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Fiscal Implications of the Federal Reserve's Balance Sheet Normalization

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Abstract

The paper surveys the recent literature on the fiscal implications of central bank balance sheets, with a special focus on political economy issues. It then presents the results of simulations that describe the effects of different scenarios for the Federal Reserve's longer-run balance sheet on its earnings remittances to the U.S. Treasury and, more broadly, on the government's overall fiscal position. We find that reducing longer-run reserve balances from $2.3 trillion (roughly the current amount) to $1 trillion reduces the likelihood of posting a quarterly net loss in the future from 30 percent to under 5 percent. Further reducing longer-run reserve balances from $1 trillion to pre-crisis levels has little effect on the likelihood of net losses.

JEL CLASSIFICATION: E58, E59, E69

KEY WORDS: central bank balance sheets, monetary policy, remittances

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1 Introduction

In the aftermath of the global financial crisis and into the Great Recession, the U.S. Federal Reserve reduced its overnight interest rate to the effective lower bound and engaged in large-scale purchases of long-term U.S. Treasury and Federal Agency securities. From the start of 2008 through the end of 2016, the U.S. central bank's balance sheet grew from $900 billion to $4.5 trillion, with assets now principally consisting of long-term U.S. Treasury notes and bonds ($2.3 trillion) and Federal Agency mortgage-backed securities ($1.8 trillion).[1]

In 2017, the Federal Reserve's Federal Open Market Committee (FOMC) started implementing a balance sheet normalization program to reduce the size of the central bank's balance sheet.[2] However, important questions remain about its longer-run size and composition. Longer-run portfolio choices could have important consequences for the level and variability of earnings remittances to the U.S. Treasury, both during and after the transition period. Of course, remittances are outcomes of the proper conduct of monetary policy and their path and volatility are not factors influencing monetary policy decisions, which are made to achieve the statutory goals of maximum employment and stable prices. Nonetheless, the central bank may have to deal with political economy concerns during the transition related to the volatility of remittances to the Treasury, including the possibility of experiencing net losses.[3]

In this paper, we simulate the transition of the Federal Reserve's balance sheet

[1] Data as of December 29, 2016. Federal Reserve balance sheet information is available weekly from Federal Reserve Statistical release (H.4.1. Factors Affecting Reserve Balances) available at: https://www.federalreserve.gov/releases/h41/.

[2] The June 2017 Addendum to the FOMC's Policy Normalization Principles and Plans is available at: https://www.federalreserve.gov/newsevents/pressreleases/monetary20170614c.htm. At its September meeting, the FOMC voted to implement this program starting in October.

[3] As will be discussed in Section 2.2, in case Federal Reserve's earnings are insufficient to provide for cover dividends, operating costs, and retained surplus, remittances to the Treasury are suspended and a deferred asset is recorded, with this debit balance representing the amount of future net earnings the Federal Reserve will need to realize before remittances to the Treasury resume.

to four alternative longer-run sizes in an effort to understand the implications for both remittances and broader fiscal outcomes. To do so, we combine two models maintained by the Federal Reserve Board: [1] the System Open Market Account (SOMA) model (Carpenter et al., 2015), which for a given interest rate scenario, generates detailed projections of the evolution of the balance sheet and associated net income; and [2] a large-scale macroeconomic model (FRB/US), which generates (among other things) future paths for interest rates as well as government revenues, expenditures, and debt. Importantly, this approach allows for general equilibrium effects as changes to the central bank's balance sheet provide (or remove) monetary accommodation, which alters interest rate paths that are important determinants of remittances and broader economic activity.[4] The results of our simulations suggest three broad takeaways.

First, the level of longer-run reserve balances affects the probability that the Federal Reserve faces net losses at some point in the future. If, in the longer run, reserve balances remain near the current level (around $2.3 trillion), the probability of realizing net losses is around 30 percent.[5] In the context of the macroeconomic model, this arises for two reasons: [1] new assets purchased to maintain the current level of reserve balances are associated with negative expected future net income owing to currently negative Treasury term premiums; and [2] net income generated from legacy assets declines as interest expenses increase (as short-term interest rates rise per the monetary policy rule) while interest income is unchanged. Of course, as of October 2017 the FOMC started

[4] Empirical studies have found that a larger balance sheet provides substantial accommodation when short-term interest rates are constrained by the effective lower bound (see, for example, Gagnon et al., 2011, D'Amico et al., 2012, and Bonis et al., 2017c). Away from the lower bound, the central bank can, in theory, keep the amount of monetary accommodation unchanged by moving short-term rates to offset the effects of the change in its balance sheet. As a result, any model of the fiscal implications of central bank balance sheet policy must also take a stand on interest-rate policy. In our analysis below using the FRB/US model, short-term interest rates are assumed to follow an inertial Taylor (1999) rule.

[5] As further explained at the beginning of Section 3, this scenario is neither consistent with the current FOMCs balance sheet normalization program nor an indication of any potential future Federal Reserve policy. We present this counterfactual, illustrative scenario only to understand the fiscal implications that could arise with reserve balances close to current levels.

implementing a balance sheet normalization program that aims at bringing the magnitude of reserve balances to a significantly lower level over the next few years.[6] In light of this development, we also consider three scenarios with lower longer-run levels of reserve balances. We find that, in contrast to the \$2.3 trillion scenario, shrinking reserve balances from their current level to a longer-run level of \$1.0 trillion reduces the likelihood of negative net earnings to less than 5 percent. In addition to not buying new assets while term premiums are negative, the smaller balance sheet provides less monetary accommodation, which, in turn, implies that short-term interest rates increase less rapidly. Further reducing longer-run reserve balances from \$1 trillion to pre-crisis levels has little effect on the likelihood of net losses.

Second, the possibility of Federal Reserve insolvency—meaning that the central bank would not be able to cover any losses with future seigniorage (Del Negro and Sims, 2015)—is truly negligible (i.e., less than 0.02 percent).

Finally, the overall fiscal impact—as measured by the ratio of federal debt to GDP at the end of our forecast horizon—of a larger longer-run level of reserve balances is positive (that is, the debt-to-GDP ratio is smaller), although the magnitude depends on the monetary policy rule assumed to govern short-term interest rates. An important caveat to our results, especially in terms of the overall fiscal impact, is that they are model-specific as they depend on assumptions embedded in the FRB/US model.

Our analysis is related to an emerging literature that projects central bank remittances flows under different portfolio normalization principles. Some research approaches this from an accounting and finance perspective and uses very detailed information about central bank securities holdings, coupled with simulated interest rate path(s), to estimate future remittances (e.g., Carpenter et al., 2015; Christensen et al., 2015). Macroeconomic analysis using simple quantitative models has also been conducted (e.g., Hall and Reis, 2015; Del Negro and Sims,

[6] See also Bonis et al. (2017b).

2015). Most of these papers suggest that the likelihood of the Federal Reserve recording losses (and temporarily ceasing remittances) is small.

Our contribution to this literature is twofold. First, we provide a broad discussion of both the institutional and the conceptual issues surrounding fiscal implications of central bank balance sheets, with a focus on the Federal Reserve. This survey strives to connect different strands of the literature related to central bank balance sheets, including macroeconomics, finance, and political economy. We also relate the more recent (post-financial crisis) contributions to an earlier literature that mainly focused on emerging economies (e.g., Stella, 1997). The second contribution relates to our simulations: this is the first study about the fiscal implications of different longer-run balance sheet sizes. Differently from other papers, we analyze the fiscal implications of balance sheet choices in a broad sense, in that we consider not only the implications for remittances but also the effects on the government's overall fiscal position.

The paper is organized as follows. Section 2 provides a broad overview of the various mechanisms by which the Federal Reserve's balance sheet has fiscal implications—from both a consolidated government budget perspective and a more narrow view that acknowledges that the central bank is an independent agency that produces an observable flow of remittances to the fiscal authority. Section 3 presents the results of our analysis of the fiscal implications of the Federal Reserve's balance sheet based on macroeconomic simulations using the SOMA and FRB/US models. Section 4 offers some concluding thoughts.

2 Central Bank Balance Sheets: Fiscal Implications and Political Economy Considerations

Monetary policy always has significant fiscal implications. In addition to influencing the interest rates at which the federal government finances its debt, monetary policy also affects broader economic activity (with implications for tax revenues and expenditures) and inflation (thus affecting the real cost of debt financing). Changes in the size and composition of the central bank's balance sheet have additional fiscal consequences. Below, we begin by discussing these implications from the consolidated government budget perspective, which, in the U.S. case, simply means adding the Federal Reserve's assets and liabilities to those of the federal government. (This implies subtracting the Federal Reserve's holdings of U.S. Treasury debt from the Treasury's liabilities, as they cancel each other out in the consolidated government's balance sheet.) This perspective is generally taken in macroeconomic models and is a useful starting point for our discussion. However, a consolidated government budget perspective ignores the fact that the fiscal authority and the central bank are different institutions, each with its own budget constraint. We therefore relax the assumption of a consolidated government budget in subsequent subsections.

Before proceeding, it is helpful to clarify a couple of issues. First, the Federal Reserve's prospective asset choices are constrained by law and for practical purposes are limited to acquiring U.S. Treasury and Federal Agency securities.[7] Federal Agency securities include debt and mortgage-backed securities (MBS) issued by congressionally chartered government-sponsored enterprises (GSEs): Fannie Mae, Freddie Mac, Federal Home Loan Bank System, Farm Credit System, and Farmer Mac. Collectively, the MBS guaranteed by Ginnie Mae, Fannie Mae, and Freddie

[7] The Federal Reserve is also authorized to purchase and hold short-term municipal debt, bankers' acceptances, and foreign sovereign debt.

Mac are referred to as "Agency MBS." Each GSE benefits from strong investor perceptions of an implied federal guarantee of their debt obligations owing to various charter provisions and past government actions (e.g., Frame and White, 2005, Frame et al., 2015).[8] Second, observed long-term Treasury bond yields can be decomposed conceptually into expectations about the future path of nominal short-term interest rates and term premiums that principally reflect compensation required by investors related to uncertainty about this expected path (e.g., Kim and Wright, 2005; Adrian et al., 2013). Estimated term premiums are typically positive and increasing in bond maturity, although have been negative at times.

2.1 A Consolidated Government Budget Perspective

We start our discussion by considering the simplest case when the Federal Reserve's balance sheet is primarily funded by currency, as was the case before the Great Recession. Here, the only portfolio choice for the central bank relates to its asset composition. For many years, the Federal Reserve purchased only U.S. Treasury securities, thus further narrowing its portfolio choice to the duration of its asset portfolio.[9] From a consolidated balance sheet perspective, the Federal Reserve's holding of U.S. Treasury debt implies that these securities effectively "cancel out." Currency, which bears zero interest, then becomes a liability of the consolidated government. As long as interest rates are positive, this activity lowers funding costs for the consolidated government.

We next consider the fiscal implications of a balance sheet expansion that involves purchases of Treasury securities financed by increasing reserves rather than by increasing currency in circulation. From a consolidated budget

[8] Nevertheless, by law, GSEs are required to clearly state that there is no guarantee. The exception is for Ginnie Mae MBS, which do carry a full-faith-and-credit guarantee from the U.S. government. Ginnie Mae is considered a "government corporation" rather than a GSE.

[9] For a history and explanation of the portfolio, see the Federal Reserve study "Alternative Instruments for Open Market and Discount Window Operations," available at https://www.federalreserve.gov/boarddocs/surveys/soma/alt_instrmnts.pdf.

perspective, Federal Reserve purchases of these securities are analogous to the Treasury replacing them with overnight debt, thereby shortening the duration of overall government liabilities. The implications for the consolidated government's funding costs depend on the duration of the securities being purchased by the Federal Reserve. If the term premium is positive, a larger central bank balance sheet should lower government funding costs (on average, over the long run) as the government collectively pays lower term premiums. However, expanding the balance sheet using interest-bearing liabilities does increase the interest rate risk associated with the consolidated government balance sheet. In other words, since the government has to refinance its debt at an uncertain future interest rate, this implies a higher expected volatility of funding costs. See Greenwood et al. (2015) for a thorough discussion of these trade-offs.

In the case in which the Federal Reserve acquires *non-Treasury* securities financed by increasing reserves, it expands both the assets and liabilities of the consolidated government balance sheet. Assuming that the yield on acquired securities carries a premium relative to Treasury securities, the effect on the consolidated government's net revenues will be positive, on average. Importantly, purchases of non-Treasury securities imply that the consolidated government is taking on additional risk. For instance, all non-Treasury assets involve some credit risk, or the risk of principal loss arising from a counterparty failing to make required payments. (In practice, however, the purchase of Federal Agency securities issued by Fannie Mae and Freddie Mac effectively carries no credit risk while the two institutions remain in federal conservatorship.) In the case of Agency MBS, the government faces prepayment risk, as changes in interest rates shift underlying cash flows forward or backward in time.

So far, we have discussed the fiscal implications stemming from how changes in the size and composition of the Federal Reserve's balance sheet affect the assets, liabilities, and associated net income of the consolidated government in partial equilibrium. But central bank balance sheet policies can also have general equilibrium effects by changing the prices of assets, goods, and services, which affects the pace of economic activity.[10] To the extent that balance sheet policies provide more accommodation, they will be associated with temporarily faster economic growth, which, in turn, increases tax revenues (e.g., due to higher income and capital gains), reduces government expenditures (e.g., lower unemployment benefits), and thus improves the path of the debt-to-GDP ratio (e.g., Rosengren, 2013). Moreover, they will put upward pressure on inflation, thus decreasing the real value of the debt. Thus, asset purchase programs can: [1] change the value of outstanding government obligations and [2] have fiscal implications beyond altering the funding costs of government debt. As we will see in our simulations below, such general equilibrium effects can be quantitatively important.

The fiscal authority may also respond to the central bank's actions, owing to differing objectives. In the U.S. case, the Federal Reserve is charged with achieving a dual mandate of maximum employment and stable prices, while the Treasury is principally concerned with minimizing debt service costs and fiscal risk. These differing goals may be inconsistent in some circumstances. For example, if Federal Reserve asset purchases lower term premiums, the Treasury may decide that it is in taxpayers' interest to issue longer-term debt. Such an action could result in upward pressure on term premiums and potentially offset the central bank's policy easing. One way to deal with this problem is to have formal coordination between the central bank and fiscal authorities. A prominent international example of this comes from the United Kingdom. According to Greenwood et al. (2014), that nation's Debt Management Office is mandated to "ensure that debt management is consistent with aims of monetary policy."

There is evidence that this tension between the objectives of central banks and fiscal authorities can be important. Greenwood et al. (2014) suggest that this was the case for the United States during the Great Recession, when the Federal

[10] This is particularly relevant when short-term interest rates are constrained by the effective zero lower bound, as in the aftermath of the Great Recession.

Reserve purchased long-term Treasury bonds as part of quantitative easing, while the Treasury issued more long-term debt to fulfill its goal of minimizing the present value of financing costs. The authors estimate that the Treasury's active maturity extension program offset 35 percent of the maturity-shortening effect of asset purchases.[11] Other researchers have suggested that the lack of coordination in Japan during the late 1990s and early 2000s might have jeopardized that nation's economic recovery and, more importantly, left monetary policymakers with a credibility issue as the public was unconvinced they could commit to future expansions (e.g., Ito and Mishkin, 2006; Kuttner and Posen, 2001; and references therein).

2.2 Central Bank Remittances and Solvency

The consolidated government budget view of central banking made in many macroeconomic models arises out of convenience. However, the Federal Reserve is an independent agency that maintains its own balance sheet and income statement, which generates an observable flow of remittances to the Treasury. By law, the Federal Reserve must distribute its earnings to the Treasury, net of operating expenses and dividends and allowing for a retained surplus of no more than $10 billion.[12] In the event that earnings are insufficient to cover these costs, then no remittances occur and a "deferred asset" is booked as a negative liability on the balance sheet.[13] Carpenter et al. (2015) provide a detailed overview of the Federal Reserve's balance sheet and income statement mechanics.

[11] Swanson (2011) describes a similar tension during the "Operation Twist" of 1961.

[12] Section 7 of the Federal Reserve Act defines the "division of earnings." These earnings principally reflect the difference between interest earned on assets and that paid on liabilities. Assets consist almost entirely of marketable securities that pay coupon interest—principally U.S. Treasury notes and bonds and Agency MBS. Liabilities are primarily currency in circulation, bank reserves, and reverse repurchase agreements. Currency pays no interest, while reserves and reverse repurchase agreements incur interest expenses.

[13] For an accounting definition of a deferred asset, see paragraph 11.96 of the Financial Accounting Manual for Federal Reserve Banks, available at https://www.federalreserve.gov/aboutthefed/files/bstfinaccountingmanual.pdf.

Separating the central bank and federal government budget constraints naturally raises questions about the determinants of central bank remittances, the probability of recording net losses, and central bank solvency. These questions had largely been ignored by much of the macroeconomic literature on advanced economies, mainly because for the Federal Reserve, (i) liabilities consisted almost exclusively of currency, and (ii) assets consisted almost exclusively of government securities with relatively short maturity (see Bukhari et al., 2013b). These two conditions implied that central bank income and remittances to the fiscal authority always remained positive, although they did vary substantially over the postwar period (e.g., Bukhari et al., 2013a). The recent financial crisis—and the central bank balance sheet expansions that followed—raised academic interest in central bank balance sheets.[14] We should stress that for emerging market central banks, balance sheet concerns have long been a topic of policy discussion. This was both because (i) assets were often denominated in foreign currency, whose value was volatile when measured in local currency; and because (ii) local banking crises often resulted in nonperforming loans being moved to the central bank balance sheet. While the remainder of this section focuses on the Federal Reserve – since it aims to provide a framework for understanding the simulation results below – some lessons also apply to other central banks.

2.2.1 Central Bank Remittances

The average size and variability of Federal Reserve remittances to the Treasury depend on some factors controlled by the central bank, including the size and composition of its balance sheet and asset sales.

The effect of increasing the size of the Federal Reserve's balance sheet on remittances depends on the classes and the maturity of the purchased assets. The

[14] A non-exhaustive and ever expanding list of recent papers includes Carpenter et al., 2015, Hall and Reis, 2015, Greenlaw et al., 2013, Bassetto and Messer, 2013, Del Negro and Sims, 2015, Christensen et al., 2015, Benigno and Nisticò, 2015, and Benigno, 2016).

base case would be the purchase of Treasury securities. As long as the term premium is positive and increasing with duration, a longer duration of Treasury securities holdings implies a higher net interest margin and, hence, higher average net income and remittances over time. However, to the extent that marginal assets are funded by issuing short-term interest-bearing liabilities (i.e., reserves and reverse repurchase agreements), acquiring longer duration assets implies more risk associated with uncertain future interest expenses. As a result, the volatility of remittances will generally increase with the duration of the purchased assets.

Since the start of the Federal Reserve's quantitative easing program, the central bank purchased (and still holds) a large share of Agency MBS guaranteed by Fannie Mae, Freddie Mac, and Ginnie Mae. During 2008:Q4 and 2009:Q1, the Federal Reserve also purchased Agency debt securities, which behave similar to Treasury securities, but with marginally higher yield spreads and volatility owing to liquidity risk premia. Agency MBS have significantly higher coupons than Treasury securities owing to the presence of embedded borrower prepayment options that make the timing of cash flows uncertain. Hence, larger holdings of Agency MBS result in higher average remittances and greater remittance volatility over time. Finally, selling assets generally results in gains or losses that are immediately recognized in income and hence generally increase the variability of remittances.[15]

Existing research has generally painted a benign picture of the Federal Reserve's net income in future years under baseline projections for the evolution of the balance sheet (e.g., Hall and Reis, 2015; Greenlaw et al., 2013; Carpenter et al., 2015; Christensen et al., 2015, Ferris et al., 2017), as they suggest that the likelihood of recording a sizable and long-lasting deferred asset is quite small. Section 3.2 presents our own simulations of Federal Reserve income using the FRB/US model under various scenarios for the future size of the balance sheet.

[15] However, in principle, asset sales could be structured in such a way as to smooth remittances, recognizing capital gains in periods when income would otherwise be low and vice versa.

2.2.2 Central Bank Solvency

Net losses and temporary negative levels of capital are not an impediment to normal central bank functioning *per se*, as the Federal Reserve would simply record a deferred asset. However, in principle, the deferred asset could become so large that it could not be expected to be covered by future earnings. In this extreme case, the central bank would effectively be insolvent.

The literature defines central bank solvency in terms of its intertemporal budget constraint: a central bank is solvent if the sum of its "tangible wealth" (the difference between the current market value of assets minus interest-bearing liabilities) plus "intangible wealth" (the expected present discounted value (EPDV) of future seigniorage) is positive.[16] The sum of the two—tangible and intangible wealth—equals the EPDV of remittances. If the central bank posts losses, but intangible wealth is positive and larger, the institution should not require recapitalization from the fiscal authority in order to pursue its mandate, as it can compensate current losses by borrowing against future remittances. However, if the EPDV of remittances were negative, the central bank would be insolvent. Of course, a central bank in a fiat money regime can always address insolvency by creating more liabilities and/or printing money (that is, generating more seigniorage), but at the cost of potentially compromising its inflation objective.[17]

The intertemporal budget constraint perspective offers a number of important implications. First, a central bank without interest-bearing liabilities cannot be insolvent as long as interest income exceeds operating expenses. Second, factors that affect the variability of remittances, such as the choice to hold assets to maturity

[16] For detailed derivations, see Bassetto and Messer (2013), Hall and Reis (2015), Del Negro and Sims (2015), or Benigno and Nisticò (2014).

[17] "Printing money" should be understood in a broad sense, including keeping the interest rate on excess reserves (IOER) lower than needed to control inflation. Stella (2005), Sims (2005), Hall and Reis (2015), Reis (2013), and Del Negro and Sims (2015) all elaborate in different ways as to why an inflation-targeting central bank is subject to an intertemporal budget constraint, even in a fiat money regime.

or use market value accounting, may be less relevant for solvency than one may initially think.[18]

Finally, the correlation between the value of tangible and intangible wealth is key to understanding whether solvency is at stake for a given adverse scenario. For instance, if scenarios in which the value of assets falls are also scenarios in which the EPDV of future seigniorage increases, then intangible wealth provides a hedge for the central bank's tangible wealth. Inflationary scenarios are generally examples in which such a hedge is in effect, as seigniorage generally increases with inflation. Del Negro and Sims (2015) and Reis (2016) emphasize the quantitative importance of the EPDV of seigniorage for assessing solvency and find that it is potentially quite large for the Federal Reserve—possibly well above the current value of interest-bearing liabilities—although uncertainty about future currency demand makes these present value calculations tentative.

2.3 Political Economy Considerations

Despite the extremely remote possibility of Federal Reserve insolvency, maintaining a large balance sheet could potentially lead to political pressure on the central bank for at least two reasons.

First, as discussed above, a large balance sheet increases the likelihood of reporting a net loss, which would trigger zero remittances to the Treasury. While a large central bank balance sheet may reduce the consolidated government funding costs on average, it can also be disadvantageous for public finances under some circumstances (e.g., when interest rates increase unexpectedly). Since Federal Reserve income statements are observable to the public, reporting a net loss lays bare such circumstances and places central bank's policies in the spotlight.

Second, large amounts of excess reserves imply substantial interest payments to

[18] Recognizing losses at once, or delaying the recognition until maturity, makes little difference for the present value calculations.

the banking sector. From the consolidated budget perspective—and to the extent that excess reserves have been issued to purchase Treasury securities—these payments simply reflect the need to finance federal debt.[19] Put differently, a central bank's decision to raise interest rates always makes funding public debt more expensive, at least initially, regardless of the size of its balance sheet and of the holders of public liabilities. Nonetheless, large payments to the banking system could result in political pressure against maintaining or raising the IOER.

Experience from other central banks—especially those in emerging markets—suggests that political economy concerns can influence a central bank's monetary policy goals, particularly under circumstances in which the mandate of the central bank is of a different nature from that of the Federal Reserve.[20] Stella (1997, 2005) notes that several central banks have suffered sizable losses that eventually interfered with the effective conduct of monetary policy.[21] Relatedly, Cukierman (2008, 2011) argues that when central bank capital becomes negative and drops below some threshold, there is a danger that the political establishment might prevent the central bank from following useful policies that could nonetheless lead to additional losses. This literature suggests that a large balance sheet, and the associated increased risk of incurring losses, can endanger central bank independence. That said, many of the countries considered in these studies are emerging economies with arguably weaker institutions than the United States, so it is not clear to what extent their experiences apply to the Federal Reserve.[22] Moreover, even among emerging markets, central bank balance sheet problems have not always led to poor monetary policy performance. For instance, Chile was able to pursue successful monetary policy for several years with negative capital,

[19] However, this is not the case when financing non-Treasury assets, such as Agency MBS.

[20] Consistent with political sensitivity, recent cross-country research identifies a discontinuity in the central bank profit distribution skewed away from losses. See Goncharov et al. (2017)

[21] Dziobek and Dalton (2005), Klüh and Stella (2008), Leone (1993), and Stella (1997, 2005, 2009) provide brief case studies. Klüh and Stella (2008) argue that central bank losses can result in a negative public perception of the institution and its leadership.

[22] Many of the central bank balance sheet problems discussed in the literature arose because the government had forced the central bank to bail out banks following financial crises.

partly because the fiscal authority was supportive of the central bank's mandate. Moreover, as discussed by Eichengreen (2015), the Czech and the Israeli central banks have also operated with negative capital for extended periods without damaging their policies.

The experience of advanced economies such as Japan and Switzerland also suggests that political economy considerations may, at times, pose constraints on central bank policy. In particular, Stella (2005, p. 338) argues that "in early 2002 the market raised questions as to the likely duration of the Bank of Japan's willingness to use its rinban operations to influence the long end of the government bond yield curve, as an eventual rise in interest rates would subject it to losses that could exhaust its capital and reserves."[23] The recent abandonment of the minimum exchange rate policy by the Swiss National Bank (SNB) is further evidence that balance sheet concerns can take center stage in policy discussions. In the SNB's own words: "Had the SNB delayed the discontinuation of the minimum exchange rate, this would only have been at the expense of an uncontrollable expansion of the SNB balance sheet by hundreds of billions of Swiss francs, and potentially by several times Swiss GDP. Such an expansion would have severely impaired the SNB's future ability to conduct monetary policy and jeopardized the fulfillment of its mandate in the long term. Moreover, given the fact that the minimum exchange rate was no longer sustainable, further intervention would have been pointless, and the enormous losses arising from it could not have been justified" (Swiss National Bank, 2015). Amador et al. (2016) provide an insightful analysis of the Swiss central bank's decision in light of its balance sheet constraints.

To address the political economy risks associated with losses, a central bank may take a range of actions. First, the central bank can provision for future losses by increasing its surplus capital in order to use it as a buffer against adverse shocks.[24]

[23] Similar concerns about possible future losses have been raised in regard to the latest Bank of Japan's balance sheet expansion (see Fujiki and Tomura, 2017).

[24] Stella (2005) observes that countries with large foreign exchange exposure on their balance

Cukierman (2008, 2011), Goodfriend (2014b,a), and Stella (2005) all advocate such an approach. However, increasing the size of surplus capital is not a feasible option for the Federal Reserve, as current law limits this surplus to $10 billion. Another clear limitation of this approach is that the fiscal authority may be tempted to appropriate some of this capital, as happened to the Federal Reserve in 1993, 2005, and 2015. Second, the central bank could make an ex ante agreement with the fiscal authority to absorb central bank losses, as is the case in the United Kingdom (e.g., McLaren and Smith, 2013). While such an agreement may seem desirable, it may also come with limits on the central bank's ability to pursue independent monetary policy (e.g., in the UK, some balance sheet actions need approval by the Treasury). Finally, the central bank could reduce its interest-bearing liabilities (and increase the EPDV of seigniorage) by increasing required reserves and not paying interest on them. However, such an action amounts to a forced transfer of resources from the banking system to the central bank—a policy change that could generate significant political opposition.

2.4 The Central Bank Balance Sheet and Monetary Policy Decision Making

As we discussed in the previous section, political economy considerations can pose constraints on monetary policy, as they create incentives for central bankers to limit remittance volatility, avoid losses, and especially reduce the possibility of insolvency.[25] Constraints can lead to suboptimal outcomes, and recent research has sought to incorporate such constraints into formal models. Benigno and

sheet tend to have mechanisms to smooth the impact of exchange rate changes movements on their accounts. This suggests that the small size of central bank capital that is characteristic of many advanced economies could be a legacy of a period in which these institutions did not actively use their balance sheet for monetary policy purposes.

[25] For the case of the U.S., the level and volatility of remittances do not prevent the FOMC from conducting monetary policy in conformity with its mandate and are thus not the focus of monetary policy decisions. As also noted by Carpenter et al. (2015), foreign central banks, such as the Czech National Bank, have operated with a negative equity position and zero remittances.

Nisticò (2015) study optimal conventional monetary policy taking into account the central bank's desire to avoid declines in net worth and the potential need for recapitalization. They find that such constraints can introduce an inflationary bias, as the central bank relies on seigniorage to shield itself from losses (since higher inflation entails an increase in the EPDV of seigniorage). Other work by Del Negro and Sims (2015) shows that—in some circumstances—a large central bank balance sheet can lead to a self-fulfilling balance sheet crisis. A sudden increase in expected inflation would cause the value of the long-duration assets held by the central bank to plummet, calling into question the solvency of the central bank. If the latter cannot count on backing from the fiscal authority, it can only restore solvency by generating more seignorage, thereby validating the inflationary expectations. However, using a simple quantitative model calibrated on U.S. data, Del Negro and Sims (2015) also find that under the current size of the central bank balance sheet, such self-fulfilling crises are extremely unlikely.

Another strand of literature suggests that balance sheet constraints can be turned to the central bank's advantage in situations in which additional obstacles are in place, such as the zero lower bound (ZLB) on nominal interest rates. This is the "signaling theory of QE" (Bhattarai et al., 2015; Berriel and Mendes, 2015; Bauer and Rudebusch, 2014), according to which the central bank, when constrained by the ZLB, engages in quantitative easing in order to signal markets its intention to keep interest rates low for a long time. It is well understood that monetary policy faces a so-called time inconsistency problem in a liquidity trap: it would like to promise low future rates in order to stimulate inflation and economic activity, but such promises may not be credible as they may conflict with future policymaker objectives. Acquiring long-term assets and funding them with short-term interest-bearing reserves implies that the central bank would face net losses if it were to raise interest rates too fast. Hence, the constraint imposed by a large balance sheet helps in addressing the time inconsistency problem because constrained policymakers are forced to stick to their promises. Finally, in a provocative paper, Benigno (2016) turns the central bank solvency concern on its head and argues that the central bank's intertemporal budget constraint can actually become a pillar of price stability. The intuition for this result closely follows the ideas behind the fiscal theory of the price level (see Sims, 2013, for a recent description), according to which the present value of government surplus pins down the real value of government debt, and therefore the price level for a given amount of existing nominal debt. Similarly, Benigno argues that a central bank with positive nominal assets can rule out hyperinflations or deflations by committing to a given stream of remittances to the fiscal authority, expressed in real terms.

3 Simulations

This section presents the results of simulations run using the Federal Reserve Board's SOMA and FRB/US models in an effort to quantify the fiscal implications of different longer-run configurations of the Federal Reserve's balance sheet.[26] Specifically, we consider four illustrative scenarios corresponding to different longer-run levels of reserve balances at the central bank: \$100 billion, which is intended to represent a return to a pre-crisis "scarce-reserves" balance sheet; \$2.3 trillion, which roughly corresponds to the level of reserves as of March 31, 2017; and two levels in between, namely \$500 billion and \$1 trillion.[27] The \$2.3 trillion longer-run reserve balance scenario means that reserves would remain at their currently elevated level. We stress that this scenario is neither consistent

[26] The FRB/US model is a large-scale estimated general equilibrium model of the U.S. economy that has been in use at the Federal Reserve Board since 1996. Further information is available at https://www.federalreserve.gov/econres/us-models-about.htm. The SOMA model (Carpenter et al., 2015) generates detailed projections of the evolution of the Federal Reserve balance sheet and associated net income, conditional on interest paths projected by FRB/US.

[27] The projections in the 2016 SOMA Annual Report for Domestic Open Market Operations consider a baseline scenario with a longer-run level of reserve balances of \$500 billion and two alternative scenarios with longer-run reserve balances of \$100 billion and \$1 trillion, respectively. See https://www.newyorkfed.org/medialibrary/media/markets/omo/omo2016-pdf.pdf.

with the current FOMCs balance sheet normalization program nor an indication of any potential future Federal Reserve policy. We present this counterfactual, illustrative scenario only to understand the fiscal implications that could arise with reserve balances close to current levels. The other scenarios, which feature a gradual reduction in securities holdings through the medium term, are in line with the FOMCs balance sheet normalization program.

3.1 Model Setup

Our simulations, which begin as of 2017:Q1 and run through 2035:Q4, require assumptions about the configuration of the Federal Reserve's balance sheet and projected paths for financial and macroeconomic variables that affect the evolution of the balance sheet and related income.[28] Importantly, all assumptions are based on publicly available sources, including the FOMC's Policy Normalization Principles and Plans as amended by the FOMC's June 2017 Addendum, survey-based expectations for policy and financial variables prepared by the Federal Reserve Bank of New York's Markets Group, and the March 2017 public version of the FRB/US model. Here, we highlight a few features that are important for understanding our results. Appendix A describes all model inputs in greater detail.

We take as our starting point the configuration of the Federal Reserve's balance sheet at the end of 2017:Q1. On the asset side of the balance sheet, we assume that no securities are ever sold. Before January 2018, proceeds from principal payments on securities held in the SOMA portfolio are assumed to be fully reinvested.[29] Specifically, maturing Treasury securities are assumed to be

[28] We also assume that the fiscal authority does not respond to the size of the Federal Reserve's balance sheet—neither in terms of its willingness to engage in deficit spending nor in terms of its debt management strategy.

[29] This assumption is in line with expectations drawn from the June 2017 Federal Reserve Bank of New York's Surveys of Primary Dealers and Market Participants. See https://www.newyorkfed.org/markets/primarydealer_survey_questions.html and https://www.newyorkfed.org/markets/survey_market_participants.html. This assumption, however, is not consistent with

rolled over, and principal payments from holdings of Agency debt and Agency MBS are assumed to be reinvested in Agency MBS.[30] We also assume that starting in January 2018, reinvestments of principal payments received from SOMA securities holdings are phased out according to the balance sheet normalization program described in the June 2017 Addendum to the FOMC's Policy Normalization Principles and Plans. Specifically, such payments are assumed to be reinvested only to the extent that they exceed gradually rising caps. Finally, we assume that no additional asset purchases are made until reserve balances reach their longer-run level, at which point purchases of only Treasury securities resume to keep up with currency and capital growth and to offset the runoff of Agency MBS as they continue to pay down.[31]

Turning to liabilities, the longer-run trajectory of the balance sheet is determined primarily by three components. First, as discussed above, the longer-run level of reserve balances is the defining feature of the four scenarios we consider and takes a value of either \$100 billion, \$500 billion, \$1 trillion, or \$2.3 trillion. Second, we assume that currency grows with nominal GDP. Finally, we assume that capital paid-in grows at an annual rate of 2.6 percent.[32]

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current FOMC policy. In fact, after its September 2017 meeting, the FOMC announced that, effective October 2017, it would initiate the balance sheet normalization program described in the June 2017 Addendum to its Policy Normalization Principles and Plans. If, instead, we had assumed a timing for the change in reinvestment policy consistent with the September 2017 announcement, it would have made little quantitative difference for our results. Bonis et al. (2017b) use October 2017 as timing for the change in reinvestment policy and obtain very similar projections for the evolution of the SOMA portfolio and reserve balances as well as a very similar estimate of the associated term premium effect (TPE) on the 10-year Treasury yield.

[30] While the maturity dates for Treasury securities and Agency debt are known with certainty, the timing of the principal paydowns on Agency MBS is uncertain and is a function of interest rates and economic conditions. For the latter, we follow Bonis et al. (2017c).

[31] In the case of the \$2.3 trillion reserve balances scenario, purchases of Treasury securities resume at the time of the change in reinvestment policy (i.e., in 2018:Q1) as reserve balances are already at their longer-run level. This implies that the balance sheet immediately starts growing at a pace mostly in line with the expansion in key liabilities items such as the value of Federal Reserve Notes and capital paid-in.

[32] Other liabilities—such as the Foreign Repo Pool, Overnight Reverse Repurchase Agreements, and the Treasury General Account—also affect the size of the balance sheet. Our assumptions for these liabilities are described in Appendix A.

The paths for financial and macroeconomic variables are generated from stochastic simulations of the FRB/US model.[33] For each of our four scenarios, these simulations are based around "modal" paths that are consistent with the March 2017 public version of FRB/US, in which the economic recovery continues. However, these paths differ across scenarios because the size of the longer-run balance sheet influences the term premium, which, in turn, affects the rest of the economy, feeding into the path for the federal funds rate as implied by the monetary policy rule and the underlying macroeconomic conditions.[34]

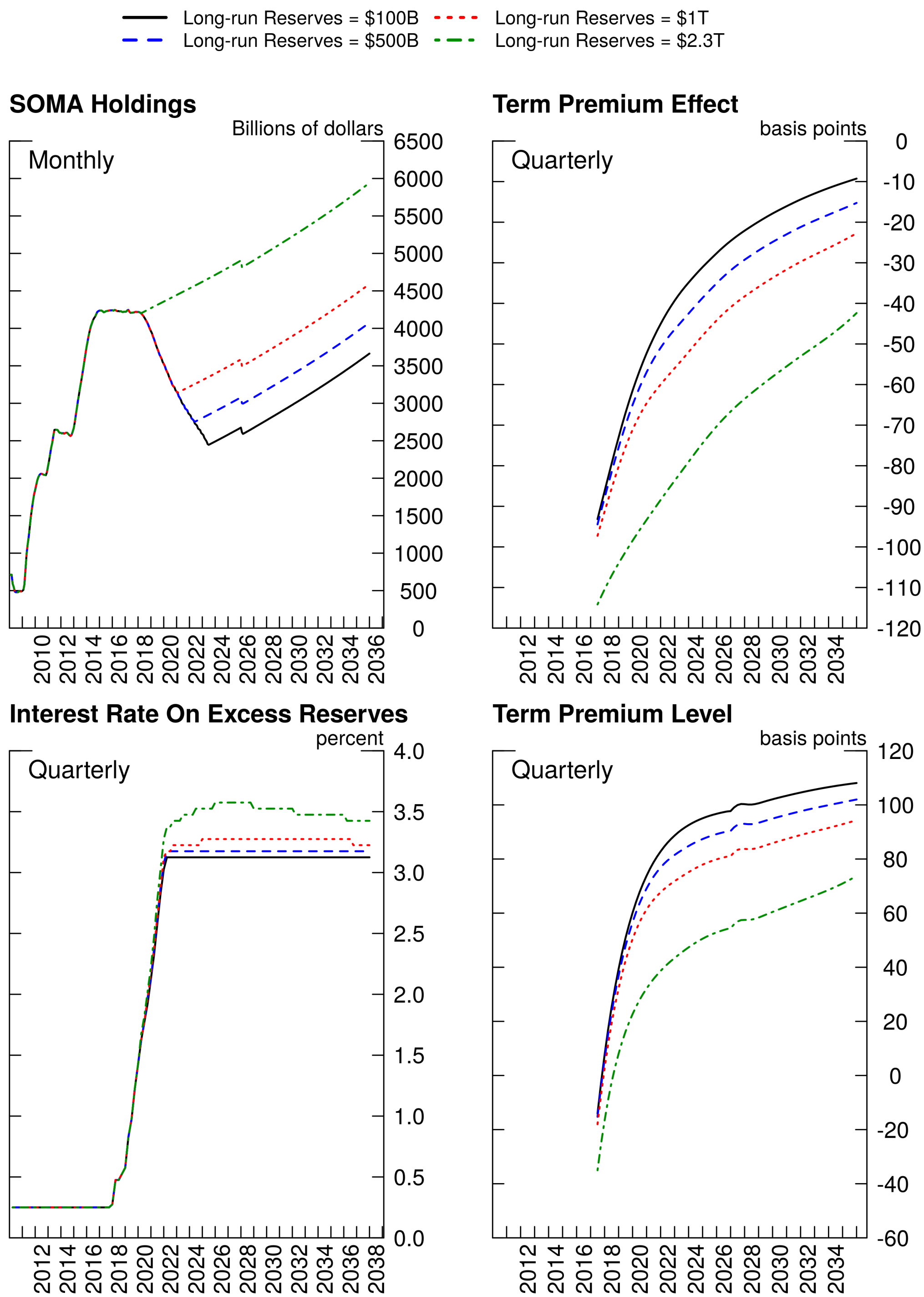
Figure 1 shows the size of the balance sheet (upper left panel) and its effect on the term premium (upper right panel) under the "modal" path for each of our scenarios. All else equal, larger sizes of the balance sheet, as implied by higher longer-run levels of reserve balances, push the term premium down, which implies more accommodative financial conditions that stimulate output and inflation, leading to a higher interest rate on excess reserves (IOER; lower left panel).[35] In the FRB/US model, the IOER is tightly linked to the federal funds rate (FFR), which is determined by an inertial Taylor (1999) rule and thus increases in response to a stronger economy and/or higher inflation. The paths for the IOER and FFR, along with the level of the term premium (lower right panel), play an

[33] Our methodology for producing stochastic simulations is the same as that described in the blog post by Ferris et al. (2017) which, in turn, follows Brayton et al. (2014). The set of financial variables includes the federal funds rate, the 5-year, 10-year, and 30-year Treasury bond rates, and the interest rate on conventional 30-year mortgages (expressed as effective annual yield). The set of macroeconomic variables includes real and nominal GDP, core and headline CPI, 4-quarter core and headline PCE inflation, and the civilian unemployment rate.

[34] In FRB/US, the term premium is the difference between the 10-year Treasury yield and a weighted average of the federal funds rates expected to prevail over the corresponding period.

[35] The effect of the balance sheet on the term premium is constructed using the estimated model of Li and Wei (2013), which is also the basis for the analyses of Bonis et al. (2017a,b), who assess the effects of Federal Reserve security holdings on term premiums for longer-dated securities. In the model, the composition of assets held by the Federal Reserve affects the supply of longer-dated securities to the private sector; when these securities become more scarce, the term premium decreases. The Li-Wei approach constructs the term premium effect by comparing the configuration of the balance sheet in each scenario to that from a counterfactual scenario in which large-scale asset purchases never occurred. However, because the balance sheet configuration does not fully revert to its counterfactual path within our projection period, the resulting term premium effect is likely to be a lower bound on the effect that would arise if the Li-Wei model looked further into the future.

Figure 1: Baseline Paths of Selected Input Variables



important role in determining our estimates of the fiscal implications of the Federal Reserve's balance sheet.[36]

3.2 Simulation Results

Our simulations illustrate how the Federal Reserve's balance sheet size influences the level and volatility of the central bank's remittances to the Treasury, as well as its broader fiscal implications as summarized by the overall effect on federal government debt. We emphasize at the outset that, although our results illustrate several general mechanisms by which the balance sheet has fiscal implications, our quantitative findings also depend on several important features of the framework we use—including how macroeconomic conditions respond to shocks, the monetary policy rate rule, and the growth rate of currency in circulation. Moreover, our results are projections and not forecasts. For instance, our assumptions about the evolution of the balance sheet are not meant to preclude the possibility that, in response to a future negative economic shock, reinvestments of maturing securities could restart or additional large-scale asset purchases could take place. Although current Federal Reserve guidance allows for the possibility of such policy responses, we do not attempt to model them.[37]

We begin by looking at earnings remittances. Table 1 reports summary statistics for each balance sheet scenario, including the average level and variability of remittances, the likelihood of recording a deferred asset and its peak size, and the market value of Federal Reserve assets less interest-bearing liabilities, which is closely related to the notion of central bank insolvency.

[36] By using the Li and Wei (2013) model, our approach implies that the size of the Federal Reserve's balance sheet can affect the term premium for a prolonged period of time. Whether the size of the balance sheet can have such long-lasting effects on interest rates is an open question on which we do not take a strong stand. Thus, we also considered simulations (discussed below) in which the balance sheet does not affect the term premium.

[37] See the last bullet of the Addendum to the FOMC's Policy Normalization Principles and Plans: https://www.federalreserve.gov/newsevents/pressreleases/monetary20170614c.htm.

3.2.1 Earnings Remittances: Level and Variability

Table 1 presents, for each of the four scenarios, the average and standard deviation (across simulations) of annual remittances.[38] Here we distinguish between what we call the "transition phase" (2017-2030), during which there are important effects stemming from the projected rise in interest rates from current low levels to their longer-run level, and the "longer run" (2031-2035).[39] We do this because, as the federal funds rate and the term premium revert to long-run levels, the relationship between the longer-run size of the balance sheet and the level and volatility of remittances varies over time. During the transition phase (2017-2030), we observe that remittances (in dollars) are smaller and more variable for the larger longer-run balance sheet ($2.3 trillion, shown in column 4 of Table 1) than for the smaller ($1 trillion and below) balance sheets. But, in the longer run (2031-2035), both the amount and variability of remittances increase with balance sheet size. All told, cumulative nominal remittances over the entire simulation horizon are about $18 billion less under the large ($2.3 trillion) balance sheet scenario than they are under the small one ($100 billion). Note also that the difference across scenarios in the present discounted value (PDV) of remittances is greater (around $70 billion) than that for cumulative nominal remittances because years further in the future—when larger balance sheets produce relatively more remittances—are discounted more heavily and because the IOER paths are higher under larger balance sheet scenarios, leading to greater discounting.[40]

Table 1 also reports the average and standard deviation of remittances *per unit of balance sheet dollars.* These measures give an indication about the rate of return on

[38] We calculate the statistics across simulations within each year and then take the mean across years.

[39] Although the projected increase in interest rates occurs during the first few years, the effect on remittances persists further because Federal Reserve asset purchases remain on the balance sheet for a long time. The "longer-run" results are meant to capture differences across scenarios once the effects of the rising interest rate have mostly dissipated.

[40] We calculate the PDV of remittances by discounting the projected stream of remittances from 2017 through 2035 using the (compounded) IOER, and we report, for each of the four scenarios, the average and standard deviation (across simulations) of the PDV for each balance sheet scenario.

Table 1: Earnings Remittances and Longer-Run Size of the Balance Sheet
(Billions of $, unless otherwise noted)

	Longer-Run Level of Reserve Balances* (Billions of $)			
	$100	$500	$1,000	$2,300
Avg. Remittances				
Dollar Values				
2017–2030	66.8	67.2	67.3	63.8
2031–2035	111.8	113.7	115.6	118.2
Per Balance Sheet Dollar**				
2017–2030	2.2	2.0	1.8	1.3
2031–2035	3.1	2.9	2.6	2.0
Std. Dev. Remittances				
Dollar Values				
2017–2030	11.1	11.8	14.4	25.8
2031–2035	21.2	20.6	22.0	33.2
Per Balance Sheet Dollar**				
2017–2030	0.3	0.3	0.4	0.5
2031–2035	0.5	0.4	0.5	0.6
PDV of Remittances***				
Avg.	563.4	558.0	547.8	493.1
Std. Dev.	141.5	141.4	142.6	153.9
Deferred Asset				
Probability of Incurring**	3.9	4.1	4.6	30.8
95^{th} %ile of Size	0.0	0.0	0.0	30.6
Maximum Realized Spell****	14	14	15	29
5^{th} %ile of Market Value of Assets less Interest-Bearing Liabilities*****	817.0	820.7	826.7	841.6

* In all scenarios, the SOMA portfolio consists only of Treasury securities. The maturity distribution is pinned down by the assumption that purchases are proportional to Treasury issuance.

** Expressed in percent

*** PDV: Present discounted value

**** Expressed in quarters

***** Minimum across periods

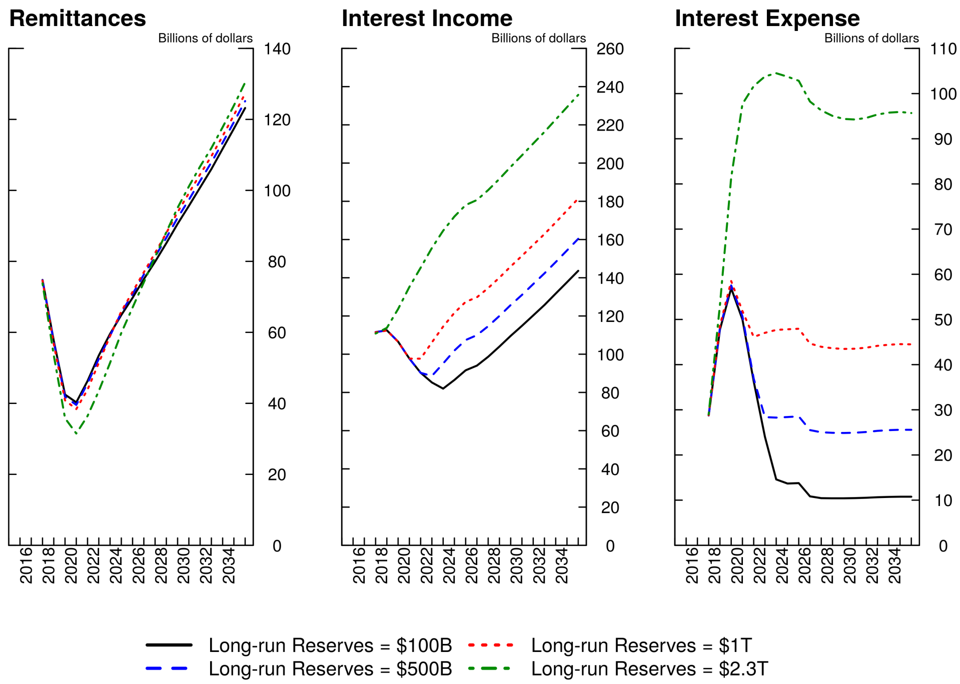
central bank assets and the variability of that return. The rate of return decreases in the size of the balance sheet (in both the transition and the longer run), which is partly driven by the feature that the larger the balance sheet, the smaller is the fraction of assets backed by currency—that is, the greater the fraction of assets backed by *interest-bearing* reserves. The variability of the return, on the other hand, varies little across scenarios.

It is also useful to look at the evolution of remittances over time. Figure 2 shows, for each of the four scenarios, average (across simulations) annual remittances, interest income, and interest expense, respectively, from 2017 to 2035. In all scenarios, average remittances decrease for the next four or five years and increase thereafter. The initial decrease is largely driven by an increase in interest expense paid on reserves, which rises sharply as short-term interest rates are projected to increase at a faster pace than the decline in the level of reserve balances at a time when the size of the balance sheet and thus the level of reserve balances remain elevated. In addition, under the largest balance sheet scenario, interest expense is further boosted owing to the more accommodative financial conditions, which lead to higher inflation and short-term interest rates. By contrast, interest income is less responsive to the prevailing level of interest rates through the medium term because it mostly reflects fixed coupon interest produced by long-term legacy assets. The subsequent increase in remittances reflects the fact that, once the longer-run level of reserve balances is reached, the Federal Reserve begins to purchase higher-yielding assets, mostly to keep up with the expansion in currency demand.[41] In the longer run, purchased assets allow the Federal Reserve to earn, on average, positive net income because the yield curve is typically upward sloping and the central bank issues short-term liabilities to finance longer-term securities.

Looking *across* scenarios, both income and expenses increase with the balance

[41] This occurs at a different time for each scenario: in 2018 for the \$2.3 trillion scenario, 2021 for the \$1 trillion scenario, 2022 for the \$500 billion scenario, and 2023 for the \$100 billion scenario.

Figure 2: Average Annual Remittances



sheet size. However, remittances do not increase, at least during the transition period. This result is driven by two factors. First, maintaining a large balance sheet implies buying securities while the term premium is still negative. Second, varying the size of the balance sheet has general equilibrium effects. A larger balance sheet implies a lower term premium—that is, new asset purchases will generate lower interest income—and also stimulates the economy, leading *ceteris paribus* to greater interest expenses (through a higher IOER).[42] After transition effects have dissipated, remittances are increasing in balance sheet size as these general equilibrium effects only partly offset the greater net interest income implied, on average, by a larger balance sheet and a positive term premium.

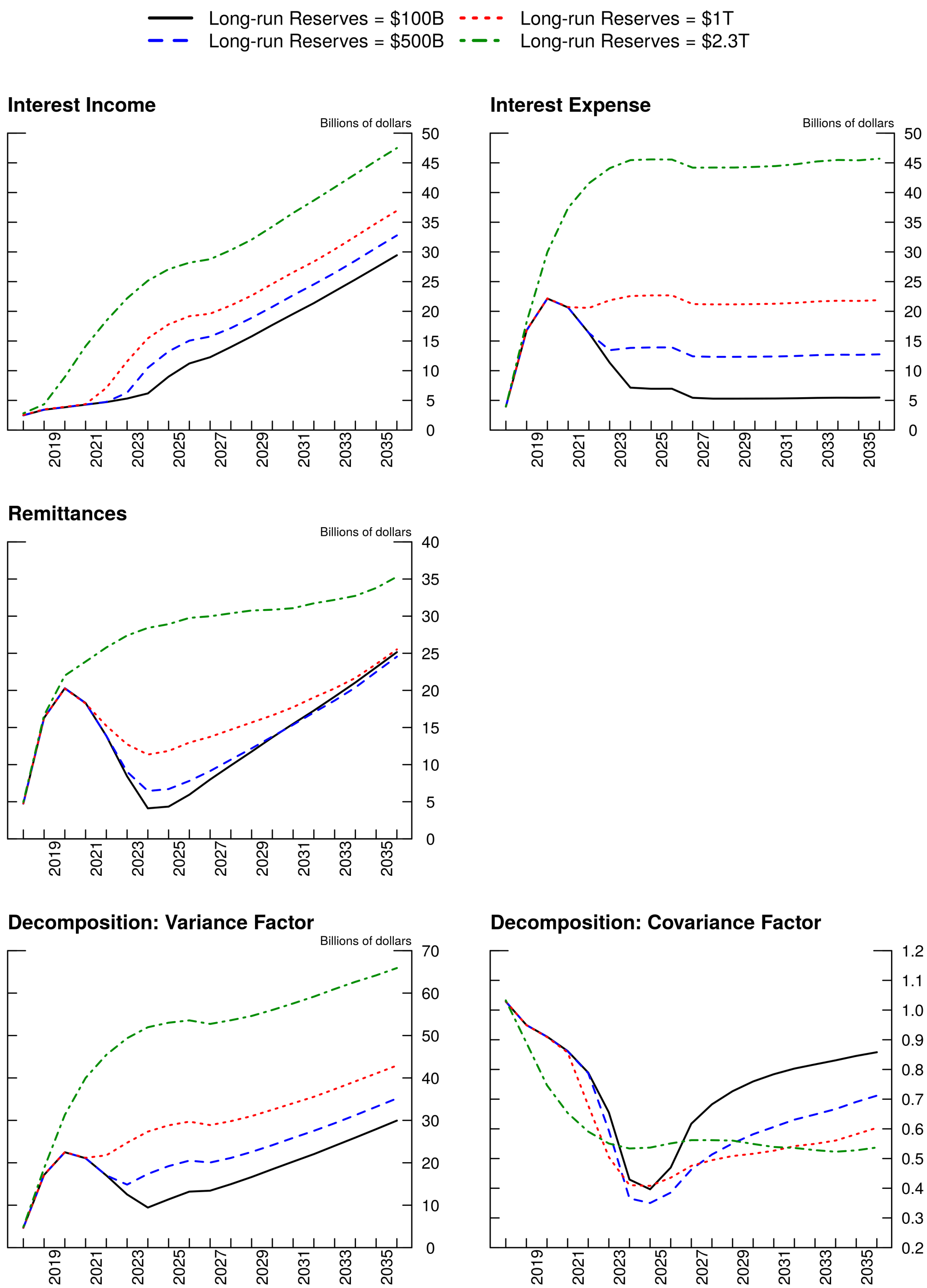
[42] The general equilibrium effects also lead to faster nominal GDP and currency growth, which work towards increasing remittances through two main channels. First, a faster pace of currency growth implies that a larger portion of the balance sheet is funded by non-interest bearing liabilities. Second, for a given level of reserves, faster currency growth implies that the Federal Reserve needs to step up its pace of purchases of Treasury securities, which ultimately generates additional interest income. However, these channels are quantitatively less important than the general equilibrium effects that lead to higher interest expense and thus reduce remittances.

To get a sense of the quantitative importance of the general equilibrium effects, we also ran simulations that abstract from them, by shutting off the effect of the balance sheet on the term premium. Consequently, these simulations only reflect the direct effects on remittances of changes in the Federal Reserve's assets and liabilities, and not those stemming from endogenous changes in interest rates. We find that average remittances are weakly increasing with the size of the balance sheet both the transition period and in the longer run. This is in stark contrast to the results shown in Table 1. We conclude that general equilibrium effects are very important.

Turning to the variability of remittances, the upper and middle rows of panels in Figure 3 plot, for each of the four scenarios, time series of the annual standard deviation (across simulations) of interest income, interest expense, and remittances for each scenario. Interest income (shown in the upper left panel) displays essentially no variability prior to balance sheet normalization (i.e., when reserve balances reach their longer-run level) because income mostly reflects the coupons of assets purchased in the past. As new securities are purchased—starting in 2018 for the $2.3 trillion scenario, 2021 for the $1 trillion scenario, 2022 for the $500 billion scenario, and 2023 for the $100 billion scenario—the variability of interest income increases and is greater (both across scenarios and over time) the larger is the size of the balance sheet. The dispersion of interest income reflects both differences in quantities (and composition) of assets purchased and differences in market interest rates at the time of purchase. Likewise, the dispersion in interest expense (upper right panel) reflects variability across simulations in both short-term interest rates and the quantity of interest-bearing reserves. For a given variance in short-term interest rates, a larger quantity of reserves implies more variable interest expense. This largely explains the variation, across both time and scenarios, of the dispersion of interest expense.

The variability of remittances (middle panel of Figure 3) largely reflects the variability of net interest income, which, in turn, reflects the variability of interest

Figure 3: Standard Deviation of Annual Remittances



income and interest expense as well as their covariance.[43] Prior to the resumption of asset purchases, the variability of remittances mirrors that of interest expense because the variability of income is essentially zero and, therefore, so is the covariance. However, after asset purchases resume, the covariance between income and expense becomes nonnegligible. This covariance (across simulations) is generally positive, reflecting the feature that short- and long-term interest rates tend to move together and can be quite large. For example, in the $1 trillion scenario, the variability of remittances actually decreases from 2020 to 2024 even though the variability of both interest income and expense is increasing. Looking across scenarios, the volatility of remittances is roughly similar for the small-to-intermediate reserve balances scenarios, but increases substantially if reserve balances remain at their current elevated levels.

To gain some additional insight, we decompose the variance of net interest income, $(I - E)$, as follows:

$$\begin{aligned} \mathrm{Var}\,(I-E) &= \mathrm{Var}\,(I) + \mathrm{Var}\,(E) - 2\cdot \mathrm{Corr}\,(I,E)\cdot \left[\mathrm{Var}\,(I)\cdot \mathrm{Var}\,(E)\right]^{0.5} \\ &= \left[\mathrm{Var}\,(I) + \mathrm{Var}\,(E)\right]\cdot \left\{ 1 - \frac{2\cdot \mathrm{Corr}\,(I,E)}{\left[\frac{\mathrm{Var}(I)}{\mathrm{Var}(E)}\right]^{0.5} + \left[\frac{\mathrm{Var}(E)}{\mathrm{Var}(I)}\right]^{0.5}} \right\}. \end{aligned}$$

We refer to the first bracketed term as the "variance factor" and to the second as the "covariance factor." The standard deviation of remittances (middle panel of Figure 3) is roughly the product of the square roots of the variance and covariance factors (lower row of Figure 3). The lower left panel shows that larger longer-run reserve balances uniformly increase the variability of remittances by increasing the sum of the variances of interest income and expense. On the other hand, the covariance factor (lower right panel) does not uniformly vary with the balance sheet

[43] Technically, remittances equal net interest earnings less non-interest expense and dividends, but the latter two components contribute little to variability. In addition, remittances are restricted to be nonnegative (i.e., if net interest earnings are negative, remittances are set to zero and a deferred asset is recorded), and if the Federal Reserve has a deferred asset, then any subsequent positive net earnings are used to pay down that asset rather than being remitted.

size. It depends on both the (across-simulation) correlation between interest income and expense and the relative variability of income and expense. Whereas the former is increasing in the longer-run size of the balance sheet, the latter is not.

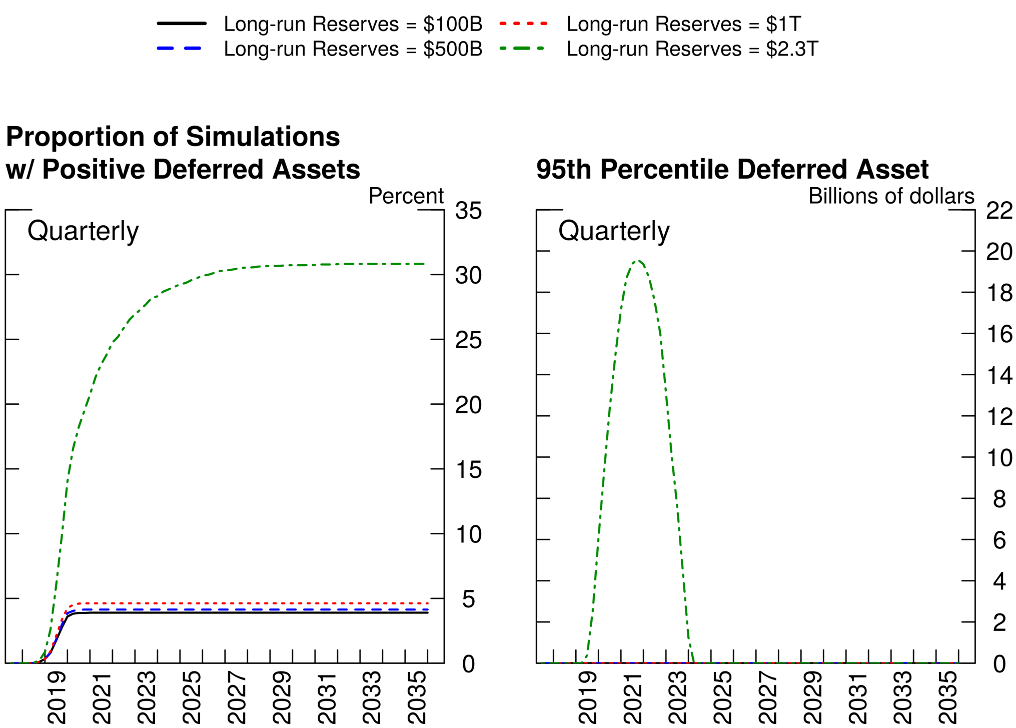
Although the longer-run (2031-2035) variability of remittances is roughly similar for the small-to-intermediate balance sheet scenarios (as displayed in Figure 3 and Table 1), the variability of remittances will be increasing in size once all transition effects have dissipated (i.e., in the true long run). As the balance sheet continues to grow, the share of interest-paying liabilities will shrink, as reserve balances remain at their longer-run level and currency continues to grow. Thus, the variability of interest expenses relative to that of interest income will also shrink toward zero, meaning that the "covariance" factor will eventually converge to one for all scenarios. The variability of remittances will then be determined exclusively by the sum of variances of income and expense, which is increasing in reserve balances.

3.2.2 Deferred Assets

Table 1 also reports summary statistics for deferred assets for each scenario, including the likelihood of recording a deferred asset (i.e., the fraction of simulations featuring negative net earnings in at least one quarter), the maximum (across periods) of the 95$^{\text{th}}$ percentile of its size (across simulations), and the maximum realized spell length (in quarters). All three measures are demonstrably higher in the \$2.3 trillion scenario than in the cases with smaller balance sheets.

The left panel of Figure 4 plots the cumulative share of simulations for each scenario that have experienced a positive deferred asset—that is, in a given quarter, it plots the share of simulations that have had a deferred asset in any quarter prior to and including that quarter. The change in the cumulative share measures how many simulations are experiencing a positive deferred asset for the first time. Losses are most common in 2018 and 2019, when short-term interest rates are projected to be rising. For the small-to-intermediate reserves scenarios, interest income declines as the balance sheet shrinks while interest expense increases (at least initially as the increase in the IOER more than offsets any reduction in reserve liabilities). By contrast, the large ($2.3 trillion) reserve scenario yields many simulations in which a deferred asset is first recorded between 2020 and 2022. This result arises because purchasing additional securities while the term premium is negative implies that those securities are expected to generate negative net income over time.[44] The larger are the purchases of such securities, the greater are the odds of booking a deferred asset. Specifically, moving from the $1 trillion to the $2.3 trillion scenario increases these odds from roughly 5 percent to over 30 percent.

Figure 4: Likelihood and Size of Deferred Assets



The right panel of Figure 4 plots the size of the deferred asset as measured by the 95$^{\text{th}}$ percentile of the distribution—which can be loosely interpreted as a

[44] As shown in Figure 1, the level of the term premium under the modal path for the $2.3 trillion reserve balance scenario is negative through the end of 2018.

"value at risk" (VaR) measure for the Federal Reserve.[45] Because the probability of recording a deferred asset is less than 5 percent for scenarios in which longer-run reserve balances are less than $1 trillion, the plotted size of the deferred asset is zero in these cases. For the large balance sheet scenario, on the other hand, the deferred asset can be as large as $30 billion.

3.2.3 (In)Solvency

As explained above, the Federal Reserve is insolvent if the EPDV of remittances to the Treasury is ever negative. In this unlikely case, the central bank would be expected to need recapitalization from the Treasury at some point in the future or to resort to "printing money." As noted earlier, the EPDV of remittances equals the sum of the Federal Reserve's "tangible" and "intangible" wealth. Tangible wealth is the market value of the Federal Reserve's assets less the value of its interest-bearing liabilities, and intangible wealth is the EPDV of future seigniorage. Although intangible wealth is difficult to estimate, we do have all the information we need to calculate tangible wealth in our simulations.[46]

Table 1 reports, for each scenario, the minimum (across periods) of the Federal Reserve's tangible wealth (as measured by the 5^{th} percentile of the distribution). Here, we see that the minimum of tangible wealth is weakly increasing in the balance sheet size. One may expect the lowest values of tangible wealth to occur for the large ($2.3 trillion) balance sheet scenario since it is associated with the largest realizations of deferred assets and unrealized capital losses such that the market value of assets

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[45] "Value at risk" (VaR) is a measure of the risk of a given portfolio over a set horizon. For example, a one-day 5 percent VaR of $1 million means there is a 0.05 probability that the portfolio will fall in value by more than $1 million over a one-day period. In our case, the right panel of Figure 4 plots threshold values such that the probability of cumulative negative net earnings on the Federal Reserve's balance sheet exceeding these values is 0.05. One study that uses a probabilistic approach to analyze the interest rate risk of the SOMA portfolio is that by Christensen et al. (2015).

[46] Specifically, the market value of assets is simply book value plus (minus) any unrealized capital gain (loss) and less the value of any deferred asset, while the value of interest-bearing liabilities is calculated by subtracting currency and capital from total liabilities.

can be significantly below book value. However, this shortfall is more than offset by the fact that non-interest bearing liabilities (mostly currency) are much larger in this scenario. All else equal, a larger balance sheet stimulates the economy, and currency grows at the rate of nominal GDP (by assumption). Finally, across all our scenarios and simulations, tangible wealth is always substantially above zero. Assuming that the EPDV of seigniorage is positive, we conclude that Federal Reserve insolvency is an extremely remote possibility under all our balance sheet scenarios.

3.2.4 Broader Fiscal Implications

We have so far focused on potential outcomes for Federal Reserve earnings remittances (and related measures), but remittances provide an incomplete characterization of the overall fiscal implications stemming from different longer-run sizes of the balance sheet. More specifically, *all else equal*, different sizes prompt more or less accommodative financial conditions, depending on the overall duration of the portfolio. In turn, different financial conditions might well affect the pace of economic expansion and thus the level of nominal tax receipts, ultimately affecting the overall fiscal position of the federal government in terms of budget balances and outstanding debt.

We use the FRB/US model to evaluate these broader fiscal effects.[47] Table 2 presents results for key fiscal variables, including federal government debt at the end of 2035 (expressed both in nominal dollars and relative to GDP), as well as nominal cumulative federal budget surpluses, tax receipts, and outlays over the simulation horizon.[48] For comparison, we also include cumulative Federal Reserve

[47] We want to stress that our analysis does not speak to the overall fiscal effects of quantitative easing, as all of our scenarios start from the same initial conditions (as of 2017:Q1). To assess those effects, one would have to consider a counterfactual scenario in which reserve balances did not increase following the Great Recession. See Engen et al. (2015) for an analysis of the benefits of the Federal Reserve's unconventional monetary policies.

[48] The federal government budget surplus is equal to the difference between tax receipts and outlays. Tax receipts are the sum of personal income tax and nontax receipts, corporate income tax accruals, indirect business tax receipts, social insurance tax receipts, and income receipts on assets and dividends. Outlays are the sum of federal government consumption expenditure, net interest,

remittances. We stress two main takeaways. First, the broader fiscal implications of different balance sheet sizes are much larger than the corresponding implications for remittances. Second, the larger balance sheet produces, on average, substantial net fiscal benefits, even though it produces somewhat lower remittances.

Table 2: Broader Fiscal Implications of the Longer-Run Size of the Balance Sheet
(Billions of $, unless otherwise noted)

	Longer-Run Level of Reserve Balances* (Billions of $)			
	$100	$500	$1,000	$2,300
Federal Government Debt, end-2035 (Avg.)				
Nominal Outstanding	34,464	34,429	34,384	34,260
Ratio to GDP**	84.1	83.9	83.6	82.7
Nominal Cumulative (2017-2035) (Avg. across Simulations)				
Federal Reserve Remittances	1,495	1,509	1,520	1,483
Federal Budget Surplus	2,351	2,365	2,383	2,425
Federal Tax Receipts	138,886	139,054	139,282	139,946
Federal Outlays	136,534	136,689	136,900	137,521
of which:				
Interest Expense	27,242	27,317	27,416	27,700

* In all scenarios, the SOMA portfolio consists only of Treasury securities. The maturity distribution is pinned down by the assumption that purchases are proportional to Treasury issuance.

** Expressed in percent

To illustrate the first result, we consider the difference between the maximum and minimum values of each variable across longer-run balance sheet sizes. The range for cumulative remittances (comparing columns 3 and 4) is a little less than

and other transfer payments. In turn, federal government consumption expenditure is the sum of federal government employee compensation and non-compensation consumption expenditure. Finally, other transfer payments include net transfer payments, subsidies less surplus, and grants-in-aid to state and local governments.

$40 billion, while the range for other variables is noticeably larger. For example, the range for surpluses (comparing columns 1 and 4) is nearly $75 billion, and the corresponding range for end-of-simulation government debt is about $205 billion.

In terms of the second result, note that moving from the small balance sheet scenario ($100 billion, column 1) to the large balance sheet scenario ($2.3 trillion, column 4) reduces average outstanding debt by over $200 billion—a decrease that is equivalent to about a 1.4 percentage point reduction in the debt-to-GDP ratio. This is the result of the large balance sheet scenario involving substantially more tax revenues (about $1.1 trillion) over the simulation horizon.[49] Thus, although cumulative remittances are $11 billion lower under the large scenario, this difference is swamped by the overall impact on the government budget position.

An important caveat of the results concerning the overall fiscal implications is that they hinge on the assumptions on interest rate policy. Specifically, inertia in the policy rule implies that the additional financial accommodation provided by a larger balance sheet is not perfectly offset by the increase in short-term interest rates, as these rise only slowly. This results in higher output for some time and, in turn, higher cumulative tax receipts. Under less inertial policies, a larger balance sheet would not be expected to boost the overall economy as much. In this case, different longer-run balance sheet sizes would produce fairly similar effects for the overall government budget position but starker differences for remittances. The larger balance sheets would be associated with even higher paths for IOER than shown in our simulations, leading to lower remittances.

[49] Increased tax receipts reflect greater economic output, which results from lower long-term interest rates associated with a large balance sheet. Increased interest expense primarily reflects higher shorter-term (less than 5-year) interest rates because much of the government debt takes the form of shorter-term securities.

4 Conclusions

This paper simulated the transition of the Federal Reserve's balance sheet to four alternative longer-run sizes in an effort to understand the fiscal implications for both remittances and broader economy activity. Our approach uses a large-scale macroeconomic model (FRB/US) to generate future paths of financial and macroeconomic variables and allows for the central bank's balance sheet to provide (or remove) monetary accommodation. The simulation results suggest the following takeaways: [1] maintaining the current level of reserve balances (around $2.3 trillion) would be associated with a significant likelihood of zero remittances (and a deferred asset) in the next few years (30 percent); [2] shrinking reserve balances from their current level to a longer-run level of $1.0 trillion (or less) would markedly reduce the likelihood of zero remittances to less than 5 percent; and [3] the likelihood of Federal Reserve insolvency—meaning that the central bank would not able to cover its losses with future seigniorage—is *extremely* remote. We should stress that our results are based entirely on the FRB/US model. More work is required to assess whether its lessons are robust to the use of different macroeconomic models and assumptions.

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A Assumptions underlying simulations

Our simulations require two main inputs: assumptions about the configuration of the balance sheet and projected paths for financial and macroeconomic variables. We discuss each in turn.

- Assumptions about the configuration of the Federal Reserve's balance sheet: Our initial condition is the configuration at the end of 2017:Q1.
  - Assumptions about the asset side:
    - No asset sales at any point in time;
    - Treasury and Agency debt holdings roll off the SOMA portfolio at maturity;
    - Agency MBS prepayments are determined by a model developed by Board staff;[50]
    - Full reinvestments of maturing securities and principal repayments are expected to cease at the beginning of January 2018;[51]
    - Consistent with the FOMC's June 2017 Addendum to its Policy Normalization Principles and Plans, once full reinvestments are ceased, principal repayments received from Treasury and Agency securities held in the SOMA portfolio will be reinvested only to the extent that those payments exceed gradually rising dollar caps.[52]

[50] See Bonis et al. (2017c).

[51] This assumption is in line with expectations drawn from the June 2017 Federal Reserve Bank of New York's Surveys of Primary Dealers and Market Participants. See https://www.newyorkfed.org/markets/primarydealer_survey_questions.html and https://www.newyorkfed.org/markets/survey_market_participants.html.

[52] The evolution of the caps is as specified in the Addendum. See https://www.federalreserve.gov/newsevents/pressreleases/monetary20170614c.htm.

Once the caps reach their respective maximums, they will remain in place until the size of the balance sheet is "normalized," that is, when reserve balances reach their longer-run level;

* Once the size of the balance sheet is normalized, purchases of Treasury securities resume to accommodate the evolution of other key liability items such as currency in circulation, capital paid-in, and reverse repurchase agreements.[53]

- Assumptions about the liability side:
  * Currency in circulation grows with nominal GDP;
  * Capital paid-in grows at an annual rate of 2.6 percent;[54]
  * Foreign RP pool: reverse repurchase (repos) agreements associated with foreign official and international accounts: set to $200 billion, consistent with median expectation from the June 2017 Surveys;
  * ON RRP: constant at $100B through the end of 2025, and zero thereafter;[55]
  * Treasury General Account (TGA): constant at $150B, consistent with the US Treasury's stated minimum;
  * Other deposits: constant at $40B, consistent with the median expectation from the June 2017 Surveys for the 2025 level;[56]

[53] Treasury securities are also purchased to replace roll-offs of Agency MBS as MBS continue to pay down.

[54] Our assumption for capital is based on the growth rate implied by the corresponding level expected to prevail in 2025 by the median respondent to the June 2017 Surveys of Primary Dealers and Market Participants. This assumption is also consistent with that made in the July update to the 2017 SOMA Annual Report. See https://www.newyorkfed.org/markets/annual_reports.html.

[55] This assumption is consistent with the median expectation from the June 2017 Surveys for the 2025 level of ON RRPs. Thereafter, it follows the policy normalization principles as outlined by the FOMC: "The Committee will use an overnight reverse repurchase agreement facility only to the extent necessary and will phase it out when it is no longer needed to help control the federal funds rate." See Policy Normalization Principles and Plans, September 27, 2014, available at http://www.federalreserve.gov/newsevents/press/monetary/20140917c.htm

[56] This item includes deposits held at the Reserve Banks by international and multilateral organizations, government-sponsored enterprises, and designated financial market utilities. It also includes certain deposit accounts other than the U.S. Treasury, General Account, for services provided by the Reserve Banks as fiscal agents of the United States. See

    * Along with our assumptions on the longer-run level of reserves—either $100 billion, $500 billion, $1 trillion, or $2.3 trillion—the items above determine the longer-run size of the balance sheet.

- Projected paths for financial and macroeconomic variables that affect the evolution of the balance sheet and the income it generates.
  - Paths of financial and macroeconomic variables—most importantly, interest rates and nominal GDP—are generated by running stochastic simulations of the FRB/US model;
  - Stochastic simulations are based around modal paths consistent with (i.e., identical to, but with one necessary exception) the March 2017 public version of FRB/US;
  - The exception arises because the modal paths are influenced by the longer-run balance sheet; as we vary its size across scenarios, the term premium is altered, and this, in turn, affects the rest of the economy;
  - Shocks relative to the modal paths are held constant across scenarios;
  - For each scenario, we conduct 5000 simulations from 2017 through 2035.

https://www.federalreserve.gov/releases/h41/current/.