] Bhattarai, Eggertsson, Gafarov (2023) suggest that large-scale asset purchases may delay the central bank increasing interest rates, thus reducing losses.

obvious short-hand for the fact that foreigners hold deposits at a domestic commercial bank that are backed by the commercial bank's reserves at the central bank.)

Looking at Table 4, we note that, unlike the closed economy case, consolidation of the domestic central bank's balance sheet with that of the domestic fiscal authority has no impact on these foreign assets. Furthermore, changes in the central bank's net worth can now arise from a changes in the value of foreign assets. Importantly, this clearly represents a wealth transfer to the foreigners and a loss to the country.

Whether this decline in central bank net worth reduces domestic social welfare depends on the reason that the central bank purchased foreign assets and incurred foreign liabilities. In most cases, the rationale is tied to a desire to stabilize a country's exchange rate in order to ensure the viability of export and import-competing industries.

With this in mind, we can turn to the Swiss example. In September 2011, the Swiss National Bank (SNB) sought to counter a "massive overvaluation" of the franc that posed "an acute threat to the Swiss economy" and "the risk of a deflationary development." Accordingly, it set a floor of CHF 1.20/€, promising to "buy foreign currency in unlimited quantities."[34] Over the next three years, until January 2015, the SNB held to this policy. But achieving this goal required purchasing an enormous quantity of euro-denominated assets. Swiss foreign exchange reserves soared from CHF 281 billion in August 2011 to CHF 508 billion in January 2015 – that is, from 44% to 76% of Swiss GDP. While the SNB abandoned the numerical exchange rate floor in January 2015, they continued to purchase foreign assets in an effort to keep their exchange rate from appreciating. The SNB's foreign exchange reserves peaked at nearly CHF 966 billion – more than 125% of Swiss GDP – in early 2022.

This level of foreign exchange reserves induces volatility in the net worth and net income of the central bank for two reasons. First, since the central bank always does its accounting in domestic currency, changes in the exchange rate matter. Second, the prices of the foreign assets change. Together, these can have a large effect.

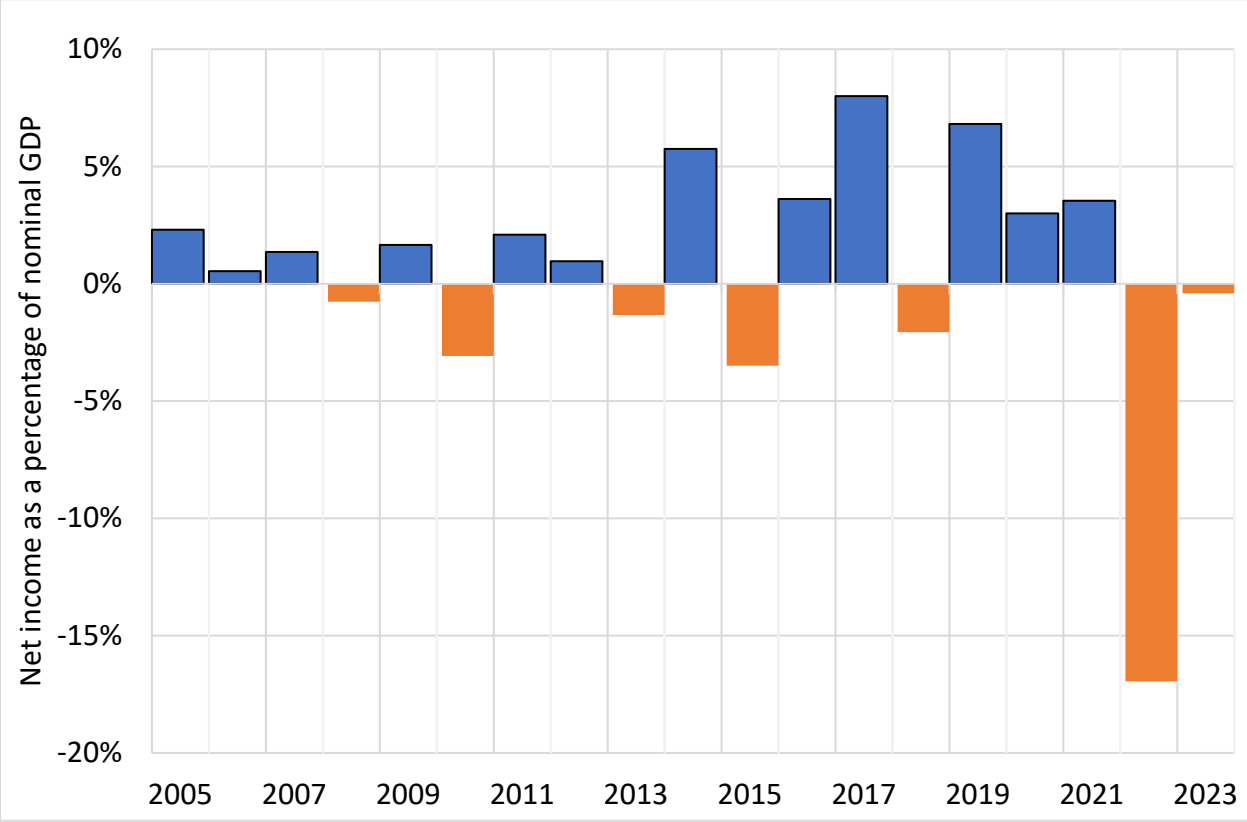
To see how large, we plot the Swiss National Bank's net income as a percentage of nominal GDP in Figure 5. In our view, numbers like +8% and -17% – the maximum and the minimum in the chart – are very large. And recall, these represent transfers between domestic residents and foreigners. Again, we need to balance these against the potential gains associated with the exchange rate policy that began in September 2011. And, in fact, the sum of the net income over the past dozen years is positive. But the volatility would seem to have at least some costs.

[34] See https://www.snb.ch/en/publications/communication/press-releases/2011/pre_20110906

Summing up, when a central bank holds substantial foreign exchange reserves, changes in net worth create wealth transfers between domestic residents and foreigners that can be substantial.

We also note that losses were at times quite large (-3.1% of GDP in 2010, -2.5% in 2025 and -2.1% in 2018) *before* the recent increase in interest rates. Thus, prior to the current discussion of the potential effects of central bank losses, the SNB experienced substantial losses without there being doubts about its ability to conduct monetary policy. One might interpret this as an example of the lack of consequences of central bank losses on central bank operations.

Figure 5: Swiss National Bank Net Income 2005 to 2023, percent of GDP



Source: Swiss National Bank.

5. Risk Sharing in a Monetary Union

We now turn to the case of the Eurosystem. If each of the national central banks (NCBs) of the member states purchases bonds of its own government and issues liabilities to its domestic banks, then this would be identical to the original closed economy case in Section 3. But this is not how the asset purchase program operates since the European Central Bank (ECB) buys a fraction of the securities mutualizing any losses. From the perspective of the citizens of a given member state in the euro area, this has characteristics of the open economy case.

To understand the mechanics of how this works, we consider a stylized example in which there are two countries of equal size. Each of the countries has a central bank and a finance ministry that issues domestic bonds. In addition, there is a common central bank (CCB). In this simple example, assume that each national central bank purchases bonds issued by their own government and nothing else. The CCB purchases bonds issued by governments in both countries, issues liabilities in the form of accounts to the NCBs and has net worth split equally between the two NCBs.[35] Changes in the value of its assets flow through to the CCBs net worth, so they are mutualized. Table 5 shows the simplified balance sheets.[36]

Table 5: Stylized Central Bank Balance Sheets in a Two Country Monetary Union

A. National Central Bank A (NCBA)

Assets	Liabilities
Government A Bonds	Common Currency
Account at CCB	Commercial Bank A Reserves
CCB Net Worth	Fiscal Authority A's Account
	Central Bank A Net Worth

B. National Central Bank B (NCBB)

Assets	Liabilities
Government B Bonds	Common Currency
Account at CCB	Commercial Bank B Reserves
CCB Net Worth	Fiscal Authority B's Account
	Central Bank B Net Worth

C. Common Central Bank (CCB)

Assets	Liabilities
Government A Bonds	NCBA's Account
Government B Bonds	NBCB's Account
	CCB Net Worth

To continue, assume that the system decides to purchase 100 bonds. Since the countries are of equal size, this means buying 50 government A bonds and 50 government B bonds. Furthermore, assume that the purchase is allocated so that the CCB owns 20 percent of the

[35] The NCB balance at the ECB may be related to the interbank payments system (TARGET2). See the discussion in Cecchetti and Schoenholtz (2018).

[36] See Kyriakopoulou and Ortlieb (2021) for a slightly different presentation.

total.[37] This means each NCB purchases 40 of their own country bonds, and the CCB purchases 10 of each country's bonds.

When interest rates change, the value of the government bonds change, and there are valuation effects on all of these balance sheets. But the impact of the mutualization through the CCB only has an impact if interest rates in the two countries change relative to one another. To see why, note that if interest rates move equally, then there is no difference between the NCBs each owning all of the government bonds that the system purchases. But if country A's interest rate rises by more than country B's, so country A's government bonds decline in value by more than country B's, then country B shares in losses that it otherwise would not have to bear.

In the more realistic case in which there are many countries of varying sizes, the same thing will happen. That is, there will be transfers from countries whose interest rates rose by less to those whose interest rates rose by more. But, in addition to the transfers depending on changes in interest rate differentials, they will also be a function of the relative size of the country.

To get a sense of how large these transfers might be, we can look at the changes in interest rate differentials combined with the holdings of a country's sovereign bonds. Take the example of Italy. The system holds €400 bn of Italian bonds with a weighted average maturity of about 7 years. This means that when Italian bond spreads rise by 1 percentage point, the mutualized losses were 1% x 7year x 20% x 400bn = €5.6bn. These are redistributed according to relative size as measured by the capital key (which combines population and GDP).[38] This means that the transfer from Germany, which represents 21% of the Eurosystem, is on the order of €1.1bn. Of course, when the spread shrinks, the direction of this transfer reverses.

Turning to the cash flows – the seigniorage revenue in the Eurosystem – these are pooled and redistributed based on country size with one important exception. The exception is that as compensation for the risk of holding its sovereign bonds, a national central bank (NCB) retains interest income in excess of the reference rate (set at the main refinancing rate). This means that when NCB's own country sovereigns have a coupon in excess of the reference rate, the NCB retains the excess. As a result, Italy is less likely to experience a cash-flow loss than, for example, Germany or the Netherlands. Looking at the results in Belhocine, Bhatia, and Frie (2023) we see that this is exactly the case.[39] Those authors projected that for 2023, the Bundesbank would have a loss on the order of 0.6% of German GDP, while the Banca d'Italia would have a very modest profit.

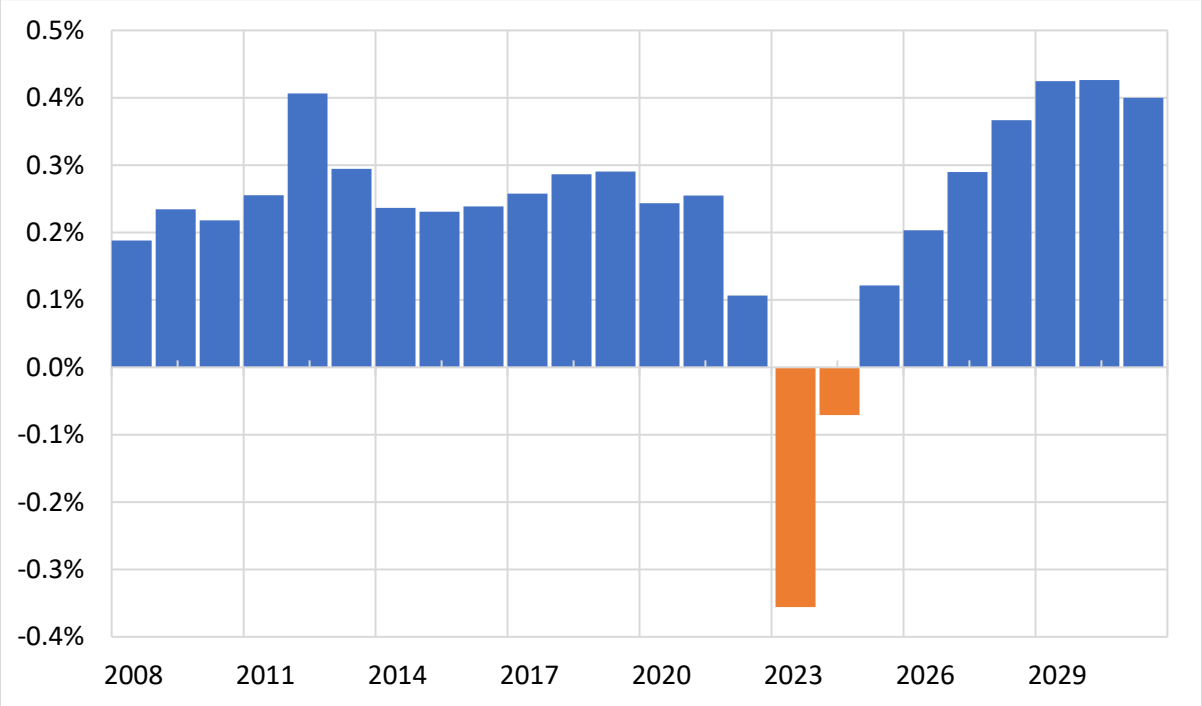
Since our interest is more in the aggregate impact that the distribution, we focus on the profit and loss for the Eurosystem as a whole. Figure 6 reproduces the relevant panel of Belhocine,

[37] This is the level consistent with the current level of risk sharing in the Eurosystem. See here.
[38] For the most recent computations of the capital key, as well as a discussion of the methodology, see here.
[39] See Belhocine, Bhatia, and Frie (2023) for a detailed description of the risk sharing and income pooling arrangements in the Eurosystem. Their full projections are in Figure 14 on page 18 of the IMF working paper version.

Bhatia, and Frie (2023)'s Figure 14. Here we note that the seigniorage revenue is generally in the range of 0.2% to 0.4% of euro area GDP – similar in magnitude to that of the Federal Reserve. But the losses appear somewhat more modest, as they only occur in 2023 and 2024 and total 0.42% of GDP – roughly half of the total for the Federal Reserve.

In summary, the effects of large-scale asset purchases in the Eurosystem appear quite modest as a percentage of GDP. This is interesting given that the total size of asset purchases is comparable to the US, while GDP is about one third lower. It is likely that the difference is due to the large share of longer-term refinancing operations (LTRO) making up Eurosystem assets.

Figure 6: Eurosystem Profit and Loss, 2000 to 2031, percent of GDP



Note: Projections were constructed in 2022, so the chart does not include actual data for 2023 reported in early 2024.
Source: Belhocine, Bhatia, and Frie (2023), Figure 14 bottom right panel. We thank Nazim Belocine, Ashok Vir Bhatia, and Jan Frie for sharing their data.

Given the modest size of losses, the fact that there is a combination of country-specific losses resulting from NCBs purchasing domestic bonds and mutualized losses is not as crucial.[40] Indeed, as pointed out, those countries holding bonds with larger spreads had smaller losses, compensating them for market-perceived differences in risk. Also, even for small effects on the

[40] Belhocine, Bhatia, and Frie (2023)'s projections suggest that the Banque de France, Bundesbank, De Nederlandsche Bank, and Banca de España will face losses, the Banca d'Italia will not.

severity and duration of recessions, benefits of asset purchase programs will have exceeded costs.

6. Conclusion

In this paper we make three contributions to the literature on consequences of quantitative easing policies to central bank balance sheets. First, we propose merging the balance sheets of the central bank and the fiscal authority into one consolidated government balance sheet. This clarifies the consequences of central bank asset purchases, emphasizing that these actions have fiscal consequences.

Second, using the consolidated balance sheet approach, we classify central bank purchases into three groups – domestic government bonds, domestic private sector bonds, and foreign securities. We trace out the effects of all three – a change in maturity structure resulting in potentially higher variation of tax liabilities as well as intra- and inter-country transfers.

Third, using ex post realized losses, we are able to quantify and describe differences in losses and transfers across central banks. For this purpose, we consider four examples: The Bank of England, the Federal Reserve, the Eurosystem, and the Swiss National Bank. In the first three, the losses are relatively small, ranging from 0.3 and 1.5 percent of GDP in a given year. By contrast, the Swiss National Bank is sustaining losses up to 17 percent of GDP. However, compared to the potential gains of avoiding more severe recessions in the face of the Global Financial Crisis and the Global Pandemic as well as earlier benefits from holding high-yielding securities funded by low-interest reserves, losses are most likely smaller.

Institutional arrangements also play an important role. We note that realized losses may have different effects depending on accounting treatments and on indemnification policies. If losses appear on the balance sheet only when sales are made, the timing of sales affects the timing of losses. This is true in the case of the Bank of England, which is currently selling a substantial fraction of bond holdings every year. In contrast, timing of sales is not relevant for the timing of losses if fair value (mark-to-market) accounting is used. Then, once the losses appear, they may become part of a deferred asset (e.g. Fed) or need to be paid by the fiscal authority in real time. The timing of fiscal consequences thus is related to the institutional arrangements.

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