Quantifying the Costs and Benefits of Quantitative Easing *

Andrew T. Levin, Brian L. Lu, and William R. Nelson

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* Levin is a professor of economics at Dartmouth College, visiting scholar at the International Monetary Fund, research associate of the NBER, and international research fellow of the Centre for Economic Policy Research (CEPR). Nelson is chief economist and an executive vice president at the Bank Policy Institute and is an adjunct professor at Georgetown University. Lu collaborated on this project during his undergraduate studies at Dartmouth College. We appreciate invaluable conversations with Michael Bordo, Christopher Erceg, Bob Hall, Mickey Levy, Debbie Lucas, Charles Plosser, and John Taylor; this paper also reflects many insights from the work of Marvin Goodfriend. However, the views expressed here are solely those of the authors and do not represent the views of any other person or institution.

1. Introduction

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At the onset of the global financial crisis and over subsequent years, the Federal Reserve and several other major central banks began engaging in large-scale securities purchases, commonly known as *quantitative easing* (QE), with the aim of providing additional monetary stimulus when short-term nominal interest rates were constrained by the effective lower bound (ELB). At that time, policymakers specifically acknowledged uncertainties about the benefits and costs of QE. For example, when the QE3 program was launched in September 2012, the U.S. Federal Open Market Committee (FOMC) noted: "*In determining the size, pace, and composition of its asset purchases, the Committee will, as always, take appropriate account of the likely efficacy and costs of such purchases."*[1]

In responding to the COVID-19 pandemic, however, the Federal Reserve deployed QE far more aggressively, as though its efficacy was fully assured and its costs were minor.[2] Over the period from March 2020 to March 2022, the FOMC purchased about $4.6 trillion in Treasuries and agency mortgage-backed securities (MBS), funding those purchases through a corresponding increase in bank reserves and overnight reverse repos. By comparison, the FOMC's previous QE programs (conducted from 2008 to 2014) added a combined total of $3.7 trillion to the Federal Reserve's securities holdings.

As shown in Figure 1, this asset purchase program –which we henceforth refer to as QE4 – doubled the size of the Federal Reserve's balance sheet and markedly shifted its composition. Paper cash (which pays no interest) accounted for nearly all of the Fed's liabilities as of 2007 (just prior to the onset of the global financial crisis), whereas interest-bearing liabilities now comprise about two-thirds of its total liabilities. Meanwhile, medium- and longer-term securities (i.e., Treasury notes and bonds and agency MBS) now comprise the bulk of the assets held in the System Open Market Account (SOMA). In effect, the Fed's balance sheet now appears similar to that of a hedge fund whose long-term assets are financed by short-term liabilities, except that such funds routinely hedge their interest rate risk whereas the Fed's portfolio is effectively "naked." [3]

In this paper, we conduct a systematic analysis of the costs and benefits of QE, using the Fed's experience with QE4 as a concrete example. To assess the costs of QE4, we analyze the characteristics of the individual securities held in the System Open Market Account (SOMA) at the end of June 2022. We construct a detailed 10-year projection of the Fed's balance sheet, and we compare this baseline projection with a counterfactual scenario

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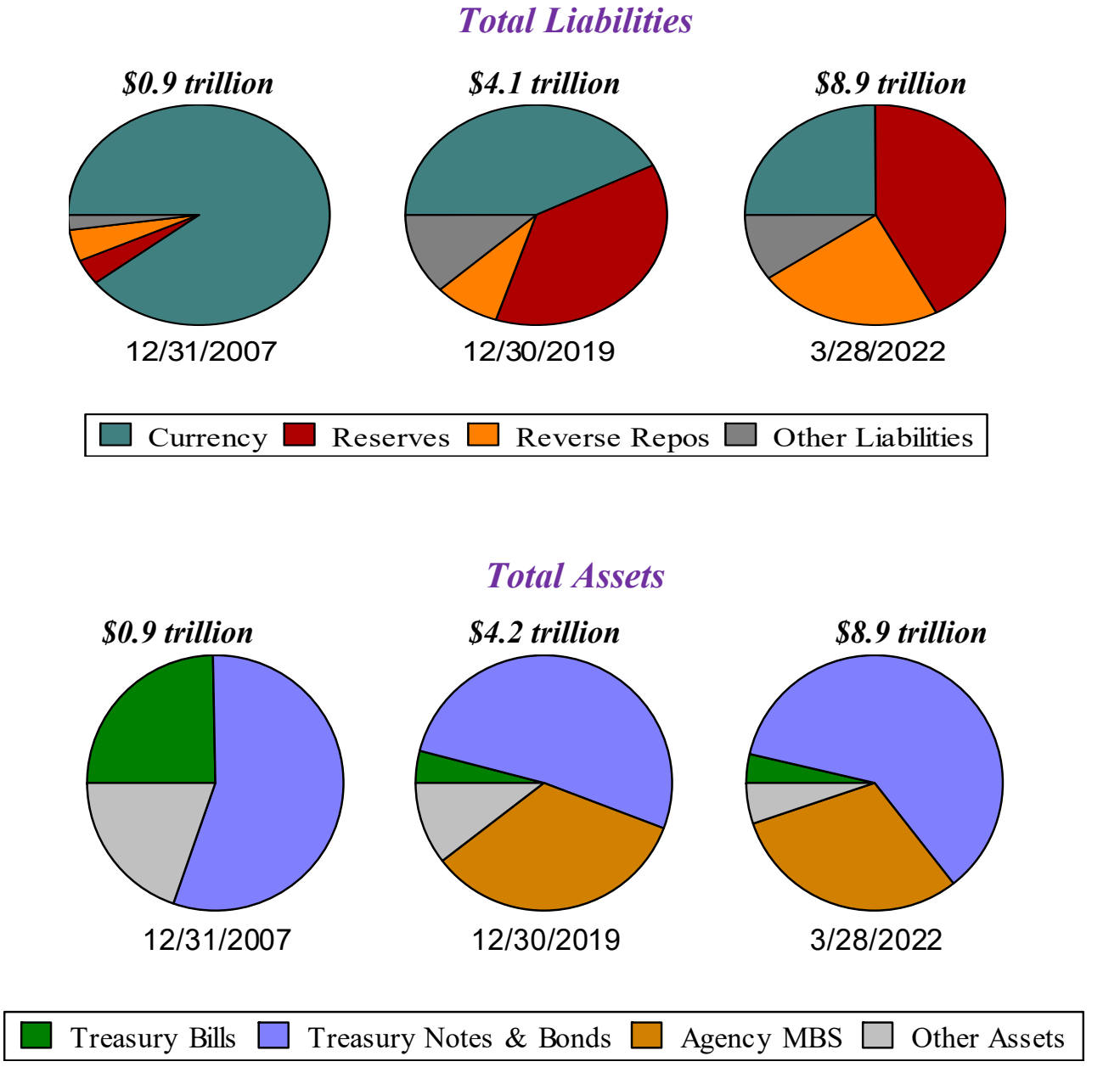
[1] FOMC Statement, September 13, 2012.

[2] This approach was foreshadowed in the Minutes of the Dec. 2019 FOMC meeting, which stated that *"A number of participants noted that the Committee's experience with forward guidance and balance sheet policies would likely allow the Committee to deploy these tools earlier and more aggressively in the event that they were needed."* (p.3)

[3] See the insightful discussion of Goodfriend (2014).

Figure 1: The Size and Composition of the Federal Reserve's Balance Sheet



***Source**: Federal Reserve Statistical Release H.4.1 (Factors Affecting Reserve Balances).*

in which the Federal Reserve provided emergency liquidity at the onset of the pandemic but did not initiate any large-scale asset purchases. To assess the potential benefits of QE4, we analyze the extent to which the program may have fostered a more rapid economic recovery, and we also consider its role in fostering financial stability and in financing budget deficits.

Our key findings can be summarized as follows:

- *Program Design*: The evolution of the QE4 program was convoluted, improvised, and inertial. Moreover, the FOMC minutes did not report on any substantive discussions of cost-benefit analysis at any stage of the program, as though the costs were minor and the benefits were clear-cut.
- *Consequences for Market Functioning*: QE4 markedly increased the Federal Reserve's footprint in the markets for Treasuries and agency MBS, with potentially adverse consequences for the functioning of these markets over time. For example, the SOMA now holds nearly 30% of the outstanding stock of Treasury notes and bonds, with an even larger footprint at the longer end of the maturity spectrum. Likewise, the SOMA now holds more than 40% of the total outstanding stock of agency MBS, and its purchases during QE4 accounted for nearly the entire issuance of agency MBS over that timeframe.
- *Balance Sheet Normalization*. Our baseline projection indicates that the size of the Federal Reserve's balance sheet will reach a trough in late 2024 and then resume expanding to meet policymakers' criterion of providing an "ample" supply of reserve balances. However, the composition of the SOMA's asset holdings will remain far from normal, with a small proportion of Treasury bills and a glacial pace of agency MBS runoff.
- *Interest Rate Risk*. By purchasing medium- and longer-term Treasuries and financing those purchases by creating short-term liabilities, the FOMC substantially reduced the average maturity of the interest-bearing liabilities of the consolidated federal government sector (which includes the Federal Reserve). In effect, while the U.S. Treasury was issuing notes and bonds during the pandemic to "lock in" low interest rates and reduce the expense of financing the federal debt over coming years, QE4 practically canceled out those efforts. The FOMC's purchases of agency MBS incurred even greater interest rate risk because mortgage prepayments decline sharply in response to higher mortgage rates.
- *Cost to Taxpayers*. Based on the term structure of interest rates at the end of June 2022, our baseline projection indicates that over the next ten years the Federal Reserve's total net interest income and its corresponding remittances to the U.S. Treasury will be about $550 billion lower than in the No-QE4 counterfactual scenario. Of course, that cost could turn out to be lower if inflation subsides more rapidly than currently anticipated. Conversely, if the path of interest rates shifts even higher (consistent with the current prescription of the Taylor Rule and other policy benchmarks), then the total cost of QE4 to U.S. taxpayers might well reach $1 trillion or higher.

Our baseline projection of the Federal Reserve's balance sheet and income is broadly similar to two other recent projections produced by Federal Reserve Board economists and by analysts at the Federal Reserve Bank of New York.[4] However, those reports did not include any counterfactual scenarios or assess the overall costs of QE4.

Our analysis builds on the conceptual framework formulated by Hall and Reis (2015), who identified several distinct forms of risk that could arise on the central bank's balance sheet. For example, exchange rate risk is highly relevant for many other central banks but not for the Federal Reserve, because its assets and liabilities are almost entirely denominated in U.S. dollars. Likewise, default risk can be substantial for central banks that engage in large amounts of direct lending to commercial institutions, whereas the Dodd-Frank Act has required the Federal Reserve to ensure that its emergency credit facilities do not pose substantial risks to taxpayers. In contrast, current statutes place no limits on the FOMC's ability to incur interest rate risk by engaging in large-scale securities purchases.

Indeed, QE is inevitably associated with incurring interest rate risk, because the central bank issues short-term liabilities to finance its purchases of medium- and longer-term securities. Even though the stated objective of QE is sometimes described as "taking duration out of private hands," that is merely the flip side of the coin, because the central bank incurs interest rate risk when it acquires such assets. Moreover, the magnitude of such risk hinges on the specific characteristics of the assets that are purchased. Thus, while FOMC meeting statements issued during QE4 characterized its purchases of Treasuries and agency MBS symmetrically, and its holdings of those securities were expanded in parallel, these two types of securities have markedly different risk profiles.

Moreover, the interest rate risk the Fed undertook in QE4 is a direct risk to U.S. taxpayers.[5] As discussed in a recent note by Federal Reserve Board staff, the Federal Reserve suspends its remittances to the Treasury if its net income falls below zero, and its balance sheet has a book entry involving a deferred asset in an amount equal to the loss.[6] Subsequent losses add to the deferred asset while subsequent gains reduce it. Remittances remain at zero until the deferred asset has been reduced back to zero. That foregone income for Treasury implies a higher level of federal debt, which must eventually be sustained by a combination of higher federal taxes or lower federal expenditures.

The remainder of this paper is organized as follows. Section 2 provides an overview of QE4. Sections 3 and 4 examine QE4 purchases of Treasuries and agency MBS, respectively. Section 5 reports on baseline and counterfactual simulations of the Federal Reserve's balance sheet. Section 6 assesses the potential benefits of QE4. Section 7 concludes.

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[4] See Anderson et al. (2022b) and Federal Reserve Bank of New York (2022a). In the latter case, our projection is similar to the projection in the +100 bp scenario, which was closer to the market outlook as of June 2022.

[5] See Nelson (2022) for further discussion.

[6] See Anderson et al. (2022a).

2. Overview of the QE4 Program

During the second half of 2019 and early 2020, the Federal Reserve held the size of its balance sheet at around $4.2 trillion, with the aim of providing an *"ample supply of reserves"* to the banking system. Over that period, the SOMA desk reinvested proceeds from maturing Treasury securities and principal payments on agency mortgage-backed securities (MBS), preserving the maturity composition of the Fed's Treasury holdings while gradually shrinking its holdings of agency MBS.

In March 2020, at the onset of the COVID-19 pandemic, the FOMC cut the federal funds rate target to a range of 0 to ¼ percent and launched a host of emergency credit facilities in its role as ***lender of last resort***.[7] The FOMC also began offering a practically unlimited supply of liquidity in the repo market, lending to institutions that provided Treasuries and agency securities as collateral.

Beyond all of those actions, however, the Federal Reserve undertook a massive role as the ***market-maker of last resort***.[8] On March 15, 2020, the FOMC stated:

> *"To support the smooth functioning of markets for Treasury securities and agency mortgage-backed securities that are central to the flow of credit to households and businesses, over coming months the Committee will increase its holdings of Treasury securities by at least $500 billion and its holdings of agency mortgage-backed securities by at least $200 billion."*[9]

One week later, the FOMC removed all quantitative limits on such purchases, simply instructing the SOMA desk to expand such holdings *"in the amounts needed to support the smooth functioning of markets for Treasury securities and agency MBS."*[10]

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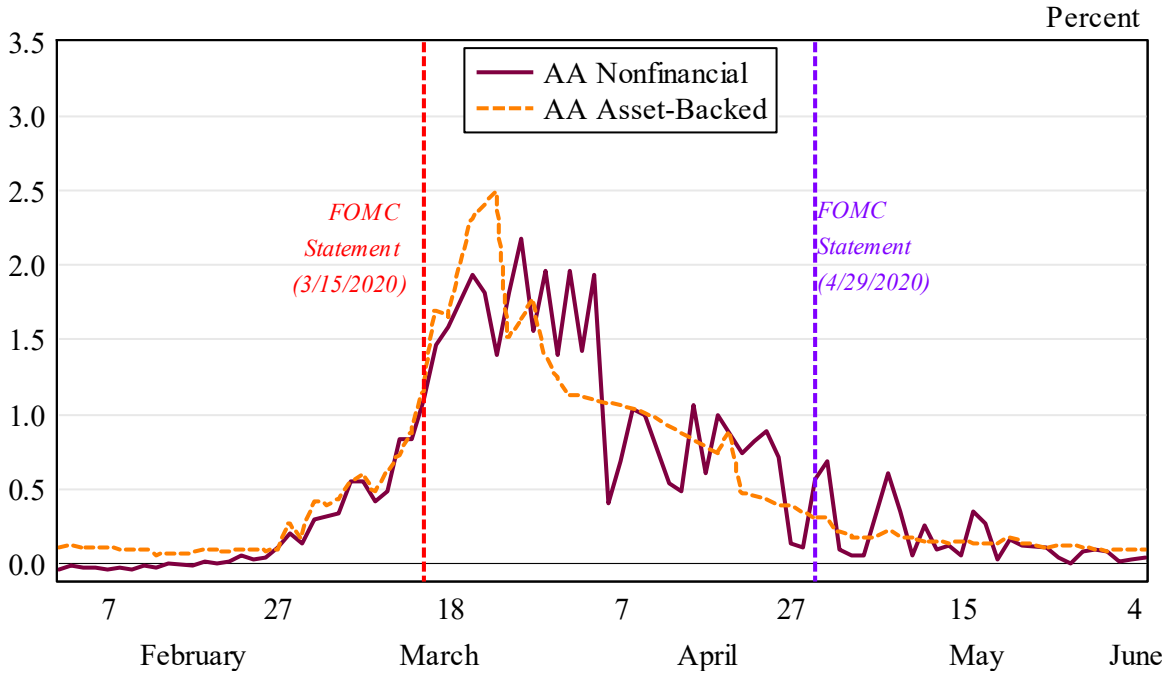
[7] The FOMC reduced the target federal funds rate by 0.5 percent on March 3 and by a further 1 percent on March 15, 2020; see FOMC (2020a,b). The Federal Reserve provided emergency liquidity to primary dealers, money market mutual funds, and commercial paper markets, and took coordinated actions with other major central banks to provide U.S. dollar liquidity in global financial markets; moreover, using funds appropriated by Congress and provided by the U.S. Treasury Department, it established programs to facilitate credit to states, municipalities, corporations, and small businesses. See Federal Reserve Board (2020a,b,c,d,e,f,g,h).

[8] This phrase was coined by Tucker (2009). Analysts at the Federal Reserve Bank of New York coined the alternate phrase "primary dealer of last resort"; see Chen et al. (2020).

[9] FOMC (2020b).

[10] FOMC (2020c). In its prior MBS purchase programs (namely, QE1 and QE3), the Federal Reserve had purchased agency securities backed by residential mortgages, whereas this announcement indicated that QE4 would include agency securities backed by mortgages on commercial properties. In fact, the SOMA purchased about $10 billion in commercial MBS, and those holdings stood at about $8.8 billion as of June 2022.

Figure 2: Spreads betweeen Rates on Commercial Paper and Treasury Bills at the Onset of the COVID-19 Pandemic



This figure shows the spread between the 90-day rate on AA-rated nonfinancial commercial paper and the 3-month Treasury bill rate (solid line) and the corresponding spread for AA-rated asset-backed commercial paper (dashed line). Source: Federal Reserve Bank of St. Louis; authors' calculations.

For agency MBS, these purchases were reminiscent of the actions that were taken in late 2008 to mitigate a sharp widening of risk spreads in mortgage financing markets. At that time, the Federal Reserve announced that it would purchase up to $500 billion in agency MBS and up to $100 billion in agency debt securities over the next several quarters.[11]

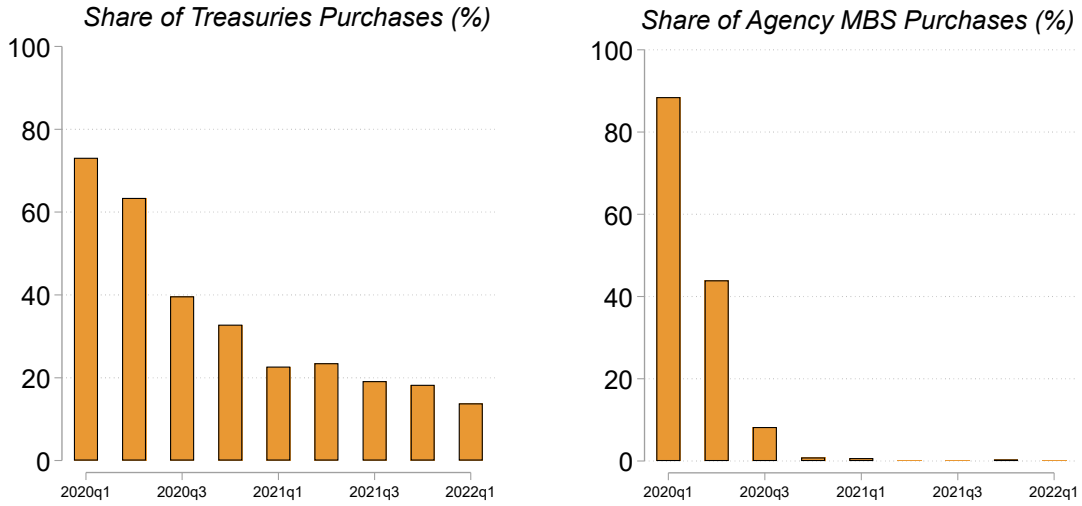
By contrast, the Federal Reserve's decision to assume the role of market-maker of last resort for Treasury securities was a fundamental departure from the standard practice of major central banks over the preceding 150 years.[12] In particular, the classic dictum of Bagehot (1873) indicated that in times of financial stress the central bank should lend freely against good collateral at rates that would encourage rapid normalization once financial strains subsided.[13] Indeed, the emergency credit facilities that the Federal Reserve deployed during

[11] Federal Reserve Board (2008). These purchases comprised a limited portion of the outstanding stock but were effective in facilitating liquidity and reassuring investors that the default risk was effectively zero.

[12] Wartme episodes were an important exception to this dictum. For example, during the 1940s the Federal Reserve cooperated with the U.S. Treasury Department in fixing yields on Treasury notes to faciltate the financing of government debt, but those arrangements ended with the Fed-Treasury Accord in 1951.

[13] Chairman Ben Bernanke (2013) referred to this dictum as follows: "When the financial system teetered near collapse in 2008 and 2009, we responded as the 19th century British essayist Walter Bagehot advised, by serving as liquidity provider of last resort to stressed financial firms and markets." See also Madigan (2009) and Baxter (2013).

Figure 3: QE4 Purchases of Seasoned Securities



Note: The left panel shows the par value of QE4 purchases of seasoned Treasuries (notes and bonds issued prior to 2019) as a share of total Treasuries purchases in each quarter. The right panel shows the face value of QE4 purchases of agency-backed residential MBS issued prior to 2020 as a share of total agency-backed residential MBS purchases in each quarter. Source: Federal Reserve Bank of New York, authors' calculations.

the global financial crisis proved effective in providing liquidity during 2008-09 and were then phased out by 2010.[14]

In contrast, by purchasing medium- and longer-term securities to address transitory liquidity strains, the Federal Reserve embarked on a path that would have lasting consequences for the size and composition of its balance sheet. From March 18 to April 29, 2020, the SOMA expanded its holdings of agency MBS by $225 billion and its holdings of Treasury notes and bonds by the eye-popping amount of $1.3 trillion. In effect, the Fed's securities purchases within that six-week period were nearly as large as the entire QE3 program (which had been conducted over a two-year period).

In its March 23 statement, the FOMC stated that it would *"closely monitor market conditions and ...assess the appropriate pace of its securities purchases at future meetings."*[15] As it turned out, financial strains subsided rapidly over subsequent weeks. Analysts at the Federal Reserve Bank of New York concluded that strains in MBS markets were practically negligible by the end of March 2020.[16] Likewise, as shown in Figure 2, conditions in money markets normalized in late March and early April 2020.

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[14] Those emergency credit facilities involved some purchases of money market instruments that had short maturities and were essentially self-extinguishing, and hence those facilities did not incur any interest rate risk.

[15] FOMC (2020c).

[16] See Chen et al. (2020), who analyzed data on options-adjusted spreads and payup rates in the MBS market.

Nonetheless, at its next regular meeting in late April 2020, the FOMC decided to continue its purchases of Treasuries and agency MBS *"in the amounts needed to support smooth market functioning."*[17] At its June meeting, the FOMC stated that *"over coming months"* it would continue to expand its securities holdings *"at least at the current pace to sustain smooth market functioning,"* and that phrasing was reiterated in the FOMC's July statement.[18] In September and November 2020, the FOMC elaborated further on its rationale, indicating that these purchases would also *"help foster accommodative financial conditions."*[19]

Evidently, FOMC directives to the SOMA desk provided broad discretion, since determining what purchases might be warranted to *"support smooth market functioning"* was a subjective judgment. As shown in Figure 3, seasoned Treasury securities (issued prior to 2019) comprised a high proportion of SOMA purchases at the onset of the pandemic, but that proportion declined sharply over subsequent quarters. Likewise, SOMA purchases of seasoned MBS (issued prior to 2020) were negligible from mid-2020 onwards. In effect, newly-issued federal debt and agency MBS comprised the bulk of the SOMA's total securities purchases during QE4.

As shown in Table 1, the SOMA's holdings of Treasury notes and bonds expanded at a steady pace of about $80 billion per month during the second half of 2020. SOMA holdings of residential MBS expanded at a more variable pace, reflecting a combination of rapid runoff of its portfolio (mainly due to elevated prepayments on seasoned mortgages in a favorable refinancing environment) as well as the usual vagaries of the MBS market (which involves purchase commitments, dollar rolls, and coupon swaps).

In December 2020, the FOMC clarified that its securities purchases were intended to *"help foster smooth market functioning and accommodative financial conditions"* and stated that its securities purchases would continue at the same pace until *"substantial further progress"* had been made towards its goals of maximum employment and price stability.[20] By specifying that both conditions would have to be met prior to the onset of tapering, the FOMC conveyed a commitment to "do whatever it takes" to achieve maximum employment and to induce a moderate overshooting of inflation—joint conditions that were immediately viewed as problematic by some observers and eventually acknowledged as overly rigid even

[17] FOMC (2020d).

[18] FOMC (2020e,f).

[19] FOMC (2020g,h).

[20] FOMC (2020i).

Table 1: The Evolution of the QE4 Program
(securities held outright, $ billions)

A. Treasury Notes and Bonds

Dates	Total Purchases	Maturing Securities	Net Change in Holdings	Average Monthly Pace
March 18 to April 1, 2020	824	-17	808	1,615
April 2 to April 29, 2020	626	-1	626	626
April 30 to July 1, 2020	346	-104	242	121
July 2 to Sept. 30, 2020	370	-142	228	76
Oct. 1 to Dec. 31, 2020	333	-93	240	80
Jan. 1 to Oct. 31, 2021	1407	-605	802	80
Nov. 1 to Dec. 31, 2021	260	-127	133	66
Jan. 1 to March 31, 2022	296	-196	101	34
Total	***4,462***	***-1,284***	***3,179***	***130***

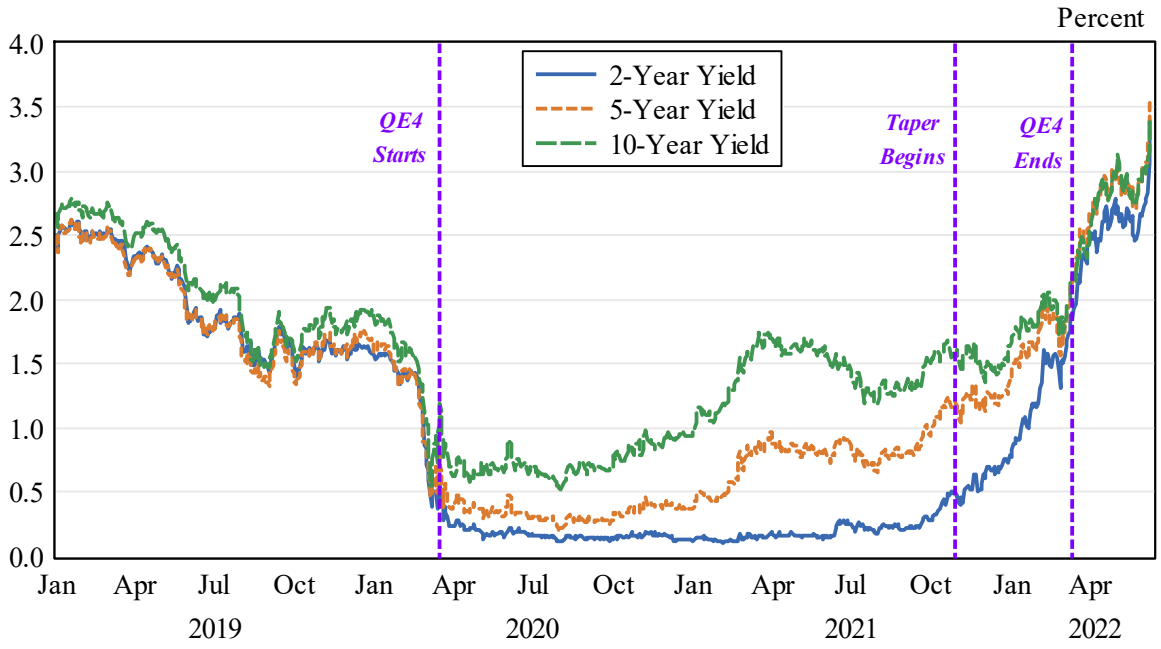
B. Agency Residential MBS

Dates	Total Purchases	Principal Payments	Net Change in Holdings	Average Monthly Pace
March 18 to April 1, 2020	107	-23	85	169
April 2 to April 29, 2020	176	-35	141	141
April 30 to July 1, 2020	408	-103	305	153
July 2 to Sept. 30, 2020	278	-207	71	24
Oct. 1 to Dec. 31, 2020	292	-236	56	19
Jan. 1 to Oct. 31, 2021	1,195	-706	489	49
Nov. 1 to Dec. 31, 2021	201	-113	88	44
Jan. 1 to March 31, 2022	230	-130	100	33
Total	***2,886***	***-1,552***	***1,335***	***54***

Note: Panel A includes all nominal and inflation-indexed notes and bonds but does not include inflation compensation (which appears as a book entry in the H.4.1 release). Panel B includes all residential MBS held outright but does not include outstanding commitments (including outright transactions, dollar rolls, and coupon swaps), commercial MBS (of which about $10 billion was purchased in spring 2020), or agency debt securities (which were not purchased during QE4). Sources: Federal Reserve Bank of New York, authors' calculations.

by many Federal Reserve officials.

Figure 4: Treasury Yields During QE4



Note: This chart shows the evolution of constant-maturity yields on U.S Treasury securities from January 2019 to June 2022. Source: Federal Reserve Board of Governors.

This forward guidance also underscored the FOMC's intent to signal policy shifts well in advance and avoid a "taper tantrum" like what had transpired during the winding down of QE3. In fact, during the first half of 2021, Federal Reserve officials insisted that they had not yet begun to discuss any plans for tapering QE4 and had not even begun to *"talk about talking about it."*

By summer 2021, however, it became evident that the tapering of QE4 would need to begin soon and at a more rapid pace than for QE3. At its July meeting, the FOMC finally acknowledged that *"the economy has made progress"* but refrained from characterizing such progress as *"substantial."*[21] In September, policymakers stated that *"a moderation in the pace of asset purchases may soon be warranted."*[22] In early November, the FOMC began tapering its purchases and signaled that the process would likely be completed over a six-month period – about twice the speed of the tapering of QE3.[23] By December, even that timeline was judged to be insufficiently rapid; the FOMC accelerated the pace of tapering and indicated that it would be completed by March 2022.[24]

[21] FOMC (2021a).

[22] FOMC (2021b).

[23] FOMC (2021c).

[24] FOMC (2021d, 2022a,b).

In early May 2022 the FOMC announced that it would soon initiate the process of shrinking its holdings of Treasuries and agency MBS, and at the beginning of June 2022 the SOMA desk began scaling back the reinvestment of principal payments on these securities.[25] Moreover, the pace of unwinding would accelerate in September 2022, and from that point onwards the SOMA's holdings of Treasuries would decline by about $60 billion per month while its holdings of agency MBS would shrink about $35 billion per month.[26]

In retrospect, the evolution of QE4 was convoluted, improvised,
and inertial. Indeed, the FOMC minutes did not report on any substantive committee discussions of cost-benefit analysis at any stage of the QE4 program. Of course, such deliberations might have been viewed as unnecessary for a program judged to have clear benefits and trivial costs.

However, the evidence points to the opposite conclusion. As shown in Figure 4, Treasury yields declined sharply at the onset of the pandemic and were already at historically low levels by mid-March 2020 and did not decline in response to the QE4 program—neither to its launch nor to the forward guidance issued later that year. Moreover, nearly all of the Fed's QE4 purchases occurred when yields were extraordinarily low. Yields began picking up in late 2021 and reached 3% by spring 2022. As we shall see, those developments have had potentially huge consequences for the Fed's net interest income and remittances.

[25] FOMC (2022c).

[26] FOMC (2022d).

3. QE4 Purchases of Treasury Securities

In its issuance of federal debt, the U.S. Treasury Department seeks to minimize the interest expense to taxpayers by fostering two key objectives: (i) minimize liquidity premiums by fostering efficient primary and secondary market conditions; and (ii) issue debt across a wide range of maturities to mitigate risks due to shifts in market rates. Unfortunately, when viewed in its entirety, the QE4 program conflicted with both of those objectives. Indeed, while many market participants viewed the FOMC's initial purchases of Treasuries during March and early April 2020 as beneficial for market functioning, its subsequent purchases may have had the opposite effect. Moreover, its overall purchases substantially increased the interest rate risk of the consolidated federal government sector (which includes the Federal Reserve).

Market Functioning

The Treasury Department issues new debt securities at regularly scheduled monthly auctions that are carefully designed to maximize the liquidity of each individual security. For example, notes with terms of 2, 3, 5, and 7 years are auctioned every month, whereas 10-year notes are auctioned once per quarter and then "reopened" by auctioning additional amounts of the same security during each of the subsequent two months using the identical maturity date, coupon rate, and security identifier (CUSIP).[27]

Prior to the financial crisis, the Federal Reserve sought to support the liquidity of Treasury securities by minimizing its "footprint" in the secondary market, diversifying its purchases across the maturity spectrum and limiting its holdings of individual Treasury securities. In the early 2000s, following consultations with the Treasury Department, the SOMA desk established a set of caps ranging from 15% for its holdings of longer-term securities (terms of 10 years or more) up to 25% for its holdings of 2-year Treasury notes.[28]

In the aftermath of the global financial crisis, officials at the Federal Reserve gave careful consideration to the risk that its QE3 program could impair market liquidity. For example, in 2013 the SOMA desk manager gave public remarks as follows:

" The Committee...is aware of the potential for large-scale asset purchases to contribute to financial market dysfunction...If the Federal Reserve were to become too dominant a buyer or holder, it could reduce the tradable supply of these securities and discourage trading among market participants, leading to diminished liquidity and price discovery. A significant deterioration in liquidity could lead investors to demand a premium for transacting in these

[27] For terms of 20 and 30 years, a new bond is issued on a bimonthly basis, and each issue is reopened during the subsequent month. Similar reopening arrangements are followed for inflation-indexed securities (TIPS) at terms of 5, 10, and 30 years, and for floating rate notes (FRNs) with a 2-year term. For further details, see TreasuryDirect (2022).

[28] Federal Reserve Bank of New York (2003).

Table 2: The SOMA Footprint in the Market for U.S. Treasury Notes and Bonds

	SOMA Holdings		CUSIP-Level Ratio to Total Issuance *(%)*	
Date	**Par Value *($ billions)***	**Share of Total Outstanding *(%)***	**Median Security**	**95th Percentile**
December 2007	494	14.3	15.2	24.2
February 2020	2,135	15.6	9.5	62.3
March 2022	5,292	28.6	25.1	65.9

Note:At each date, this table shows the par value of the SOMA's holdings of Treasury notes and bonds (in $ billions), the ratio of those holdings to the total outstanding stock of Treasury notes and bonds (in %), and summary statistics regarding the distribution of the ratio of SOMA holdings to total issuance of each individual security (median and 95th percentile), where those statistics are weighted by the par value of SOMA holdings of each individual security. Sources: Federal Reserve Bank of New York, TreasuryDirect, authors' calculations.

markets, ultimately raising borrowing costs and undermining the program's policy goal."[29]

In contrast, in their deliberations about QE4, Federal Reserve officials apparently concluded that the program would not be constrained by concerns about how the Fed's dominance in holding particular securities might have adverse effects on market functioning.

Indeed, as shown in Table 2, QE4 markedly increased the Fed's footprint in the Treasury market. The SOMA now holds nearly 30% of the outstanding stock of Treasury notes and bonds, with a correspondingly high proportion of nearly every individual security. Moreover, its footprint is even larger at the higher end of the maturity spectrum; for Treasuries with terms of 10 years or more, the SOMA now holds than 25% of almost every CUSIP, and it holds more than 60% of the total outstanding issuance of a large fraction of such CUSIPs.

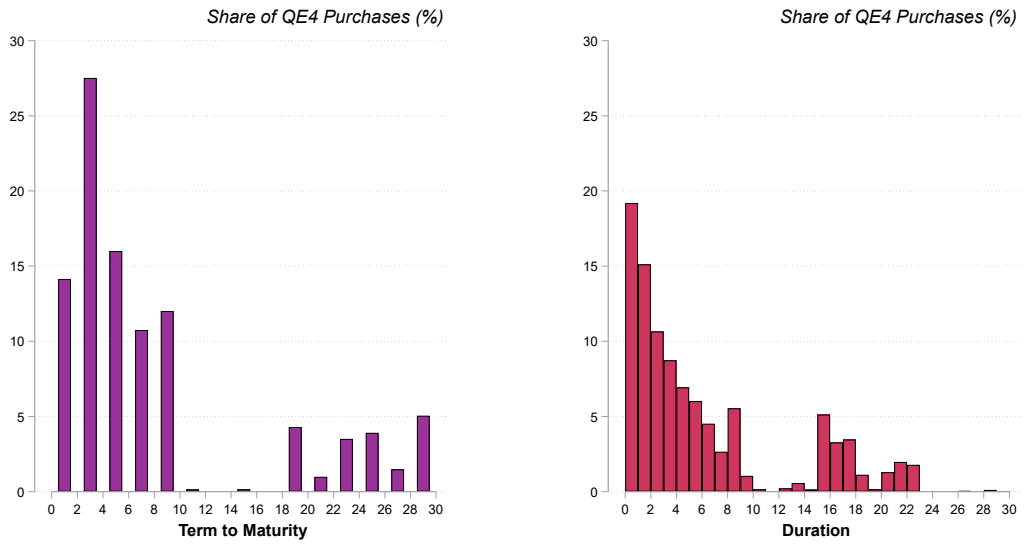
Ironically, while the Federal Reserve initiated QE4 to foster market liquidity, its increasingly dominant footprint in the Treasury market may have been counterproductive. Indeed, this program could be viewed as the latest instance in a sequence of policy actions that have exacerbated market dysfunctions and hence laid the groundwork for further intervention.[30]

That irony is deepened by the fact that it could be very costly for the Federal Reserve to reverse the impact of QE4 by engaging in secondary market sales of its Treasury holdings. Such sales would effectively be competing with the U.S. Treasury Department's regularly

[29] Potter (2013).

[30] Nelson (2021a).

Figure 5: The Maturity and Duration of Treasury Securities Purchased during QE4



Note: The left panel shows the distribution of the term to maturity (measured at the time of purchase) of Treasury securities purchased during QE4. The right panel shows the distribution of the Macauley duration of those securities as of March 31, 2022, where duration is computed using a discount factor of 2.5%. Source: Federal Reserve Bank of New York, authors' calculations.

scheduled auctions, undermining the depth of the primary market and increasing the cost to taxpayers. Consequently, the FOMC plans on gradually unwinding its Treasury holdings by allowing maturing securities to roll off its balance sheet over coming years.

Maturity Structure

As shown in the left panel of Figure 5, the maturity composition of QE4 purchases of Treasury securities has a bimodal distribution. About 80% of its purchases had terms to maturity of 10 years or less as of the date of purchase, while the remainder had much longer terms of 18 years or more. Consequently, a large fraction of these QE4 purchases will mature and roll off the Federal Reserve's balance sheet over the next few years.

This bimodal pattern of the maturity composition partly reflects the role of "market-maker of last resort" that the Federal Reserve undertook during the spring and early summer of 2020. At that time, the SOMA desk purchased a large amount of seasoned long-term Treasuries that were already close to maturity, presumably from financial institutions that were seeking to liquidate their holdings of such securities instead of using them as collateral in the repo market. In fact, the SOMA purchased $651 billion in Treasury notes and bonds that matured during late 2020 and 2021 and then reinvested those proceeds in purchases of more recently-issued securities.

Table 3: QE4 and the Liabilities of the Consolidated Federal Government Held by the Public

	Marketable Treasury Securities		Interest-Bearing Liabilities of Consolidated Federal Govt.	
Date	**Par Value** ***($ trillions)***	**Average Maturity** ***(years)***	**Par Value ($ trillions)**	**Average Maturity** ***(years)***
December 2007	4.3	4.6	3.5	4.7
February 2020	16.1	5.9	14.1	4.9
March 2022	22.5	6.2	20.0	4.0

Note: The marketable securities issued by the U.S. Treasury Department are held by the Federal Reserve or the public (i.e., excluding non-marketable securities held by the Social Security Administration and other federal agencies). The interest-bearing liabilities of the consolidated federal government include marketable Treasury securities held by the public (not those held by the Federal Reserve) and the interest-bearing liabilities of the Federal Reserve (bank reserves and reverse repos) net of its holdings of agency MBS and agency debt. Sources: Federal Reserve Board of Governors, Federal Reserve Bank of New York, U.S. Treasury Department, authors' calculations.

As shown in Table 3, QE4 had a marked impact on the maturity composition of the interest-bearing liabilities of the consolidated federal government, that is, the combined liabilities of the U.S. Treasury and the Federal Reserve held by the public. As of March 2022, the average maturity of marketable Treasuries was about 6.2 years, just a notch higher than its pre-pandemic level. However, the Fed purchased a substantial fraction of those securities and funded its purchases by creating short-term liabilities.

Consequently, QE4 reduced the average maturity of the consolidated federal government's interest-bearing liabilities by about 0.9 years. In effect, while the U.S. Treasury was issuing notes and bonds during the pandemic to "lock in" low interest rates and reduce the expense of financing the federal debt over coming years, QE4 practically canceled out those efforts.

Duration and Interest Rate Risk

FOMC officials may have expected that QE4 would have only minimal impact on the Federal Reserve's remittances, i.e., the program would not incur any significant cost to taxpayers.[31] In particular, during 2020 and most of 2021, FOMC participants anticipated that interest rates would remain low over coming years.[32] Under that baseline outlook, the interest income from securities purchased during QE4 would generally be aligned with the interest expense from financing those purchases, and hence net interest income would be roughly unchanged on average over time.

Nonetheless, QE4 was associated with asymmetric and potentially huge interest rate risks. In a scenario of continued weak aggregate demand, QE4 would likely have generated positive net interest income, because the federal funds rate would have remained near zero over a longer period, but the magnitude of that upside risk was limited by the fact that the Treasury yields had already declined to historically low levels at the onset of the pandemic.[33] By contrast, scenarios of robust aggregate demand and persistently constrained aggregate supply posed substantial downside risks to the Federal Reserve's net interest income and remittances, because intensifying inflationary pressures could warrant a far steeper path of the federal funds rate. Such a scenario began emerging as a material risk in spring 2021 and subsequently became the reality that the Federal Reserve is now facing.

The duration of a security is a useful benchmark for assessing its interest rate risk, because modified duration serves as a measure of how the market price of the bond would be affected by a 1% parallel increase in the level of interest rates at all horizons.[34] For a coupon-bearing security, the duration is substantially lower than the term to maturity, because the coupons comprise a large portion of the present discounted value of the security.

The right panel of Figure 5 shows the duration of the $3.8 trillion in Treasury securities that were purchased during QE4 and held in the SOMA on March 31, 2022, using a discount rate of 2.5%.[35] These securities have a weighted average duration of 6.2 (computed using the par

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[31] The data provided with the New York Fed's report "Open Market Operations During 2020" includes projections for Fed net income under a baseline, +100 bp, +200 bp, and +300 bp scenarios. In all cases, the Fed projected that net income would remain positive. See data for Chart 37 in the spreadsheet available at https://www.newyorkfed.org/medialibrary/media/markets/omo/omo2020-xls.xlsx

[32] For example, in the FOMC projections published in September 2021, the "dot plot" indicated that the median participant anticipated only a single quarter-point rate hike in late 2022, while the median projection for the target federal funds rate was 1% at the end of 2023 and 1.8% at the end of 2024; see FOMC (2021b).

[33] However, the upside risk to the Fed's net interest income was limited by the fact that the yields on QE4 purchases were extraordinarily low.

[34] Macauley duration is computed as the weighted average of the present discounted values of the payments generated by the security (i.e., principal and coupon payments), where each discounted payment is weighted by its time horizon in years. Modified duration uses the same formula but divides by the coupon rate and hence is slightly lower than Macauley duration.

[35] This chart excludes $651 billion in Treasuries purchased during QE4 that matured prior to March 31, 2022.

value of individual security holdings as weights). Consequently, the standard approximation indicates that the 2% upward shift in the level of interest rates which transpired between October 2021 and June 2022 reduced the market value of these securities by about 12%, i.e., a mark-to-market loss of about $450 billion.

Of course, duration has several shortcomings as a metric for quantifying the costs of QE4. Duration gauges the response of the market valuation to a level shift in interest rates at all horizons, whereas actual changes in the term structure of interest rates may exhibit more complex patterns. Moreover, duration is reasonably accurate for assessing the implications of small shifts in interest rates but does not capture the non-linearities associated with larger shifts. Finally, as Federal Reserve officials frequently note, the market valuation of the SOMA portfolio has no direct implications for monetary policy, especially given that the FOMC is very unlikely to engage in any substantial sales of its securities holdings. Thus, to gauge the costs of QE4 to taxpayers, it is essential to analyze its implications for the Fed's net interest income and remittances, which will be considered in section 5 below.

4. QE4 Purchases of Agency Residential MBS

As with Treasuries, the Federal Reserve incurs no credit risk in holding agency MBS, because these securities are issued by government-sponsored enterprises (GSEs) that have essentially been nationalized. Nonetheless, there are some key intrinsic differences between agency MBS and Treasuries:

- An agency residential MBS is a "pass-through" security for which receipts of principal and interest are linked to the aggregated payments on a specific pool of residential mortgages held by the GSE which issued the security.[36] These principal payments are received at a monthly frequency, whereas the entire face value of a Treasury security is paid at its maturity date.
- The flow of principal payments on agency MBS can be volatile due to swings in mortgage prepayments, which in turn hinge on homeowner's decisions about refinancing an existing mortgage or selling their property (in which case the mortgage must be fully repaid). Indeed, the online factsheet of the Financial Industry Regulatory Authority (2022) refers to *"the general complexity of MBS"* and notes that *"investors who draw comfort from a dependable and consistent semiannual payment may find the unpredictability of MBS unsettling."*
- Prepayments on agency MBS magnify the interest rate risk of these securities, because prepayment rates tend to vary inversely with the level of mortgage rates, i.e., a decline in rates induces a wave of refinancing, whereas a pickup in rates not only mitigates refinancing incentives but may also inhibit housing turnover. In particular, these securities are characterized by *negative convexity*: The duration of the security shortens when interest rates drop and lengthens when interest rates rise.
- Agency MBS tend to trade actively following issuance and are then acquired by *"buy and hold"* institutions that hedge the interest rate risk via derivatives or other aspects of their portfolios. Consequently, most agency MBS become relatively illiquid over time, especially compared with Treasury securities.[37]

These characteristics are relevant in assessing the impact of the Fed's QE4 program on the functioning of the agency MBS market and in gauging the associated interest rate risk.

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[36] The vast majority of agency MBS are linked to 30-year fixed-rate mortgages with no prepayment penalty, and the coupon rate of each MBS is linked to the weighted-average coupon rate on the underlying mortgage pool.

[37] The interest rate risk of a specific MBS cusip hinges on the predictability of its prepayment rate, which in turn reflects the observable features of the underlying mortgage pool, including the distribution of borrower characteristics (such as geographical location and credit score) and the distribution of mortgage coupon rates.

Table 4: The SOMA Footprint in the Market for Agency-Backed Residential MBS

Date	Total Outstanding *($ billions)*	SOMA Holdings		CUSIP-Level Ratio to Total Issuance *(%)* Percentiles		
		Face Value *($ billions)*	Share *(%)*	25th	Median	75th
December 2007	4,302	0	0	0	0	0
December 2019	5,016	1,409	28.1	27	100	100
March 2022	6,502	2,715	41.7	57	74	92

Note: At each date, this table shows the total amount outstanding of agency-issued residential MBS (in $billions), the face value of the SOMA's holdings of such securities (in $billions), the ratio of its holdings to the total outstanding (in percent), and summary statistics for the distribution of the ratio of SOMA holdings to the total outstanding amount of each individual security, where those statistics are weighted by the face value of SOMA holdings of individual securities. Sources: Federal Reserve Bank of New York, Federal Reserve Board of Governors (Z.1 release, table L.125), authors' calculations.

Market Functioning

Prior to 2008, the Federal Reserve allowed its repo counterparties to use GSE-issued securities as collateral, but its outright holdings of such securities were generally negligible. However, in November 2008 the Federal Reserve initiated large-scale purchases of agency housing-related securities, and by the time that the QE3 program concluded in late 2014, the SOMA held about $1.75 trillion in agency MBS.[38] In 2017 the FOMC began gradually shrinking its agency MBS holdings.[39]

As shown in Table 4, QE4 magnified the Federal Reserve's footprint in the mortgage market. Over the nine quarters ending in 2022Q1, the SOMA's holdings increased by $1.3 trillion while the total outstanding amount of agency MBS increased by about $1.5 trillion. Consequently, the Federal Reserve now holds more than 40% of the total outstanding amount of agency MBS, and its purchases during QE4 accounted for nearly the entire increase in the outstanding stock of agency MBS over this period.

[38] Federal Reserve Board (2014).

[39] In October 2017 the FOMC began shrinking its balance sheet by limiting the reinvestment of principal payments on its agency MBS holdings. Starting in July 2019, the FOMC instructed the SOMA desk that agency MBS principal payments in amounts up to $20 billion per month would be used to purchase Treasury securities while any additional agency MBS principal payments beyond that threshold would be reinvested in agency MBS purchases. At that time, the SOMA held about $1.4 trillion in agency MBS, and hence this strategy would have gradually eliminated those holdings by around 2025.

Figure 6: The Liquidity of SOMA Holdings of Agency Residential MBS at the End of QE4

Note: This figure reports the distribution of the Bloomberg Liquidity Score for agency-backed residential MBS held in the SOMA as of May 12, 2022. This score ranges from 0 to 100 and denotes the ranking of each security's liquidity relative to the universe of all government and corporate debt securities.
Source: Bloomberg LQA, Federal Reserve Bank of New York, authors' calculations.

The Federal Reserve's footprint is also evident from its holdings of each individual MBS security relative to its outstanding amount. As of March 2022, the SOMA's holdings consisted of over 28,000 distinct CUSIPs, but most of those CUSIPs were seasoned securities for which most of the principal had previously been repaid. Consequently, nearly all of the face value of the SOMA's holdings ($2.2 trillion, or 94% of the total) was in a much smaller set of 1,582 CUSIPs for which its holding of each individual security exceeded $100 million, and the bulk of those securities were issued in 2020 or 2021 and purchased during QE4. And for most of those individual securities, the SOMA's holdings comprise more than half of the total outstanding face value.

Given its outsized role in the MBS market, the Federal Reserve may well have been a "price setter" rather than a "price taker" in conducting its QE4 purchases. About $1.3 trillion of these securities were purchased in just 126 transactions, each of which involved a face value exceeding $5 billion.[40] And many of those transactions involved CUSIPs that were not actively trading in the secondary market, and hence the purchase price would necessarily be negotiated between the SOMA desk and the primary dealer holding the security. However, the Federal Reserve does not release any information about the actual prices paid for its individual securities.[41]

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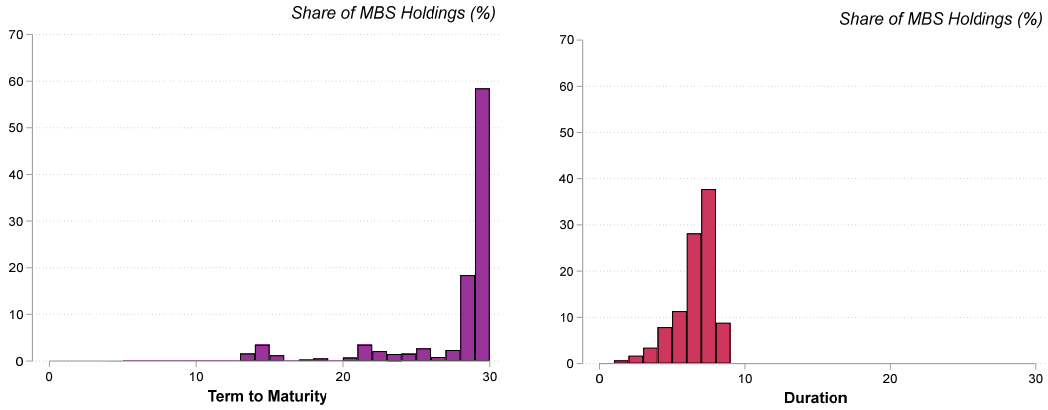
[40] The single largest transaction during QE4 occured in mid-December 2020, when the SOMA purchased $26 billion in face value of a newly-issued Freddie Mac MortPass security (cusip 3132DWAW3). The SOMA made additional purchases of that security on two occasions in early 2021 ($7 billion in mid-January and $4 billion in mid-February), so that its total holdings comprised nearly 60% of the total issuance of this particular security.

[41] The Federal Reserve Bank of New York publishes weekly data regarding the face value of every individual security held in the SOMA (identified by CUSIP), while the aggregated value of unamortized premiums and discounts on securities purchases is published in the Federal Reserve Board's weekly H.4.1. release.

Figure 7: The Maturity and Duration of SOMA Holdings of Agency Residential MBS after the End of QE4



Note: This figure reports on the characteristics of agency-backed residential MBS held in the SOMA as of May 11, 2022. The left panel shows the distribution of the term to maturity of those securities, and the right panel shows the distribution of the Macauley duration computed using a discount factor of 2.5%. Source: Federal Reserve Bank of New York, Bloomberg, authors' calculations.

Figure 6 reports on the liquidity of the SOMA's agency MBS holdings as of mid-May 2022, using Bloomberg Liquidity Assessment (LQA) scores. At that time, about one-fourth of the MBS held in the SOMA had very high liquidity, comparable to that of U.S. Treasuries (which typically have Bloomberg liquidity scores of 97 or higher). However, most of the SOMA's holdings were notably less liquid—especially securities whose coupon rates were already well below prevailing market interest rates at that time. Of course, the liquidity of these holdings could decline even further in scenarios involving even higher levels of market interest rates. These liquidity scores underscore the potential difficulties in initiating active sales of the Federal Reserve's MBS holdings, rather than simply allowing its holdings to roll off passively due to scheduled payments and prepayments of mortgage principal.

Duration and Interest Rate Risk

As shown in the left panel of Figure 7, at the conclusion of QE4 most of the SOMA's holdings of agency MBS had terms to maturity close to 30 years, while a small fraction had terms to maturity close to 15 years. This pattern reflects the characteristics of the Fed's QE4 purchases, i.e., 90% of its MBS purchases were securities with a term of 30 years, and most of the securities purchased were issued in 2020 or 2021.[42]

As with a 30-year Treasury bond, the bulk of the income from an agency MBS is received long before its maturity date, and hence the duration of the security is much shorter than its term to maturity. To assess the duration of each security, we use Bloomberg's cash flow

[42] As shown in Table 1, the total face value of the SOMA's agency MBS purchases was about $2.9 trillion, of which 87.5% had a term of 30 years, 12% had a term of 15 years, and 0.5% had a term of 20 years.

Table 5: Conditional Prepayment Rates and Duration of the SOMA Portfolio of Agency Residential MBS

Assessment Date	Projected Level of Conditional Prepayment Rate *(percent)*	Projected Duration *(years)*
Nov. 14, 2021	14.6	4.5
May 12, 2022	7.3	6.6
Ratio	***0.52***	***1.4***

Note:At each date, this table shows the weighted average conditional prepayment rate (CPR) and the weighted average duration of the SOMA's agency MBS holdings on that date, using Bloomberg projections of the each security's CPR at a 24-month horizon and weighting each individual security by the face value of its SOMA holdings. Source: Bloomberg, Federal Reserve Bank of New York, authors' calculations.

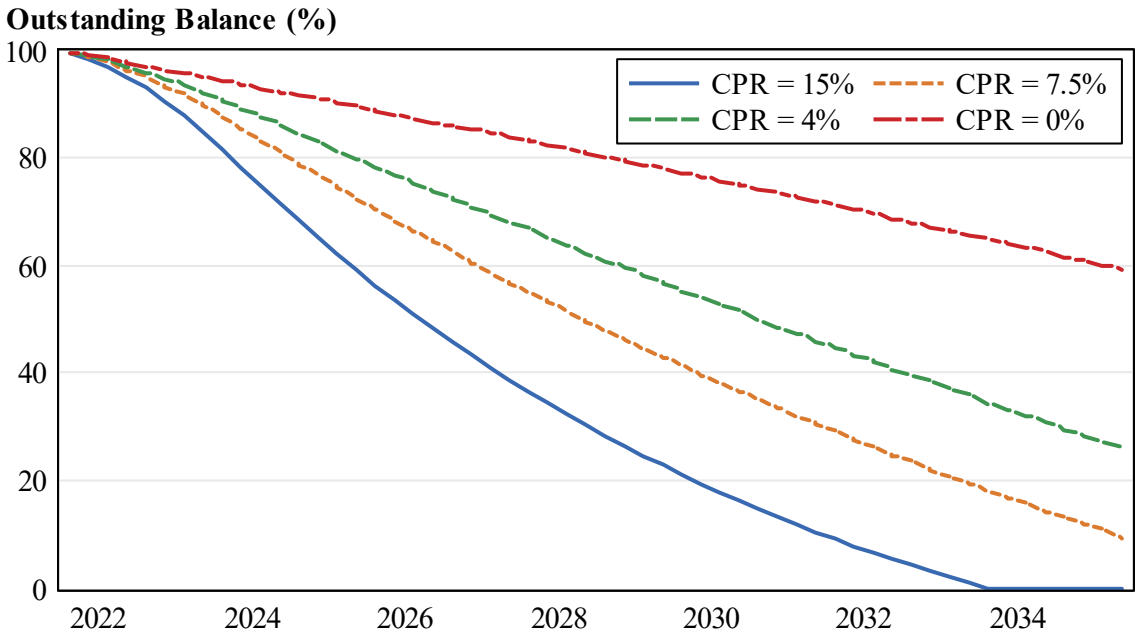
projections at a specified date. These projections include coupon payments as well as scheduled payments and prepayments of mortgage principal, using Bloomberg's proprietary model of the trajectory of conditional prepayment rates (CPRs) as a function of the outlook for mortgage rates and the specific characteristics of each individual MBS. We compute the duration of each security using a fixed discount factor of 2.5%.

As shown in the right panel of Figure 7, following the conclusion of QE4 all of the agency residential MBS in the SOMA portfolio had projected durations under 10 years. As of mid-May 2022, the SOMA held a total of $2.7 trillion in agency MBS, and the weighted average duration of those securities was 6.6 (using the face values of the individual security holdings as weights). Thus, a first-order approximation indicates that the 2% upward shift in the level of interest rates which transpired between October 2021 and June 2022 reduced the market value of the SOMA's MBS portfolio by about 13%, i.e., a mark-to-market loss of about $350 billion.

As noted above, an intrinsic characteristic of agency MBS is that a rise in the prevailing mortgage rate tends to reduce prepayment rates and hence lengthen the duration of the security. That pattern of negative convexity is apparent in Table 5, which shows that the weighted average CPR of the SOMA's MBS holdings was halved over the period from November 2021 to May 2022. Consequently, the projected duration of the SOMA's MBS portfolio rose markedly from 4.5 in November 2021 to 6.6 in May 2022.

Finally, as shown in Figure 8, the decline in prepayment rates significantly reduces the pace at which agency MBS roll off of the Federal Reserve's balance sheet. In particular, for a security with a CPR of 15%, the SOMA's holdings would be roughly halved over the next four years and would be close to zero by the end of the decade. By contrast, with a CPR of 7.5%, the half-life is notably longer, and the SOMA's holdings at the end of the decade

Figure 8: Conditional Prepayment Rates and the Evolution of Agency MBS Holdings



Note: This figure illustrates how the SOMA's holdings of a given agency-backed MBS evolve over time for alternative levels of the conditional prepayment rate on that security. Source: authors' calculations.

would be roughly 40% of its current amount. Moreover, in alternative scenarios involving higher prevailing mortgage rates, the CPR would likely decline further and the process of winding down the Fed's MBS holdings would become even more prolonged.

5. Assessing the Net Interest Cost of QE4

The Federal Reserve was not established to generate public revenue, but it does have the sole power to issue paper currency, and that authority has been highly profitable because the Fed pays no interest on its currency liabilities while accruing interest on the corresponding assets in its portfolio. Throughout most of its history, the Federal Reserve has simply used a small portion of that net interest income to cover its operating expenses and pay dividends on its capital, while the remainder has been remitted to the U.S. Treasury. In effect, the Federal Reserve's monopoly on issuing paper cash is roughly analogous to the classic fable about the goose that lays golden eggs. The Fed has a fiduciary responsibility to care for the goose and to ensure that the public receives the proceeds from the golden eggs.

Indeed, the interest rate risks associated with QE can result in substantial costs that are ultimately borne by U.S. taxpayers. When the FOMC engaged in QE4, it purchased securities by issuing interest-bearing liabilities of bank reserves and/or reverse repos. If interest rates had subsequently followed a shallow trajectory, then the Fed would have accrued greater net interest income and correspondingly greater remittances. In reality, however, interest rates have increased much more sharply than anticipated, thereby reducing the Fed's net interest income and curtailing its remittances. To proceed with the foregoing analogy, the "golden eggs" associated with the issuance of paper cash will be used to cover the cost of QE4 instead of being remitted to the Treasury.

To quantify the net interest expense of QE4, we assess the likely trajectory of the Federal Reserve's balance sheet over the coming decade, using detailed information about the SOMA's securities holdings as well as the normalization plans adopted by the FOMC. We then compare that baseline trajectory to a counterfactual scenario with no QE4 purchases, as well as an even simpler scenario in which the Federal Reserve's assets consist solely of short-term Treasury bills.

The FOMC's Normalization Plan

In May 2022 the FOMC announced that it would begin shrinking the SOMA account during the following month by setting target amounts for the rolloff of Treasury securities and caps on the rolloff of agency MBS.[43] In particular, its holdings of Treasuries would decline by $120 billion in 2022:Q2 and at a quarterly rate of $180 billion thereafter; these declines would predominantly reflect maturing Treasury notes and bonds but would be augmented as needed by allowing maturing Treasury bills to roll off instead of being reinvested into new Treasury bills. Meanwhile, its holdings of agency MBS would be allowed to decline by up to $70 billion in 2022:Q2 and by up to $105 billion in subsequent quarters, reflecting the flow of principal payments on those securities.

[43] See FOMC(2022d).

The FOMC's normalization plan indicates that these adjustments will continue until the balance sheet approaches a size judged to be consistent with an "ample" supply of reserves. Subsequently, the FOMC will resume expanding its holdings of Treasury securities as needed to continue fostering ample reserves, while principal payments on agency MBS would be reinvested into Treasury securities.

Constructing the Baseline Path

In light of the FOMC's plans, we construct a baseline path for the Federal Reserve's balance sheet.[44] On the asset side of the balance sheet, we project principal and interest payments for each of the individual securities held in the SOMA as of 29 June 2022:

- The projection for each nominal Treasury security simply reflects its par value and maturity date as well as the semiannual coupon rate for Treasury notes and bonds.
- For *Treasury inflation-protected securities (TIPS)*, we also project the accumulated amount of inflation compensation based on median projections of annual CPI inflation taken from the Survey of Professional Forecasters (SPF) as published by the Federal Reserve Bank of Philadelphia in May 2022 (the latest available release).
- For *agency residential MBS*, we use Bloomberg's proprietary cashflow projections (downloaded on 27 June 2022).
- For *agency commercial MBS,* our projections assume that outstanding principal is repaid in equal monthly installments over the life of the security.
- *Unamortized premiums and discounts* (which had a net value of about $300 billion at the end of June 2022) are amortized on a straightline basis over seven years.
- Emergency credit facilities established during the pandemic (which had outstanding balances of about $50 billion as of June 2022) are assumed to diminish gradually at a steady pace of 5% per quarter.

Our analysis indicates that the overall size of the balance sheet is likely to approach the "ample reserves" threshold near the end of 2024. From that point onwards, we assume that the balance sheet expands at an annual rate of 4%, roughly in line with nominal GDP. We assume that the SOMA gradually rebuilds its holdings of Treasury bills and that purchases of Treasury notes and bonds are allocated across maturities in roughly the same proportions as the SOMA's purchases during the second half of 2019.[45] The yields on these securities are computed using the Federal Reserve Board's forward rate estimates as of 29 June 2022.[46]

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[44] See Appendix B for a detailed description of our projection methodology.

[45] For simplicity, we assume that the SOMA does not acquire any additional TIPS and that it reinvests the proceeds from maturing floating-rate notes (FRNs).

[46] See Gurkaynak, Sack, and Wright (2011), Federal Reserve Board (2022b).

Table 6: Baseline Path of SOMA Assets under the FOMC's Normalization Plan

Year	Quarter	Total Assets	Agency MBS	Treasury Notes & Bonds	Treasury Bills	Other Assets
			Par Value at End of Quarter ($ billions)			
2022	***Q2***	***8,980***	***2,707***	***5,406***	***326***	***541***
			Quarterly Change ($ billions)			
2022	Q3	-187	-52	-95	-25	-15
	Q4	-250	-55	-176	-4	-15
2023	Q1	-252	-57	-176	-4	-15
	Q2	-253	-59	-177	-3	-15
	Q3	-254	-60	-177	-3	-15
	Q4	-255	-60	-153	-27	-15
2024	Q1	-255	-60	-169	-11	-15
	Q2	-254	-60	-177	-3	-15
	Q3	-253	-59	-160	-20	-15
	Q4	-96	-58	-126	102	-15
			Par Value at End of Quarter ($ Billions)			
2024	***Q4***	***6,670***	***2,129***	***3,819***	***329***	***393***

Note:This table shows the par value of the SOMA's assets as of 2022:Q2 and 2024:Q4 (in $ billions, end of quarter) and the change in its assets during each intervening quarter. Sources: Federal Reserve Bank of New York, authors' calculations.

Table 7: Baseline Path of SOMA Liabilities under the FOMC's Normalization Plan

Year	Quarter	Total Liabilities	Reserves	Reverse Repos	Currency	Other Liabilities
			Balance at End of Quarter ($ billions)			
2022	***Q2***	***8,980***	***3,109***	***2,492***	***2,279***	***1,100***
			Quarterly Change ($ billions)			
2022	Q3	-187	114	-344	30	13
	Q4	-250	-177	-118	32	14
2023	Q1	-252	-175	-117	28	12
	Q2	-253	-176	-117	28	12
	Q3	-254	-176	-117	27	12
	Q4	-255	-175	-116	25	11
2024	Q1	-255	-175	-117	25	11
	Q2	-254	-175	-116	26	11
	Q3	-253	-174	-116	26	11
	Q4	-96	-81	-54	27	12
			Balance at End of Quarter ($ Billions)			
2024	***Q4***	***6,670***	***1,739***	***1,159***	***2,552***	***1,221***

Note:This table shows the Federal Reserve's liabilities as of 2022:Q2 and 2024:Q4 (in $ billions, end of quarter) and the change in its liabilities during each intervening quarter. Sources: Federal Reserve Bank of New York, authors' calculations.

Turning now to the liabilities side of the Federal Reserve's balance sheet, our projection embeds the following elements:

- The outstanding stock of *currency in circulation* (which was about $2.3 trillion at the end of June 2022) is assumed to expand over time in line with nominal GDP, using the median outlook as published in the May 2022 SPF.[47]
- Likewise, the *U.S. Treasury's general account* at the Fed (which held about $650 billion at the end of June 2022) is assumed to expand in line with nominal GDP. For simplicity, we abstract from seasonal patterns in the evolution of this account.
- The Federal Reserve's interest-bearing liabilities are actively managed in line with the SOMA's total assets minus its other liabilities. In particular, *reserve balances* and *reverse repos* move in parallel over time, so that these two components comprise 60% and 40% of total interest-bearing liabilities, respectively.

Table 6 shows the details of our baseline projection for the SOMA's securities holdings through the end of 2024. Over that horizon, the quarterly maturation of Treasury notes and bonds will be just below $180 billion, and hence only a modest rolloff of Treasury bills will be needed to meet the FOMC's shrinkage target.[48] In contrast, principal payments on agency MBS are projected at around $60 billion per quarter, well below the cap set by the FOMC. In effect, as noted in the previous section, the runoff of agency MBS will be quite protracted due to the sharp drop in mortgage prepayment rates.

Table 7 reports the corresponding details for the baseline path of Federal Reserve liabilities. In particular, reserves shrink gradually to around $1.7 trillion at the end of 2024, similar to the level of reserve balances in early 2020 before the launch of QE4. Meanwhile, reverse repos reach a trough of about $1.2 trillion in late 2024—nearly $1 trillion above its level as of early 2020.

Constructing the No-QE4 Counterfactual Path

We now consider a counterfactual scenario in which the FOMC did not initiate QE4. In this scenario, the Federal Reserve would still have proceeded with launching emergency credit facilities at the onset of the pandemic as well as subsequently establishing the standing reverse repo facility. However, the SOMA's holdings of agency MBS would have continued to run off, while its holdings of Treasury notes and bonds would have expanded gradually over time, consistent with the "ample reserves" criterion. Moreover, the SOMA would

[47] The May 2022 SPF reports projections for nominal GDP through 2023. Beyond that horizon, we project nominal GDP using the sum of the SPF's projections for the real GDP growth rate and the personal consumption expenditures (PCE) inflation rate.

[48] For maturing Treasury inflation-protected securities (TIPS), principal payments at maturity include the accumulated amount of inflation compensation as well as the par value of the security.

have expanded its holdings of Treasury bills in line with the expansion of its reverse repos, thereby avoiding any maturity mismatch between those assets and liabilities.

To construct the counterfactual path of the Fed's balance sheet in the absence of QE4, we start by identifying the individual securities that were held by the SOMA on 27 February 2020 and that had not matured as of June 2022. Of course, QE4 augmented holdings for many of these securities. Consequently, we proceed as follows:

- For each *agency residential MBS*, the counterfactual holding as of 29 June 2022 is obtained from the actual SOMA holding by subtracting the cumulative amount of purchases during QE4 (net of principal repayments on such purchases).[49] We then use Bloomberg's proprietary cashflow projections to compute the counterfactual path of principal and interest payments for each security.
- For *Treasury notes and bonds*, the counterfactual holding as of 29 June 2022 is obtained from the actual SOMA holding by subtracting the bulk of QE4 purchases, apart from a modest growth factor consistent with gradual expansion of the Fed's balance sheet over that time period (i.e., 2020:Q2 to 2022:Q2). As in our baseline forecast, the counterfactual projection for each of these securities simply reflects its par value, maturity date, and coupon rate (as well as projected inflation compensation on the SOMA's counterfactual TIPS holdings).
- From 2022:Q3 onwards, the SOMA expands its holdings of nominal Treasury notes and bonds at an annual rate of 4%, consistent with normal growth of nominal GDP.[50] The maturity composition of these purchases is identical to that assumed in our baseline projection, and the yields on these securities are computed using the Federal Reserve Board's forward rate estimates as of 29 June 2022.

Comparing the Evolution of SOMA Holdings

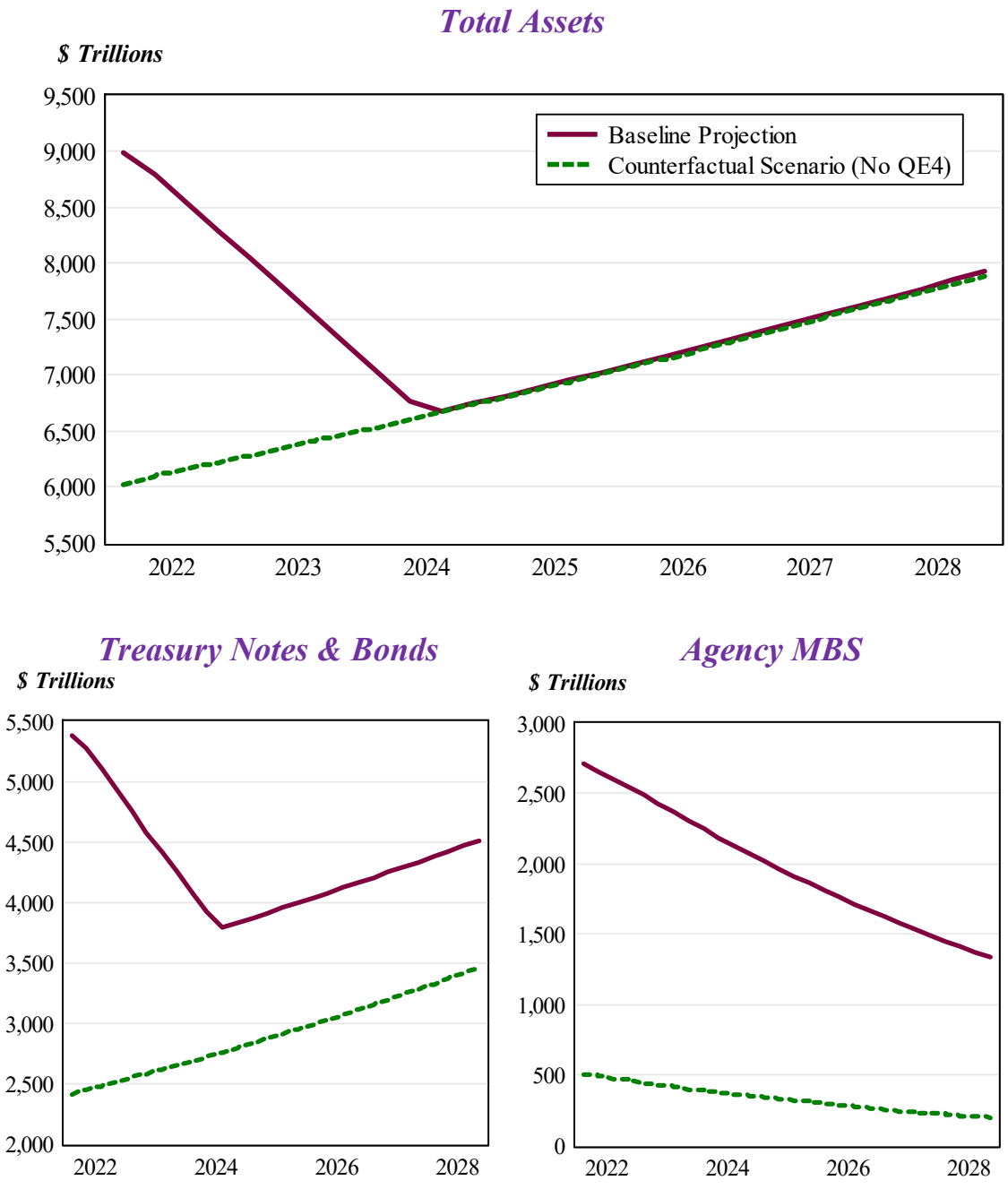
As shown in the upper panel of Figure 9, the path of total SOMA assets in the baseline projection converges with that of the counterfactual scenario in late 2024, consistent with the judgment that the overall size of the Federal Reserve's balance sheet will be normalized at that time. Both trajectories expand at roughly the same pace thereafter, consistent with the FOMC's stated goal of providing an ample supply of reserve balances over time.

Nonetheless, it is evident that the composition of the SOMA's asset holdings under the baseline projection will remain far from normal throughout the remainder of the decade,

[49] For the agency MBS cusips held on 27 February 2020, the holdings of those cusips totaled about $565 billion as of 29 June 2022, of which about $62 billion corresponded to QE4 purchases (net of subsequent principal payments on such purchases). Consequently, the no-QE4 counterfactual scenario has agency MBS holdings of $503 billion at the end of the second quarter of 2022.

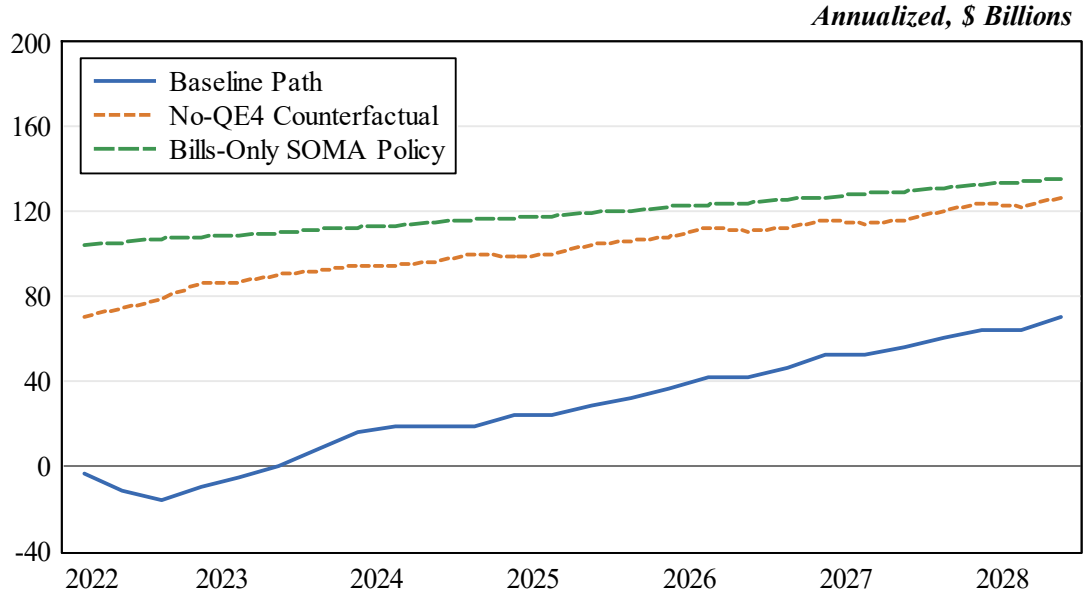
[50] As in our baseline projection, our counterfactual scenario assumes that the SOMA does not acquire any additional TIPS and that it reinvests the proceeds from maturing floating-rate notes (FRNs).

Figure 9: Comparing the Trajectory of SOMA Assets in the Baseline and the Counterfactual Scenario



Source: Federal Reserve Bank of New York, Bloomberg, authors' calculations.

Figure 10: Assessing the Net Interest Cost of QE4



Source: Federal Reserve Bank of New York, Bloomberg, authors' calculations.

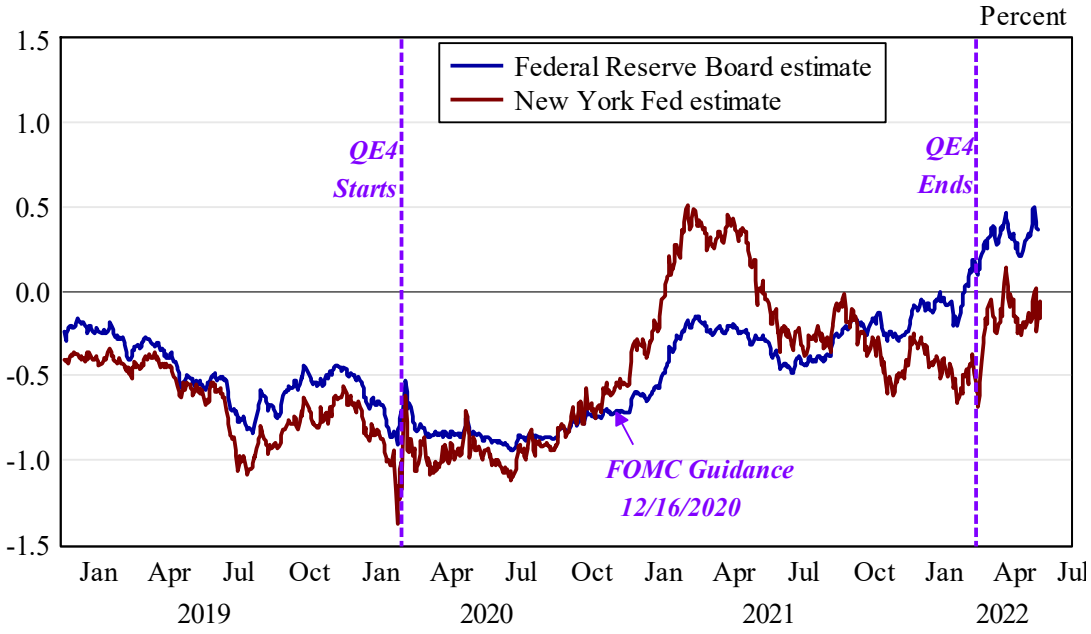
reflecting the glacial pace of agency MBS runoff as well as the relatively low holdings of Treasury bills relative to notes and bonds. As shown in the lower panels of Figure 9, the post-2024 gap between the two projections is about $1 trillion for SOMA holdings of Treasury notes and bonds and even larger for SOMA holdings of agency MBS.

In effect, under the FOMC's current normalization plans, the SOMA portfolio will continue to embed a high degree of interest rate risk for the foreseeable future due to the long terms to maturity of many QE4 securities purchases. By contrast, under the counterfactual scenario, the Federal Reserve's reverse repo liabilities can be directly matched by corresponding holdings of Treasury bills, consistent with allowing the size of this standing facility to expand or contract flexibly while avoiding any substantial interest rate risk.

Cost to Taxpayers

As shown in Figure 10, the Federal Reserve's net interest income (and hence its remittances to the U.S. Treasury) will be far lower than in the No-QE4 counterfactual scenario. Indeed, this comparison indicates that QE4 will have a total cost to taxpayers of about $550 billion. Of course, that cost could turn out to be lower if inflation subsides more rapidly than currently anticipated. Conversely, if the path of interest rates shifts even higher (consistent with the current prescription of the Taylor Rule and other policy benchmarks), then the total cost of QE4 to U.S. taxpayers might well reach $1 trillion or higher.

Figure 11: Did QE4 Reduce the Term Premium?



Source: Federal Reserve Board of Governors, Federal Reserve Bank of New York.

5. Assessing the Potential Benefits of QE4

Macroeconomic Benefits

When the FOMC launched QE3 in September 2012, its statement indicated that the program *"should put downward pressure on longer-term interest rates, support mortgage markets, and help make broader financial conditions more accommodative."*[51] According to the underlying analytical framework, purchasing longer-term securities would reduce the term premium and hence facilitate lower borrowing costs.[52] For example, in early 2013 the Federal Reserve Board staff sent a memo to the FOMC indicating that $500 billion in securities purchases would reduce the 10-year Treasury yield by about 20 basis points.[53]

This analytical framework played a central role in the FOMC's review of its policy framework in 2019-20, in which participants concluded that its balance sheet tools could be deployed *"earlier and more aggressively"* than in prior programs.[54] From September

[51] FOMC (2012).

[52] For a range of initial estimates, see Chen et al. (2011), Chung et al. (2011), Krishnamurthy and Vissing-Jorgensen (2011), Cambron et al. (2012), Hamilton and Wu (2011), and Wu and Xia (2016). More recently, Hamilton (2018) and Bordo and Levin (2019) found that QE3 had practically negligible effects on economic activity and inflation; see also Greenlaw et al. (2018).

[53] Durdu et al. (2013).

[54] FOMC (2019c). See also Sims and Wu (2020, 2021).

2020 onwards, the FOMC characterized its QE4 purchases using similar terms; in addition to helping sustain smooth market functioning, its securities purchases would *"help foster accommodative financial conditions, thereby supporting the flow of credit to households and businesses."*[55] Indeed, that characterization continued to be used in FOMC meeting statements throughout 2021.[56]

The Federal Reserve itself produces two independent estimates of the term premium: (a) Federal Reserve Board estimates using the methodology of Kim and Wright (2005), and (b) Federal Reserve Bank of New York estimates using the methodology developed by Adrian, Crump, and Moench (2013).[57]

As shown in Figure 11, neither of these term premium estimates exhibited any substantial decline in the wake of the launch of QE4, even after financial strains had largely subsided. That pattern is evidently inconsistent with the analytical framework used in rationalizing QE4. In effect, these estimates do not provide any significant evidence that the program was successful in reducing borrowing costs or spurring a stronger economic recovery.

Of course, it is always possible that term premiums would have been higher if there had been no QE4 or that the two Fed models of term premiums are not producing accurate estimates over this interval. But it is notable that, according to the minutes of the November 2020 FOMC meeting, when discussing QE4 several meeting participants "…noted the possibility that there may be limits to the amount of additional accommodation that could be provided through increases in the Federal Reserve's asset holdings in light of the low level of longer-term yields.."[58]

Federal Budget Deficits

While QE3 was underway, Federal Reserve Board staff analysis (circulated to the FOMC in 2013 and released to the public after a five-year lag) noted that the program could have significant fiscal benefits by stimulating a somewhat faster economic recovery, thereby boosting federal tax receipts and reducing unemployment insurance payments and other transfers.[59] Those considerations seem less relevant for QE4, because the economic recovery was facilitated by enormous fiscal stimulus as well as extraordinarily rapid development and dissemination of COVID-19 vaccines, and the additional stimulative effect from QE4 is unclear.

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[55] FOMC (2020g,h).

[56] FOMC (2021d).

[57] See Federal Reserve Board (2022a) and Federal Reserve Bank of New York (2022b).

[58] FOMC (2020j).

[59] See Clouse et al. (2013).

When the FOMC was contemplating forward guidance about QE4 at its November 2020 meeting, participants noted that the program *"could also help guard against undesirable upward pressure on longer-term rates that could arise, for example, from higher-than-expected Treasury debt issuance."*[60] Such statements seem reminiscent of the late 1940s, when the Federal Reserve coordinated directly with the U.S. Treasury to hold down the interest cost of financing the federal debt, but inconsistent with the Federal Reserve's subsequent commitment to foster its statutory mandate rather than facilitating deficit financing.[61] Indeed, such actions could undermine the Federal Reserve's ability to determine the stance of monetary policy without being subject to political interference.[62]

Our foregoing analysis indicates that the *ex post* fiscal costs of QE4 are likely to be very large. In our baseline scenario, the Federal Reserve's remittances to the U.S. Treasury will be about $550 billion less than if QE4 had not been conducted, and the ultimate cost to taxpayers could turn out to be $1 trillion or more. (By comparison, the entire U.S. federal defense budget as of 2020 was about $800 billion.) As noted by Lucas (2022), the Federal Reserve's securities purchases were fiscally neutral from an *ex ante* perspective as long as those transactions occurred at fair market prices (a condition that seems questionable in light of the size of the purchases and the illiquidity of the securities). In any case, the *ex post* losses underscore that QE4 incurred a high degree of interest rate risk that is certainly relevant in evaluating the program.

Market Functioning

The Federal Reserve purchased over $1 trillion in Treasuries in March and early April 2020. Duffie (2020) carefully examines that period and concludes that the Federal Reserve's intervention was crucial in stabilizing the U.S. Treasury market. Likewise, Fleming and colleagues (2022) report that many measures of illiquidity in Treasury and mortgage markets reached extraordinary levels in mid-March 2020 and improved rapidly and significantly over subsequent weeks. Similarly, Vissing-Jorgensen (2021) notes that while the announcement of the Fed's purchases in March 2020 did not reduce Treasury and MBS rates, the execution of those purchases did reduce rates.

Those emergency purchases of Treasuries comprised nearly one-fourth of the total size of QE4, and hence the Federal Reserve's market intervention should not be viewed as having been costless. Indeed, the magnitude of such costs may well boost the rationale for enacting Treasury market reforms (such as modifying the supplementary leverage ratio requirement, expanding access to the standing repo facility, and establishing a broad central clearing

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[60] FOMC (2020j).

[61] An objective of facilitating Treasury debt issuance could help explain why QE4 included substantial purchases of short-dated securities, since those purchases did not take duration out of private hands and hence would not have been expected to reduce term premiums.

[62] See Plosser (2017).

mandate) to mitigate the risk of future episodes that might require similar costly interventions. Moreover, the Federal Reserve could develop contingency plans for a term repo facility that could provide liquidity at longer terms (e.g., 1 or 2 years), thereby returning to Bagehot's dictum rather than continuing to serve as the "market-maker of last resort" on an ongoing basis.

By contrast, the SOMA made only modest purchases of agency MBS in March and early April 2020. In this case, the key question is why the Federal Reserve subsequently ramped up its agency MBS purchases and then maintained that flow of purchases for nearly 18 months, particularly in a context of an overheated housing market and reasonably smooth functioning of mortgage financing from April 2020 onwards. Indeed, the minutes of the November 2020 FOMC meeting state that some participants *"expressed concern that maintaining the current pace of agency MBS purchases could contribute to potential valuation pressures in housing markets*", but the minutes do not indicate that any response was made to those concerns.[63]

[63] FOMC (2020j).

6. **Conclusion**

In this paper, we have conducted a systematic analysis of the costs and benefits of QE4, using detailed data on the SOMA's security holdings as of June 2022. Our analysis indicates that QE4 markedly increased the Federal Reserve's footprint in the markets for Treasuries and agency MBS, with potentially adverse consequences for market functioning. Our balance sheet simulations indicate that QE4 is likely to have a total cost to taxpayers of about $550 billion. However, since it did not have any significant effects on the term premium, it remains unclear whether QE4 was associated with any substantial macroeconomic benefits.

Of course, our cost-benefit analysis has been conducted from an *ex post* perspective, after the end of the QE4 program. Future research should revisit these issues from an *ex ante* perspective, perhaps drawing on real-time data on financial market options prices. It should be noted that in early 2026 the FOMC will publish the transcripts of its meetings held in 2020 along with the internal staff materials that were provided to inform those deliberations; perhaps Federal Reserve officials could consider releasing some of those materials at an earlier date to facilitate analysis of QE4 from an *ex ante* perspective.

In carrying out its role in overseeing the Federal Reserve, the U.S. Congress could consider holding public hearings to facilitate "lessons learned" from the experience with QE4. In light of such hearings, members of Congress could then consider whether any new legislative action might be appropriate. For example, Congress could strengthen its oversight by making the Federal Reserve's inspector general fully independent (as with other major government agencies) and/or commissioning the General Accounting Office (GAO) to engage in comprehensive reviews of the Federal Reserve on a fixed schedule. Such GAO reviews would appropriately include all aspects of the Federal Reserve's monetary policy framework but would refrain from commenting on FOMC decisions about the stance of monetary policy. Finally, Congress could consider whether to constrain the FOMC's ability to incur interest rate risk, analogous to the constraints on credit risk established by the Dodd-Frank Act.

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