The Federal Reserve's Balance Sheet as a Financial-Stability Tool[*]

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September 2016

[*] Prepared for the Federal Reserve Bank of Kansas City's 2016 Economic Policy Symposium in Jackson Hole. We thank Matteo Maggiori, Adi Sunderam and Matt Rutherford for helpful conversations and Randall Kroszner for his discussion. An Internet Appendix is available at http://www.people.hbs.edu/rgreenwood/JH2016_IA.pdf.

I. Introduction

In this paper, we argue that the Federal Reserve should use its balance sheet to help reduce a key threat to financial stability: the tendency for private-sector financial intermediaries to engage in excessive amounts of maturity transformation—i.e. to finance risky assets using dangerously large volumes of runnable short-term liabilities. Specifically, we make the case that the Fed can complement its regulatory efforts on the financial-stability front by maintaining a relatively large balance sheet, even when policy rates have moved well away from the zero lower bound (ZLB). In so doing, it can help ensure that there is an ample supply of government-provided safe short-term claims—e.g. interest-bearing reserves and reverse repurchase agreements. By expanding the overall supply of safe short-term claims, the Fed can weaken the market-based incentives for private-sector intermediaries to issue too many of their own short-term liabilities. And, crucially, we argue that the Fed can crowd out private-sector maturity transformation in this way *without compromising the ability of conventional monetary policy to focus on its traditional dual mandate of promoting maximum employment and stable prices*.

To put our work in context, recall that in recent years, there has been a vigorous debate about whether monetary policy should be used to lean against threats to financial stability, especially when doing so might compromise the central bank's ability to hit its targets for employment and inflation. On one side of the fence, a number of prominent observers have invoked what amounts to a separation principle: monetary policy should stick to its traditional knitting, because it is not possible to satisfactorily solve for multiple goals with a single instrument. According to this view, threats to financial stability should be addressed via enhanced regulation alone. Put differently, the costs of allowing current employment and inflation to deviate from their respective targets are likely to be unacceptably large compared to any future economic benefits that might accrue from using monetary policy to lean against financial-market imbalances.[1]

On the other side, some have argued that existing regulatory tools are imperfect in both their effectiveness and scope of coverage. And these imperfections may loom particularly large when the configuration of market interest rates and spreads creates strong incentives for financial intermediaries to either "reach for yield" on the asset side of their balance sheets or to fund on an overly short-term basis on the liability side. According to this logic, an advantage of monetary

[1] See Bernanke (2002, 2015a), Yellen (2014) and Svensson (2015; 2016a; 2016b) for articulations of this view.

policy is that it "gets in all the cracks," in the sense of acting directly on the market rates and spreads that confront all actors in the financial system, irrespective of the regulatory regime they operate under. Nevertheless, advocates of this viewpoint don't deny that it is less than ideal to have more goals than instruments. Rather, they simply argue that falling short on one particular goal—e.g., current employment relative to target—may be a price that is sometimes worth paying to do better on another goal, namely financial stability, and, by extension, future employment.[2]

Interestingly, while this debate has been going on, the monetary policy toolkit has become more multi-dimensional, as central banks have dramatically expanded their balance sheets in an effort to circumvent the limitations associated with the ZLB. However, the regulatory and financial-stability implications of larger central-bank balance sheets have not received much attention. Instead, the focus has been on whether, given the ZLB constraint, central bank asset purchases can be an effective substitute for conventional monetary stimulus.

The main message of this paper is that the added dimensionality that a large central-bank balance sheet affords may be quite valuable away from the ZLB, but no longer for the purpose of providing traditional monetary-policy accommodation. Rather, by influencing the relative yields on safe claims at the front end of the yield curve, a plentiful supply of central-bank liabilities—e.g., interest-bearing reserves or overnight reverse repurchase agreements (RRP)—*can reduce the economic incentives for private-sector intermediaries to engage in excessive amounts of maturity transformation*. Because this incentive effect operates through market-determined prices, it applies to both regulated and unregulated financial intermediaries. Thus, the impact of a large central-bank balance sheet can be said to get in all the cracks of the financial system, much like conventional monetary policy. However, given the extra degree of freedom associated with an additional tool, a central bank that uses its balance sheet in this way would remain free to set the *level* of the short-term policy rate according to the usual macroeconomic stabilization criteria, and would not have to sacrifice meeting its targets for current inflation and employment in order to make further progress on the financial-stability front.

The first step in our argument is to note that much of the time—and particularly away from the ZLB—the very front end of the yield curve tends to be steeply upward-sloping. For example, over the period 1983-2009, the yield on one-week Treasury bills averaged 72 basis points less than

[2] See, e.g., Borio and Drehmann (2009), Stein (2013, 2014), Adrian and Liang (2016), and Juselius et al (2016).

the yield on six-month T-bills. A natural interpretation of this phenomenon is that the shortest-maturity safe claims have many of the same properties as traditional money and that certain investors, such as money-market funds, are willing to pay a substantial premium for these money-like attributes.[3] Moreover, in a world where the Treasury's issuance of the shortest-maturity bills is insufficient to fully satiate this demand for money-like claims, the resulting money premiums at the front end of the curve create a strong incentive for private-sector intermediaries to fill the void and replicate something like one-week bills, for example by funding themselves with overnight repurchase agreements or short-maturity asset-backed commercial paper.

This observation suggests a potential crowding-out motive for government debt maturity. In previous work, we and others have documented that when the supply of T-bills increases, this front-end money premium declines in magnitude, and private-sector issuance of short-term paper declines.[4] In other words, when the government creates more in the way of short-term safe claims, it reduces the incentive for the private sector to step in and manufacture such claims. Given the systemic-risk externalities associated with private-sector maturity transformation, we argue that it is desirable for the government to be an aggressive supplier of safe short-term claims, thereby encouraging private firms to lengthen the maturity structure of their own funding. We flesh out this line of reasoning and present some of the relevant empirical evidence in Section II below.

However, even if one accepts the premise that an increased supply of short-term government liabilities would have a beneficial impact on financial stability through this crowding-out channel, it does not follow that the central bank needs to be the institution that provides these claims. The job could instead be handled by the finance ministry. In other words, rather than advocating for the Fed to provide, say, an extra $3 trillion in reserves or RRP to the market so as to discourage private-sector issuance of short-term debt, it would seem that one could equally well recommend that the Treasury Department shorten its debt maturity profile to supply $3 trillion more of short-term bills and $3 trillion less of longer-term bonds.

In Section III of the paper, we take on this Fed-versus-Treasury question and identify the following tradeoff. On the one hand, it would appear that the Fed has a comparative advantage in providing very short-term government liabilities, because as the sole provider of the final means

[3] See Gorton (2016), Gorton and Metrick (2012), and Stein (2012).

[4] See Greenwood, Hanson, and Stein (2015), Sunderam (2015), Krishnamurthy and Vissing-Jorgensen (2015), and Carlson, Duygan-Bump, Natalucci, Nelson, Ochoa, Stein, and Van den Heuvel (2016).

of payment, it does not face the same kind of "auction risk" that the Treasury does. Concretely, if the Treasury had to roll over $3 trillion of one-week bills every week at auction, it might be concerned about the possibility that there would be insufficient demand on a given date and that the auction might fail, leaving it unable to pay off the maturing bills and forcing it to default on its obligations. By contrast, while interest-bearing reserves are in many ways economically similar to overnight Treasury bills, the Fed doesn't have to re-auction them in order to pay off investors, and there is no corresponding notion of default. Again, this is because these central bank reserves are already the final means of payment.

Against this advantage of the Fed, there is a potential political-economy disadvantage. When the Fed maintains a larger balance sheet, it effectively takes over a part of the traditional debt management role from the Treasury, along with the associated fiscal risk. For example, if the Fed holds an extra $3 trillion of long-term Treasuries in order to be able to issue $3 trillion of interest-bearing reserves and RRP, it faces correspondingly more variation in its profits—and hence in its remittances to the Treasury—due to variations in the general level of interest rates. Now, from a consolidated government balance sheet perspective, one might argue that it doesn't matter whether it is the Fed or the Treasury that bears this interest-rate risk: the ultimate taxpayer exposure is the same either way. However, to the extent that the decision of how much of this risk to take is viewed by Congress and the public at large as being in the proper domain of fiscal policy, a Fed that is protective of its political independence might prefer not to be the agency that chooses the government's overall debt-maturity stance, especially when—unlike in the quantitative-easing (QE) era—doing so is not as obviously motivated by an attempt to deliver on its traditional monetary-policy mandate.

While we believe that this political-economy consideration should be taken seriously, we argue that it can be managed to a significant extent. This is because, for the purpose of crowding out private maturity transformation and in sharp contrast to QE, what mostly matters is *the size of the liability side of the Fed's balance sheet, not the total duration of the bonds it holds on the asset side*. As we quantify in detail below, the Fed may be able to accomplish much the same thing from a financial stability perspective by backing its money-like liabilities with bonds that have an average maturity of somewhere between two to six years, as opposed to the current value of approximately 8.6 years.

In other words, one can envision an outcome in which the Treasury still does almost all of the economically meaningful debt management decision-making with respect to the overall duration of the government debt, and the Fed is only responsible for the "last mile," with relatively little consequence for the consolidated government's exposure to interest-rate risk. Thus, while we argue that the Fed should maintain a relatively large balance sheet measured in nominal dollars going forward, we do not believe that it needs to maintain its large current net interest-rate exposure. Indeed, our calculations suggest that, once the need for QE-style monetary accommodation wanes, the Fed can significantly reduce its current interest-rate exposure while continuing to supply a similar quantity of money-like claims. Such a strategy should help to ease any political-economy concerns about the Fed overstepping its fiscal boundaries.

In Section IV, we turn to a series of more detailed implementation issues. The first of these concerns the appropriate mix of the Fed's liabilities in terms of reserves versus RRP. In its communications to date, the Fed has expressed reservations about the RRP program, saying that it "will use an overnight RRP facility only to the extent necessary and will phase it out when it is no longer needed to help control the federal funds rate."[5] We argue that, from the perspective of our crowding-out paradigm, these reservations are misplaced. An advantage of the RRP program is that it creates a set of safe claims that are available to a wide range of investors, including, for example, money-market funds. By contrast, only regulated depository institutions are eligible to earn interest on reserves. If the ultimate goal is to offer a form of short-term government debt that competes effectively as a substitute for short-term private-sector claims, the wider eligibility associated with the RRP program is a significant advantage. To be clear, the logic of our crowding-out argument in Sections II and III suggests that the ideal policy would be for the Fed to directly issue short-term securities—i.e., "Fed bills"—that can be held by all investors. Our proposal to significantly expand the RRP program can thus be seen as a second-best approximation to this ideal, but one that can be comfortably achieved in the current institutional framework.

As a practical matter, this logic implies that it is desirable to reduce the wedge, which currently stands at 25 basis points, between the interest that the Fed pays on reserves (IOR) and the interest it pays on overnight RRP. Doing so would encourage a Fed liability mix more heavily tilted towards RRP and one that more efficiently crowds out private-sector creation of money-like

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[5] Federal Reserve Open Market Committee statement on "Policy Normalization Principles and Plans," September 17, 2014, available at http://www.federalreserve.gov/newsevents/press/monetary/20140917c.htm.

claims. Indeed, in the spirit of Milton Friedman, a natural frictionless benchmark would be one in which the Fed effectively sells its liabilities to the highest bidder, which would amount to allowing these rates to be driven to equality in equilibrium.[6] While various real-world frictions may ultimately weigh against going all the way to this IOR-equals-RRP limit, it seems to us like a more natural starting point for discussion, as opposed to the current policy, which begins with a strong and not-clearly-articulated presumption against the RRP program.[7]

Section IV also considers the interaction of the liability side of the Fed's balance sheet with two of the most important regulatory innovations in recent years, namely the supplementary leverage ratio (SLR) and the liquidity coverage ratio (LCR). For example, we note that the SLR has had the effect of taxing a relatively benign form of private-sector money creation that occurs when dealer banks offer their customers the ability to repo finance their inventories of long-term Treasuries. To the extent that the Fed steps in and takes over this specific money-creation role by doing more RRP against its own holdings of Treasury bonds, it can be said to be helpfully compensating for the distortion created by the SLR. We view this as another variation on our core theme, which is that the Fed's balance sheet can, if thoughtfully deployed, serve as a valuable complement to its efforts on the regulatory front.

Finally, in Section V, we ask whether the crowding-out motive that we emphasize applies with greater force in some interest-rate environments than in others. We conjecture that it may become all the more urgent for the Fed to use its balance sheet to lean against private-sector money creation when short rates move away from the ZLB. This is because, when short rates are very low, investors seeking a safe place to put their cash are likely to be content with insured bank deposits, which represent a relatively stable source of funding for the financial system. However, as short-term market rates rise, the rates on certain bank deposit products (transactions accounts, savings accounts) tend to lag behind, and we provide evidence that funds flow out of these products and into money-market funds, which in turn invest in more runnable types of claims such as

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[6] Friedman (1969) argued that the government should expand the monetary base until the opportunity cost of holding money was equal to the social cost of creating additional money.

[7] In this regard, we are following Gagnon and Sack (2014), who argue in favor of this RRP-equals-IOR limit and a permanent expansion of the Fed's balance sheet, emphasizing that these changes would enhance monetary control, create an efficient level playing field between banks and non-bank financial institutions, and save money for taxpayers. Bernanke (2015b) also points out that an expanded Fed balance sheet would enhance monetary transmission and alleviate the shortage of safe assets.

wholesale bank CDs, asset-backed commercial paper, and repo.[8] In other words, rising short-term rates tend to be associated with a change in the composition of financial-sector liabilities, away from sticky insured bank deposits and towards more flighty forms of what might be called shadow-bank money. Thus, as rates rise, it arguably becomes all the more important to have a policy tool that can mitigate the risks associated with such shadow-bank money creation.

II. The Crowding-Out Role of Short-Term Government Liabilities

In this section, we review the basic crowding-out argument from Greenwood, Hanson, and Stein (2015), hereafter GHS. We then summarize some of the supporting empirical evidence. In the Internet Appendix, we sketch a simplified version of the GHS model.

II.A. The Logic of Crowding Out Private-Sector Maturity Transformation

GHS begin with the observation that there is a *special demand for financial claims that are safe, short-term, and liquid*—i.e., claims that share many of the core attributes of traditional money. As a result, these money-like financial claims, including Treasury bills and highly-rated short-term private debt, typically command a meaningful money premium in equilibrium—i.e., they offer rates of interest that appear to be too low from a textbook risk-return perspective.

Figure 1 plots the evolution of money-like claims in the U.S. economy as a percentage of GDP from 1951–2015, broken down by different instruments in Panel A and by different end-users in the nonfinancial sector in Panel B. In Figure 1, we estimate the net supply of money-like claims to nonfinancial end users. Note that because financial intermediaries themselves hold many money-like claims, this net supply is far lower than the gross supply of these claims.[9] Figure 1 shows that total money-like claims began at 42% of GDP in 1951, declined steadily until 1978 when they bottomed at 22% of GDP, and have risen back to 42% of GDP in 2015.

What are these money-like claims? The claims in Figure 1 include T-bills, checking deposits, money market fund shares, as well as other short-term private debt (open market paper, repurchase agreements, and foreign deposits).[10] The U.S. Treasury can create money-like claims

[8] Our argument in Section V is based on ongoing research that Hanson is carrying out with Juliane Begenau and Adi Sunderam, both of Harvard Business School.

[9] See Gallin (2013) for an excellent discussion of the difference between gross and net financial intermediation flows as well as a rigorous approach to estimating the latter based on the Financial Accounts of the United States.

[10] Figure 1 does not include savings deposits, which are typically longer term and less liquid than money-like claims.

by issuing short-term T-bills. Alternatively, the Federal Reserve can do so by issuing reserves or reverse repurchase agreements in order to finance purchases of longer-term Treasury bonds, which are also safe but do not command the same money premium due to their longer maturity. Private financial intermediaries can also issue money-like claims. This function is performed by traditional insured depository institutions that offer government-insured checking deposits, as well as by more lightly regulated shadow banks that create uninsured money-like claims—money market fund shares, open market paper, and repurchase agreements—backed by assets that are sometimes risky, long-term, or illiquid.

Turning to the composition of money-like claims, Panel A shows that government-backed money-like claims—checking deposits and T-bills—have declined in relative importance compared to money fund shares and other short-term private debt. Specifically, checking deposits and T-bills accounted for over 99% of all money-like claims in 1951. This fraction fell somewhat during the late 1970s and then fell rapidly from 1995 to 2007, reaching just 31% in 2007Q2 on the eve of the financial crisis. Since the crisis, these government-backed money-like claims have accounted for a growing fraction of the total, rising to 58% in 2015.

Where does the demand for these claims come from? Panel B shows that household ownership of money-like claims has been fairly stable over the past 65 years, averaging 16% of GDP. However, corporate holdings of such claims have increased substantially since the early 1990s, rising from 5% of GDP in 1990Q4 to 10% in 2015Q4.[11] Consistent with Bernanke's (2005) discussion of a global savings glut, foreign holdings of U.S.-produced money-like claims have also risen sharply since the early 2000s.[12]

How much money-like short-term debt should the Treasury and Federal Reserve issue to the public? GHS point out that while issuing more short-term debt may help satiate the public's demand for these securities (and also lower the government's overall cost of financing), doing so exposes the government to the risk that it will have to refinance maturing debt at higher interest rates in the future. Because large shocks to the interest bill can force the government to either raise taxes or cut back on desirable expenditures, fiscal prudence—the desire to smooth tax rates and expenditures over time—suggests that it is unwise for the government to be overly reliant on short-

[11] See Bates, Kahle, Stulz (2009) for an analysis of the evolution of corporate cash holdings.

[12] See also Caballero, Farhi and Gourinchas (2008) and Caballero and Farhi (2016) on the macroeconomic implications of the demand for safe assets.

term debt. Greenwood, Hanson, Rudolph, and Summers (2015) point out that the same fiscal risk logic applies to the Federal Reserve, since buying long-term Treasury bonds and mortgage-backed securities financed with interest-bearing reserves or RRP introduces volatility into the remittances that the Fed ultimately returns to Treasury.

Thus, if the government were the only actor in the economy that could issue money-like claims, the optimal maturity of government debt would be pinned down by a simple tradeoff that balances the direct monetary benefits of issuing shorter-term debt against the greater fiscal risk that doing so entails. This logic suggests that concerns about refinancing risk should become more important as the total debt burden goes up, and the government therefore should opt for a longer debt maturity as the debt-to-GDP ratio rises. As can be seen in Figure 2, this prediction is consistent with U.S. government debt management policy during the post-war era. The figure plots the weighted average maturity of outstanding U.S. government debt against the debt-to-GDP ratio using monthly data from 1952 to 2015. The two series are strongly positively correlated—the correlation coefficient is 0.61. Indeed, as debt levels have increased sharply since the 2008 financial crisis, Treasury officials have cited refinancing risk as a material consideration driving their recent decision to term out the maturity of the debt.[13]

However, the government's choice of how much money-like paper to issue is complicated by the fact that the private sector can also issue short-term money-like claims. Financial intermediaries find short-term debt attractive for the same reason as the government: because of the money premium, it is cheaper than longer-term funding. But, private money creation comes with its own set of risks. In particular, private financial intermediaries that rely heavily on short-term financing may be forced to liquidate assets in the event of an adverse shock. As a result, short-term financing may amplify the transmission of financial distress across institutions, as one intermediary's fire sales cause price declines that threaten the solvency of others and, potentially, the stability of the broader financial system. These threats—which stem from the financing choices of private financial intermediaries—are not taken fully into account when individual intermediaries choose how to fund themselves. Thus, there is an externality associated with capital structure choice that leads to a socially excessive level of private short-term funding (Stein, 2012).

[13] According to the minutes from the November 2009 Treasury Borrowing Advisory Committee meeting, the TBAC recommended "lengthening the average maturity of debt from 53 months to 74–90 months" based on the "potential for inflation, higher interest rates, and rollover risk." See https://www.treasury.gov/press-center/press-releases/Pages/tg348.aspx.

One response to this externality is to try to limit intermediaries' use of short-term debt with regulation. The recently-introduced liquidity coverage ratio (LCR) and net stable funding ratio (NFSR) rules, for example, are attempts to reign in excessive maturity transformation. However, such regulations may only be partially effective, because they do not apply to shadow banks, leading activity to migrate to unregulated intermediaries. Moreover, any form of regulation may have its own deadweight costs, for example by discouraging certain desirable activities along with the undesirable ones.

Given the imperfections of regulation, GHS argue that a useful complement to a purely regulatory approach is *for the government to issue more short-term debt than it otherwise would in a world with no externalities in private-sector money creation*. The idea is that, by issuing additional short-term debt itself, the government can depress the money-like yield premium on short-term debt, thereby reducing its attractiveness as a form of financing for private-sector intermediaries. A key assumption underlying this argument is that short-term government debt and short-term private debt are partial substitutes for each other.

In summary, GHS present two reasons for the government to supply the economy with an ample amount of short-term debt. The first is that it is cheap to do so, reflecting the monetary benefits accruing to the holders of short-term government claims; the financing savings realized are effectively a generalized form of seignorage. The second is the crowding-out argument developed above. Importantly, the logic of crowding out implies that the appeal of providing short-term government claims is greater in settings where either: (i) regulation imposes greater unintended costs on the economy; or (ii) private-sector money creation can more readily migrate from the regulated traditional banking sector to the less-regulated shadow banking sector. We believe that the latter qualification applies particularly well to the institutional environment in the U.S. and other advanced economies. And as we argue in Section V below, it may become all the more relevant once interest rates begin to rise meaningfully above the ZLB.

II.B. Empirical Support for the Crowding-Out Argument

Our crowding-out argument rests on three related assumptions. First, there is a special demand for money-like claims. Second, the demand for money-like claims is downward sloping, so the government can influence the premium on money-like claims by adjusting the supply of T-bills, or in the Fed's case, the supply of reserves or RRP. Third, short-term government debt and short-term private debt are partial substitutes, so changes in the money premium caused by shifts in government supply also influence the amount of private maturity transformation. GHS present detailed evidence in support of these claims; we summarize and update the relevant evidence here.

II.B.i. The Money Premium on Short-Term Treasuries

A simple way to illustrate the premium commanded by the shortest-term Treasury bills is shown in Panel A of Figure 3, which plots the average spread between the 26-week bill and bills of various other maturities over the sample period 1983 to 2009. On average, the one-week T-bill offers a yield that is 72 basis points less than that of a 26-week bill.

A limitation of looking at raw T-bill yields is that we may conflate the fact that the term structure is upwards sloping simply because investors expect rates to rise, with the specific money premium that we seek to capture here.[14] In an effort to control for the general shape of the term structure, Panel A of Figure 3 also shows the average spread from 1983 to 2009 between actual T-bill yields and fitted T-bill yields. The fitted yields are based on the flexible model of the Treasury yield curve from Gürkaynak, Sack, and Wright (2007). Gürkaynak et al estimate Svensson's (1995) six-parameter model of the yield curve using notes and bonds with remaining maturities greater than three months. The n-week "z-spread", $z_t^{(n)} = y_t^{(n)} - \hat{y}_t^{(n)}$, captures the extent to which n-week T-bills have yields that differ from what one would expect based on a flexible extrapolation of the rest of the yield curve, i.e. that portion from three months on out.

As can be seen in the figure, the z-spreads for short-term bills are economically large. Four-week bills have yields that are roughly 40 bps *below* their fitted values. And, for one-week bills, the average z-spread is about 60 bps. Our interpretation of these z-spreads is that they reflect a money-like premium on short-term T-bills, above and beyond any safety and liquidity premiums embedded in longer-term Treasury yields.[15]

A second way to cleanly capture the premium associated with short-term T-bills—and to net out the effects associated with the expectations hypothesis—is shown in Panel B, where we

[14] In practice, it seems unlikely that expectations of rising interest rates could explain the sizable 72 basis point average spread between one-week and 26-week bills. For instance, from their introduction in late 1988 until 2009, the average spread between six-month fed funds futures and the current effective fed funds rate was only eight basis points.

[15] Krishnamurthy and Vissing-Jorgensen (2012) argue that *all* Treasuries, including long-term Treasuries, embed a safety and liquidity premium that reduces their yields relative to a textbook risk-versus-return view. They estimate that this premium on long-term Treasuries averaged 73 basis points from 1926 to 2008. However, the money premiums in Figure 3 reflect a further premium on short-term Treasuries above and beyond that on long-term Treasuries.

plot the realized annualized returns of holding a T-bill with *n* weeks to maturity in excess of the one-week bill rate, computed over the same 1983-2009 period. These results follow Carlson et al (2016), with the logic being that if a money premium exists, then it should be more profitable to buy bills with longer maturities and hold them, as opposed to rolling over a series of one-week bills. Panel B of Figure 3 confirms that this is indeed the case.

II.B.ii. The Response of the Money Premium to Shifts in Treasury Bill Supply

The above plots refer to the *average level* of the money premium. But in the time series, the value of this premium depends on the supply of T-bills, consistent with a downward-sloping demand curve for short-term money-like claims. Figure 4 shows that *z*-spreads are less negative—i.e., the shortest-maturity T-bills have relatively higher yields—when the supply of T-bills is larger. Specifically, each quarter from 1983 to 2009, we plot the average *z*-spread for four-week bills alongside the ratio of T-bills to GDP. As can be seen, there is a positive relationship between the two series in levels ($R^2 = 0.19$): when there are more of the safest short-term securities, the convenience premium on these securities declines.

Table I shows this more formally. We estimate weekly regressions of the *n*-week *z*-spread on *BILLS*/*GDP* for *n* = 2, 4, and 10:

$$z_t^{(n)} = a^{(n)} + b^{(n)} \cdot (BILLS / GDP)_t + c^{(n)} \cdot t + \varepsilon_t^{(n)}. \tag{1a}$$

To compute *BILLS*/*GDP* each week, we use detailed data on the size and timing of Treasury auctions. We include a linear time trend as a control to remove any common trends in the data. Table I shows that *z*-spreads respond positively to the supply of T-bills. For instance, the coefficient of 5.8 ($t = 2.3$) in column (1) of Panel A means that a one-percentage-point increase in the ratio of bills to GDP (roughly half of a standard deviation) leads to a 5.8 bps increase in the two-week *z*-spread. As in Figure 2, Table I shows that the effect is strongest for very short-term bills: the coefficient on the two-week spread is more than twice that for the 10-week spread.

We next estimate equation (1a) in changes to focus on the high-frequency variation in the data. Specifically, we regress four-week changes in the *n*-week *z*-spread on four-week changes in *BILLS*/*GDP* for *n* = 2, 4, and 10:

$$\Delta_4 z_t^{(n)} = a^{(n)} + b^{(n)} \cdot \Delta_4 (BILLS / GDP)_t + \varepsilon_t^{(n)} \ . \tag{1b}$$

Columns (4) to (6) of Panel A show that, when estimated in changes, the slope coefficients $b^{(n)}$ are generally larger than the estimates from the levels regressions in columns (1) to (3). However, the estimates are not significant for the full 1983–2009 period.[16]

Because bill yields and bill supply are simultaneously determined in equilibrium, this evidence is subject to an obvious endogeneity concern. Specifically, the government might respond to a rise in the demand for short-term money-like assets by tilting its issuance towards bills. Indeed, Figure 4 shows that *BILLS*/*GDP* jumps in the fall of 2008 just as *z*-spreads plummet—the telltale sign of an endogenous supply response to positive demand shock. If T-bill supply responds to money demand shocks, this would tend to bias our OLS estimates downward. To address this concern, we focus on the 1983 to 2007 period in Panel B of Table I, thereby omitting the financial crisis and focusing on a period when the demand for money-like financial claims was arguably more stable. As expected, the coefficients are roughly twice as large and are more precisely estimated when we omit 2008 to 2009. For instance, the estimated response of two-week *z*-spreads to a one-percentage-point increase in *BILLS*/*GDP* rises from 5.8 bps in Panel A to 16.7 basis points in Panel B.

Admittedly, simply dropping the outlying 2008 and 2009 observations is ad hoc. To better address this endogeneity concern, GHS adopt an instrumental-variables strategy designed to exploit plausibly exogenous variation in T-bill supply. Specifically, we rely on the fact that much of the high-frequency variation in the supply of T-bills is associated with seasonal fluctuations in tax receipts: the Treasury tends to expand the supply of short-term bills ahead of statutory tax deadlines (e.g., April 15) to meet its ongoing cash needs, and these borrowings are then repaid rapidly following the deadlines. Thus, in the first stage, we regress $\Delta_4(BILLS/GDP)$ on a set of week-of-year dummies; in the second stage, we regress changes in *z*-spreads on fitted values from the first stage. Consistent with the idea that the demand for money-like claims was fairly stable outside of the 2008 to 2009 episode, these IV estimates are similar to the OLS estimates for 1983–2007, but are much larger than the OLS estimates for the 1983–2009 sample.

[16] Consistent with the idea that there is a special demand for short-term safe assets as opposed to simply all safe assets irrespective of their maturity, GHS show that *z*-spreads respond strongly to fluctuations in T-bill supply but not to fluctuations in non-bill Treasury supply.

II.B.iii. The Response of Private-Sector Issuance to Shifts in Treasury Bill Supply

Next, we provide direct empirical support for the idea that an increase in the supply of short-term government debt crowds out the issuance of short-term financial paper. Specifically, in Table II, we regress the ratio of unsecured financial commercial paper to GDP—arguably the most direct form of private money creation that we can measure at high frequencies—on the ratio of T-bills to GDP. Other than the different dependent variable, the specifications mirror those in Table I. That is, we estimate:

$$(FINCP/GDP)_t = a + b \cdot (BILLS/GDP)_t + c \cdot t + u_t, \tag{2a}$$

and

$$\Delta_k (FINCP/GDP)_t = a + b \cdot \Delta_k (BILLS/GDP)_t + \Delta_k u_t, \tag{2b}$$

for changes computed at a variety of different horizons *k*. We obtain weekly data on outstanding commercial paper from 2001 to 2009, monthly data from 1992 to 2009, and quarterly data from 1952 to 2009. Panel A reports results for samples ending in 2009, and Panel B reports results for samples ending in 2007.

Table II shows that financial commercial paper issuance falls when the supply of T-bills rises. The estimated coefficients on *BILLS/GDP* and Δ_k(*BILLS/GDP*) in Table II are almost always negative and statistically significant, with means of -0.13 in Panel A and -0.24 in Panel B. The interpretation is that, on average, for every dollar increase in T-bills, financial commercial paper falls between 14 and 24 cents.

Many of the coefficients in Table II are identified using high-frequency variation in T-bill supply. While this variation provides a useful source of identification in Table I, we wouldn't necessarily expect private issuance to respond as quickly as yields to changes in T-bill supply. Consistent with the notion of gradual adjustment on the part of private intermediaries, the magnitude of the crowding-out coefficient on T-bills in equation (2b) typically rises as we consider differences at longer horizons. And the coefficients from the levels-on-levels regressions tend to be larger than those on from the differences-on-differences regressions.

Complementary evidence comes from Sunderam (2015), who shows that asset-backed commercial paper (ABCP) issuance is elevated when liquidity premiums on T-bills are high and that increases in T-bill supply depress liquidity premiums and ABCP issuance. Similarly, Carlson et al (2016) document that increased T-bill issuance crowds out financial commercial paper, nonfinancial commercial paper, ABCP, and time deposits. Using vector autoregressions, they find that the supply of private money-like claims typically responds within two to three months to shocks to the supply of T-bills. Krishnamurthy and Vissing-Jorgensen (2015) take a somewhat related approach that exploits low-frequency variation in government debt supply. Specifically, using annual data from 1875 to 2014, they show that increases in the ratio of U.S. government debt to GDP are associated with reductions in the net short-term debt of the financial sector. However, they focus on changes in all forms of government debt, not just T-bills, so their results are less directly applicable to thinking about optimal debt maturity.

III. Fed versus Treasury as the Primary Supplier of Short-Term Claims

Thus far, we have argued that by expanding the supply of safe short-term claims, the government can discourage private-sector maturity transformation, thereby complementing its efforts on the regulatory front. However, this line of reasoning does not establish a unique role for the Federal Reserve. After all, any desired supply increase could, in principle, be implemented simply by having the Treasury issue more short-term bills, thereby shortening the average maturity of the government debt. Indeed, Congress has historically delegated the choice of debt maturity to the Treasury and not to the Fed. And many would argue that this arrangement is appropriate given the inherently fiscal nature of these debt management choices: the maturity of the government's debt determines taxpayers' exposure to interest-rate risk. So why should the Fed, as opposed to the Treasury, take the lead in expanding the supply of short-term safe claims?

III.A The Fed's Comparative Advantage: Supplier of Final Means of Payment

To answer this question, it is useful to begin by looking at the Treasury's issuance behavior at the very front end of the yield curve. As of year-end 2015, the weighted average maturity of the outstanding public debt was 5.7 years. Just 11% of the outstanding debt was in the form of T-bills, and only 3.6% of the debt (just 2.6% of GDP) was in bills maturing in less than 30 days—precisely those bills that our analysis of yield differentials in the previous section suggested are in the greatest demand by investors looking for money-like debt instruments.

It is interesting to contrast the Treasury's issuance behavior at the front end of the curve with that of private financial intermediaries. Figure 5 compares the maturity distribution of T-bills with that of privately issued commercial paper as of year-end 2015. We plot the cumulative percentage of each instrument outstanding by weeks to maturity. The figure makes clear that the private sector is much more aggressive than the Treasury in providing the shortest maturity claims. Moreover, by focusing just on commercial paper—and omitting other private money-market instruments such as repurchase agreements, which are usually structured as overnight loans—the figure significantly understates the differential between Treasury and private sector intermediaries. Considering the financial stability risks associated with very short-term private funding, we find this divergence to be particularly striking.

What explains the Treasury's apparent reluctance to more fully satiate the market's demand for short-term bills, thereby leaving a large void for the private sector to fill? In public testimony, Treasury officials tend to speak of a tradeoff between the lower costs associated with financing at the short end of the yield curve versus the increased "refunding risk" that such an approach necessarily entails.[17] Evidently, this refunding risk limits the Treasury's willingness to finance itself using short-term T-bills as a general matter and (as we noted earlier) does so even more when the aggregate debt burden goes up, since refunding risk looms larger in absolute dollar terms at those times.

For our purposes, it is crucial to distinguish between two different types of refunding risk. The first, which we label "duration risk," captures the idea that the shorter the average maturity of the debt, the more the government's interest expense—and hence required future tax rates—will increase if the general level of interest rates rises. To the extent that the deadweight losses from taxation are a convex function of tax rates, the Treasury should limit its duration risk exposure in order to limit the variability of tax rates over time. This is the form of fiscal risk that we discussed in the previous section when reviewing the GHS model and that has been explored in a large literature on optimal government debt maturity.[18]

A second distinct type of refunding risk might be called "auction risk." The idea here is that as debt maturity becomes more skewed towards shorter-term bills, the Treasury has to conduct larger and more frequent T-bill auctions, and such auctions are, independent of the general level of interest rates, a source of potential concern in their own right. For example, with larger and more frequent T-bill auctions, the probability of an auction failure—e.g., a situation where the Treasury does not receive enough bids to auction the desired quantity of bills at any reasonable

[17] See Gensler (1998) and Ramanathan (2008). In Congressional testimony, Gensler argued that "Treasury finances across the yield curve" because "a balanced maturity structure mitigates refunding risks."

[18] See, for example, Barro (1979), Bohn (1990), and Aiyagari, Marcet, Sargent, and Seppala (2002).

price—might be expected to rise. While such a failure might be promptly cured by rounding up more participants and re-running the auction later in the day, the failure itself might be both politically damaging and hurt investor confidence, thereby raising the Treasury's future borrowing costs. Auction risk as we have defined it has received far less attention in the academic literature on government debt maturity, but it figures prominently in practitioner thinking.[19]

With this distinction in place, we can make a couple of observations. First, as noted by Greenwood, Hanson, Rudolph and Summers (2015), if the only source of refunding risk for the Treasury was due to duration risk, nothing could be gained by having the Fed issue short-term liabilities instead of the Treasury, as the net impact on the consolidated government balance sheet would be the same either way. For instance, if the Federal Reserve decided to finance an additional $1 trillion in long-term Treasuries with interest-bearing reserves, the Fed's income—and hence its remittances to the Treasury—would bear the same exposure to rising rates as the Treasury would if it were it to replace $1 trillion in long-term bonds with short-term T-bills. Thus, a desire to help the Treasury manage its duration risk exposure obviously cannot be a coherent rationale for the Fed to maintain a larger balance sheet.

Second, if duration risk were the only problem, then a "barbell" debt management strategy of issuing mostly short-term and long-term debt—while largely avoiding intermediate maturities—might allow the Treasury acting on its own to provide more of the most highly-valued short-term claims without meaningfully increasing the government's overall duration risk. Consider the following example. As of December 31, 2015, the average maturity of the $1.5 trillion of T-bills was 83 days, with only $474 billion having a remaining maturity of 30 days or less. Now suppose the Treasury eliminated the $488 billion of bills with maturities greater than 100 days and replaced them with more sought-after 30-day bills. In the simple case where interest-rate movements across the yield curve are governed by a single-factor model, the Treasury could fully offset the duration-exposure impact of this swap by simultaneously replacing $15 billion of 10-

[19] See Friedman (1964), Cecchetti (1988), and Garbade (2012). Garbade (2004) argues that, prior to the emergence of regular auctions in the early 1970s, the U.S. Treasury paid a significant premium to avoid the potential for an undersubscribed offering. In recent years, the Treasury Borrowing Advisory Committee has cited "reduced rollover risk" as a benefit of issuing longer-term debt (https://www.treasury.gov/resource-center/data-chart-center/quarterly-refunding/Documents/dc-2006-q1.pdf). Other G7 governments emphasize the importance of auction risk. For instance, the Bank of Canada notes that "execution risk is still the most important risk regardless of market conditions." Indeed, the United Kingdom Treasury suffered high-profile auction failures in 2002 and 2009.

year bonds with 30-year bonds.[20] The fact that the Treasury has not made more use of this barbell approach suggests that duration exposure may not be the only factor constraining its issuance of the shortest-maturity T-bills and that auction risk may also play an important role.

A further clue pointing in the same direction is the Treasury's 2014 decision to begin issuing floating-rate notes (FRNs). Treasury FRNs have a contractual maturity of two years but pay a variable interest rate tied to the realized auction yield on 13-week bills. As shown in Figure 6, FRNs have been issued at non-trivial yield spread to the 13-week bill rate, with FRN investors receiving an average of 11 basis points above the 13-week bill rate. This raises the question of why FRNs are appealing to the Treasury. From a duration-risk perspective, FRNs are identical to 13-week bills, only more expensive. So why not just sell more 13-week bills and pocket the savings? A natural answer is that because FRNs have a longer contractual maturity, they don't have to be rolled over as often and hence contribute less to auction risk. Indeed, a key stated rationale for introducing FRNs was to "reduce Treasury's roll-over burden."[21] Thus, we interpret the existence of expensive FRNs as strong evidence that when the Treasury says it is concerned with "refunding risk," part of what it has in mind is auction risk, rather than pure duration risk.

If this is indeed the case, then there is a meaningful distinction between short-term claims produced by the Fed and the Treasury. And because the Fed is the sole provider of the final legal means of payment, the Fed arguably has an important comparative advantage over the Treasury in supplying such claims. To see this point, think about what happens if the Treasury has a large quantity of maturing T-bills coming due that it needs to roll over at an upcoming auction. It is obligated to pay the holders of these maturing bills in legal tender—i.e., with Fed-created reserves. If for some reason the upcoming bill auction were to fail, the Treasury would be in default on its existing obligation, with all the attendant consequences of such a highly visible default. By contrast, there is no analogous notion of the Fed being at risk of default: a holder of reserves is only ever entitled to ask for either the same reserves, or for currency, which the Fed can also

[20] Swapping \$488 billion of bills with an average maturity of 169 days for 30-day bills achieves a net reduction in maturity of 139 days. At the time of writing, the duration of an on-the-run 30-year Treasury bond was 21.5, and the duration of a 10-year bond was 9.1. To offset the reduction in the maturity of bills, the Treasury could swap $\$488 \times (139 \div 365) \div (21.5 - 9.1) = \$15$ billion of 10-year bonds for 30-year bonds. This calculation is only suggestive, because if there is more than one factor governing yield-curve movements, the offset is no longer perfect, although some of the appeal of the barbell approach remains. See Greenwood, Hanson, and Stein (2015) for a formal analysis.

[21] See the minutes from the January 31, 2012 meeting of the Treasury Borrowing Advisory Committee available at https://www.treasury.gov/press-center/press-releases/Pages/tg1404.aspx.

elastically provide. So interest-bearing reserves, while similar to overnight T-bills in terms of their duration risk exposure, effectively do not have to be rolled over and hence involve no auction risk. In this sense, central bank reserves are closer in spirit to infinite-maturity floating rate notes than to overnight Treasury bills.

Relatedly, the Fed can afford to be indifferent to the quantity taken up in its overnight reverse repurchase agreement program (RRP) auctions, because if there is less RRP outstanding, the quantity of reserves seamlessly expands to fill the gap.[22] Indeed, the take-up in RRP auctions routinely spikes around quarter-ends due to window-dressing demand from money market funds. For instance, RRP take-up jumped from $162 billion on December 24, 2015 to $475 billion on December 31st, before falling back to $117 billion on January 7, 2016. However, because these swings in outstanding RRP are perfectly offset by changes in the quantity of bank reserves, the size of the Fed's balance sheet remains fixed and does not need to expand around quarter-ends.

Figure 7 provides some further perspective on the magnitude of the Fed's comparative advantage over the Treasury as a supplier of very short-term claims. We plot selected Fed liabilities alongside the quantity of T-bills, with those bills maturing in less than 30 days broken out separately. As of 2015Q4, the outstanding quantity of interest-bearing Fed liabilities (reserves and RRP) was over seven times that of the shortest-maturity T-bills. Specifically, on average over 2015Q4, there were only $381 billion of outstanding T-bills with a maturity of 30 days or less. However, depository institutions held $2,566 billion of interest-bearing reserves at the Fed, and the outstanding quantity of Fed overnight RRP averaged $127 billion.[23]

Of course, this doesn't prove that the Treasury couldn't supply far more in the way of short-term bills if it were prodded to do so. It only shows that, for whatever reason, it hasn't done so in the past, even in the face of a strong economic incentive, while the Fed has demonstrably had no problem in expanding its short-term liabilities very rapidly. We suspect that a differential exposure to auction risk lies at the heart of this marked divergence, though this is admittedly hard to prove.

[22] This observation may help to explain a key difference between T-bill auctions and RRP auctions. In a T-bill auction, the Treasury seeks to sell a fixed quantity of bills, presumably because it has to come up with enough in the way of proceeds to pay off maturing debt. In an RRP auction, the Fed sets a rate and lets the quantity adjust however it may; the Fed doesn't have to care in any funding-needs sense if the resulting quantity is small or even zero.

[23] Our figures for overnight repo do not exactly match end-of-quarter numbers reported in the Financial Accounts of the United States because we purposefully take quarterly averages of daily outstanding volumes; we do this to avoid overemphasizing quarter-end spikes in reverse repo that we discussed above.

The thrust of our argument thus far is that it may be attractive for the Fed to maintain a large balance sheet even when there is no longer a need for any QE-type monetary accommodation. This is because, in doing so, it can produce short-term safe claims more effectively than the Treasury. In other words, if we decided that we wanted an extra $3 trillion of government-provided short-term claims in order to crowd out private-sector maturity transformation, this may be more efficiently accomplished by having the Fed buy $3 trillion of longer-term bonds from the Treasury and finance these bonds with reserves and RRP, as opposed to having the Treasury retire the same amount of long-term debt and replace it with one-week T-bills. In the former case, there is no issue of auction risk to worry about, while in the latter case the increase in the size and frequency of bill auctions would be unprecedented.

III.B The Fed's Comparative Disadvantage: Taking on Fiscal Risk

There is an important caveat to this line of reasoning, however. When the Fed maintains a large balance sheet, thereby converting a significant quantity of longer-term Treasuries into short-term interest-bearing claims, it is effectively taking over part of what has been the Treasury's traditional debt management role, along with the associated interest-rate risk. While the Fed purposefully took on this kind of fiscal risk with its QE programs in the wake of the financial crisis, it did so in the explicit pursuit of its Congressionally-mandated objective of returning the economy to full employment while constrained by the ZLB. It would arguably be a bigger stretch relative to the Fed's traditional role to maintain this level of fiscal exposure once the economy has fully recovered, and the ZLB constraint no longer binds.[24]

Indeed, a natural way to interpret the arguments of those who would like to see the Fed's balance sheet revert to its pre-crisis size is that they believe the proper role for an independent Federal Reserve is to take the minimum level of fiscal risk consistent with its dual mandate.[25] According to this view, the fiscal risk-taking associated with debt maturity choice ought to properly be lodged with the executive branch in the Treasury Department, and to deviate from this

[24] Some have suggested that the Fed's large balance sheet, and the associated risk of remittances turning negative, may limit its willingness to raise rates in the future (Woodford, 2012; Bhattarai, Gafarov, and Eggertsson, 2015).

[25] Mishkin (2010), Rudebusch (2011), and Dudley (2013) all argue that low or negative remittances could put political pressure on the Fed. See also Del Negro and Sims (2015). Hall and Reis (2013), Christensen, Lopez, and Rudebusch (2015) and Carpenter, Ihrig, Klee, Quinn and Boote (2013) explore simulations of remittances and the Federal Reserve's balance sheet under different paths of interest rates.

approach absent a compelling logic grounded in the Fed's monetary-policy mandate runs the risk of jeopardizing the Fed's independence.

While these political-economy concerns deserve to be taken seriously, there are reasons to think that they can be managed to a significant extent. For our purposes, there is a crucial distinction between *the size of the liability side of the Fed's balance sheet and the total dollar duration of the bonds it holds on the asset side*. This is a key difference relative to QE, where it was important for the Fed to buy long-duration bonds so as to depress term premiums. By contrast, if the goal is simply to supply a large quantity of very short-term liabilities, this can be done even if the assets backing these liabilities have a shorter weighted average maturity of, say, two to five years. Thus, even if the nominal size of the Fed's balance sheet was kept at its current level of roughly \$4.5 trillion, it should be possible to significantly reduce the amount of fiscal risk that a balance sheet of this size poses.

Figure 8 provides some illustrative calculations of how our proposal might work. Panel A shows the current maturity breakdown of marketable Treasury securities, based on data from the Center for Research in Securities Prices (CRSP) and the December 2015 Monthly Statement of the Public Debt. As of December 31, 2015, the outstanding quantity of Treasury debt, consisting of bills, notes, bonds, TIPS, and FRNs, totaled \$13.2 trillion. The public debt had a weighted average maturity of 5.7 years. The black bars in the figure denote the distribution of the Fed's \$2.5 trillion of Treasury holdings, which are tilted towards longer-term issues and have a weighted average maturity of 8.6 years. T-bills are marked separately in the figure; note that the Fed currently does not hold any bills. The \$1.9 trillion of the Fed's holdings of mortgage-backed securities (MBS) are not shown.

The three remaining panels in Figure 8 show alternate scenarios which maintain the current size of the Fed's balance sheet, while varying the weighted average maturity of its Treasury holdings. Each of these scenarios assumes that the Fed runs off its portfolio of MBS and reinvests the proceeds in Treasuries, keeping its balance sheet at \$4.5 trillion.

Panel B shows an extreme scenario in which the Fed scales up its current portfolio, reinvesting its MBS proceeds so as to maintain the weighted average maturity of its Treasury holdings at 8.7 years. This scenario would involve large purchases of long-term Treasuries, leading to the Fed owning 100% of the outstanding amount of 21- to 26-year bonds. In this case, for purposes of the figure, we allocate any residual amount over 100% to 29 and 30 year bonds.

Panel C shows the more realistic scenario in which the Fed holds \$4.5 trillion of Treasury notes, bonds, TIPS, and FRNs—but not T-bills—in proportion to their outstanding amount, thereby mimicking the maturity distribution of outstanding Treasury debt. The Fed currently does not hold any T-bills, and the thrust of our crowding-out argument suggests that this would be a desirable policy going forward: all else equal, the Fed should aim to maximize the amount of short-term government debt available to the public. This scenario takes the average maturity of Treasuries held by the Fed down to 6.4 years, a reduction of 2.2 years from the status quo in Panel A. Since the Fed would own only 39% of each outstanding issue in this scenario, such a reconfiguration of the balance sheet seems feasible; by way of comparison, in some longer maturity buckets, the Fed currently owns more than 65% of all outstanding issues.

Panel D presents a more aggressive shortening of the Fed's balance sheet: we assume that the Fed concentrates its holdings in all issues (again excluding T-bills) with a remaining maturity of less than five years, holding those securities in proportion to the amount outstanding. This would reduce the weighted average maturity of the Fed's portfolio from 8.6 years to just 2.2 years but would still preserve the Fed's ability to issue a large amount of very short-term claims in the form of excess reserves and reverse repo. To maintain this maturity structure on a \$4.5 trillion balance sheet would involve the Fed owning 62% of the outstanding amount of shorter maturity notes and bonds. So while it represents quite a dramatic reduction of the Fed's duration position, even a maturity profile of the sort shown in Panel D does not seem to be pushing the envelope any more so than the Fed's current asset mix, at least in terms of the metric of fractional ownership of individual Treasury issues.

In Table III, we present estimates of how these different configurations of the Fed's balance sheet might impact long-run fiscal risk. We report nine different Fed balance sheet scenarios: three different balance sheet sizes—\$1.5 trillion, \$3 trillion, and \$4.5 trillion—and three different asset-side maturity structures—portfolios with weighted average maturities of 2.2, 6.4, and 8.7 years, corresponding to the maturity profiles in Figure 8. For each of these scenarios, we present estimates of the long-run volatility of (i) the consolidated government's interest expense and (ii) the net interest income that the Federal Reserve remits to the Treasury. The former is our preferred measure of fiscal exposure, as it captures the more economically relevant notion of taxpayers' overall exposure to rising rates.

The consolidated federal interest expense is the interest that the government pays on its liabilities that are held by the public (i.e., net of Fed holdings), including both publicly held Treasury debt and interest-bearing Fed liabilities. The consolidated interest expense in dollars is

$$INT_t^{TOT} = INT_t^{UST} - REMIT_t^{FED}(\tau_{FED}, Z), \tag{3}$$

where INT_t^{UST} is the dollar interest expense on Treasury debt, and $REMIT_t^{FED}(\tau_{FED}, Z)$ is the Fed's remittance to the Treasury in dollars.

To simulate the Treasury's interest expense, INT_t^{UST}, we assume a total Treasury debt of D = \$13 trillion with a weighted average maturity (WAM) of τ_{UST} = 5.7 years. We assume that the Treasury uses a uniform issuance "ladder." For example, if the Treasury's weighted average maturity was five years, we would assume that each month the Treasury refinances the maturing 10-year bonds that it issued 10 years ago by issuing new 10-year bonds. This implies that the percentage interest expense on a five-year WAM portfolio is just a 120-month moving average of 10-year yields, i.e., $\sum_{j=1}^{120} y_{t-(j-1)}^{(10)} / 120$, where $y_t^{(n)}$ denotes the *n*-year yield at time *t*. More generally, the interest expense (in dollars) on a total debt of *D* when the Treasury follows a uniform issuance ladder with a weighted-average maturity of τ_{UST} years is given by

$$INT_t^{UST} = D \times \frac{\sum_{j=1}^{12\times\tau_{UST}} y_{t-(j-1)}^{(2\times\tau_{UST})}}{12\times\tau_{UST}}. \tag{4}$$

We simulate Fed remittances similarly, assuming that the distribution of maturities in the Fed's portfolio is uniform—i.e., that the Fed follows a simple ladder investment strategy. Remittances, in dollars, for a balance sheet of size *A* that invests in Treasuries with a weighted average maturity of τ_{FED} years and is financed with fraction *Z* of interest-bearing reserves are:

$$REMIT_t^{FED}(\tau_{FED}, Z) = A \times \left(\frac{\sum_{j=1}^{12\times\tau_{FED}} y_{t-(j-1)}^{(2\times\tau_{FED})}}{12\times\tau_{FED}} - Z \times r_t \right). \tag{5}$$

We simulate the term structure of interest rates using 100,000 years of monthly term structure data, compute the consolidated federal interest expense and remittances using equations (3), (4), and (5), and then obtain long-run volatilities by taking the standard deviation of these series. Term structure data is based on simulations of the model in Greenwood, Hanson, and Vayanos (2015) (GHV), adopting parameters from Table I of their paper. Our simulation methodology and the GHV model are described in the Internet Appendix.

Consider Panel A of Table III, where we assume that Fed's balance sheet remains at $4.5 trillion. Throughout Table III, we assume that non-interest bearing currency in circulation is fixed at $1.5 trillion. Thus, we assume that a $4.5 trillion Fed balance sheet is financed with 1/3 of non-interest bearing currency and with 2/3 of interest-bearing reserves and RRP.

Columns (1), (2), and (3) of Table III show how the volatility of the consolidated federal interest expense varies across Fed balance sheet scenarios. Looking at each of the three panels in Table III, we see that, for a given balance sheet size, the Fed's contribution to consolidated fiscal risk is always *increasing* in the weighted average maturity of its asset holdings. For example, if the Fed maintains a $4.5 trillion balance sheet with a WAM of 8.7 years, the volatility of consolidated interest expense is $200 billion or 1.54% of the $13 trillion debt. If the Fed reduces the maturity of its holdings to 2.2 years, the volatility of consolidated interest expense drops considerably, to $141 billion per year. The intuition is straightforward: the longer the Fed's assets portfolio, the greater is the quantity of short-term debt that the consolidated government needs to refinance each period, and therefore the more volatile is the government's consolidated interest expense.

Table III makes it clear that, by reducing the WAM of its Treasury holdings aggressively enough, a Fed with a $4.5 trillion balance sheet can make roughly the same modest contribution to consolidated fiscal risk as one that maintains a much smaller pre-crisis-style balance sheet but that holds a more representative mix of Treasuries. Concretely, as shown in column (2) of Panel C, a Fed with a $1.5 trillion balance sheet that holds a pro-rata fraction of all outstanding Treasuries (excluding bills) delivers a consolidated interest expense with a long-run volatility $136 billion. This is very close to the $141 billion figure that one gets with a $4.5 trillion balance sheet when the Fed holds only Treasuries maturing in less than five years. Simply put, varying the WAM of the Fed's Treasury portfolio is a potent tool for adjusting its contribution to fiscal risk, and—unlike changing the nominal size of the balance sheet—is one that allows the quantity of Fed-produced safe short-term claims to be kept constant.

Columns (4), (5), and (6) of Table III show the corresponding volatility of Federal Reserve remittances to the Treasury. In Panel A and Panel B, our conclusion remains the same: reducing the WAM of US Treasury bonds held by the Fed reduces remittance volatility in much the same way that reducing WAM reduces overall fiscal risk. In Panel C, however, the result flips: reducing the WAM of Federal holdings *increases* remittance volatility.[26] In this case, where the two metrics produce opposing results, we believe that looking at the volatility of consolidated interest expense is more meaningful, particularly if the ultimate point is to ask what the Fed's behavior implies for overall fiscal risk, defined as taxpayer exposure to rising interest rates.

The message from our analysis is that one can easily envision an outcome in which the Treasury still does much of the economically-meaningful decision-making with respect to the overall duration risk exposure of the government debt, and the Fed is only left with responsibility for the "last mile," with relatively little consequence for the consolidated government's exposure to interest-rate risk. Moreover, if it so desired, the Treasury could always raise the weighted average maturity of its issuance to offset any increase in fiscal risk posed by a large Fed balance sheet. In other words, the consolidated government could implement the kind of "barbell" strategy discussed in Section III by having the Treasury term out further at the same time that the Fed issues more short-term liabilities.

IV. Implementation Issues

Having argued that the Federal Reserve should maintain a larger balance sheet in order to expand the supply of safe short-term claims, we now turn to a series of implementation issues. The first concerns the precise nature of the liabilities that the Fed should supply and, in particular, the choice between interest-bearing reserves and overnight reverse repurchase agreements (RRP). The next set of issues concerns the ways in which the Fed's balance sheet interacts with two of the most prominent post-crisis regulatory innovations, namely the heightened supplementary leverage ratio (SLR) that now applies to the largest U.S. bank holding companies and the liquidity coverage ratio (LCR). We consider these issues in turn.

IV.A The Optimal Mix of Reserves and RRP

Table IV presents a stylized version of the Fed's balance sheet as of 2015Q4. To smooth over the large seasonal swings in the mix between RRP and reserves, we present quarterly averages of weekly and daily quantities. Total assets, predominantly in the form of Treasury securities and

[26] What explains this counterintuitive finding? In the scenario considered in Panel C, the Fed maintains a balance sheet of $1.5 trillion that is entirely financed by currency. Since currency is effectively a long-duration liability (the rate it pays is a constant at zero) the volatility of net income is minimized by matching it with long-duration assets.

agency mortgage-backed securities, total roughly $4.5 trillion. On the liability side, the two largest categories are paper currency, at $1.36 trillion, and reserve balances, which are deposits at the Fed by depository institutions, at $2.57 trillion. The volume of overnight RRP outstanding is in the ballpark of $127 billion, although this amount tends to rise around quarter-ends. Thus the quantity of reserves outstanding is nearly 20 times that of overnight RRP.

To understand how these quantities are determined in equilibrium, one needs to know the interest rates paid on both reserves and RRP, as well as the counterparties eligible to receive these rates. Depository institutions (DIs) as well as government-sponsored enterprises (GSEs) are allowed to make deposits at the Fed—i.e. to hold reserves balances. However, only DIs are paid the interest rate applicable to reserves (IOR), which is currently set by the Fed at 50 basis points. By contrast, while the rate paid on the RRP program is set 25 basis points lower than the IOR rate, there is a wider set of counterparties eligible to receive this rate. In addition to DIs and GSEs, there are currently more than one hundred money market funds that are approved counterparties for the RRP program.

The Fed directly sets the IOR rate and the RRP rate and thereby influences both market-determined rates, such as the federal funds rate, as well as the relative quantities of reserves and RRP outstanding. Consider the fed funds rate, which has recently traded in the neighborhood of 37 basis points. At first glance, it might seem odd that the fed funds rate lies below the IOR, as this configuration appears to allow for an immediate riskless arbitrage: a DI could borrow in the funds market at 37 basis points, deposit those funds with the Fed at 50 basis points, and pocket the 13 basis point difference. However, there are two types of costs associated with this arbitrage, which allow the wedge between the fed funds rate and the IOR rate to be sustained in equilibrium. The first of these is the FDIC's deposit-insurance assessment, which applies to the total liabilities of all domestic DIs. A domestic bank that engages in IOR arbitrage expands its balance sheet and, in so doing, increases its FDIC assessment; this is a marginal cost of undertaking the trade. Notably, branches of foreign banks do not face this FDIC assessment because their deposits are not insured, and hence they are at a comparative advantage in performing the IOR arbitrage. In part for this reason, more than a third of total reserves are now held by foreign banking organizations.

A second cost associated with IOR arbitrage stems from the leverage ratio, which requires banks to maintain a minimal level of equity to all assets, including riskless assets like reserves.

Because IOR arbitrage necessarily expands a bank's balance sheet, if a bank perceives its leverage ratio to be a binding constraint, it will be reluctant to engage in IOR arbitrage unless the trade is sufficiently profitable to compensate for the shadow value of the constraint.

Thus, the existence of a sizable spread between IOR and market-determined rates suggests that the banking system is glutted with reserves. On one hand, almost all the reserves in the system will be held by banks in equilibrium, because they are the only institutions who can earn the IOR rate. On the other hand, because banks find it costly to further expand their balance sheets—both because of FDIC assessments and the perceived tightness of the leverage-ratio constraint—banks have to be offered an IOR rate that is well in excess of market-determined rates in order to be willing to absorb such a large quantity of reserves.

By contrast, the Fed can finance itself at a considerably lower rate by making use of the RRP facility. This is because the market for RRP is not restricted to DIs who are subject to various regulatory frictions and hence is more competitive. In effect, Fed RRP is a very close substitute for overnight T-bills, as both are riskless claims that can be bought by money funds.

This observation begs a question in the spirit of Friedman (1969): taking the asset side of its balance sheet as given, why shouldn't the Fed structure the liability side so as to minimize its total interest expense? As a practical matter, this could be accomplished simply by raising the RRP rate towards the IOR rate and thereby—assuming there is not a cap on the size of the RRP facility—encouraging a shift in the equilibrium mix of reserves and RRP. For example, instead of maintaining a 25 basis-point differential between the IOR and RRP rates, this wedge could be narrowed to, say, 10 basis points or perhaps even less, depending on how elastically the equilibrium quantities of reserves and RRP adjust.

Reducing the IOR-RRP spread and shifting the Fed's funding mix to the more open and competitive RRP market would potentially create social value in two related ways. First, and most obviously, it would save taxpayers a meaningful amount of money. With over $2.5 trillion of reserves outstanding, even a modest 10 basis-point reduction in the Fed's total funding cost amounts to $2.5 billion of taxpayer savings per year. Moreover, these savings effectively come directly out of the rents earned by banks—to a large extent foreign banks—as a result of the imperfectly competitive and frictional nature of the market for reserves. Second, this taxpayer savings is the flip side of a more efficient allocation of the Fed's liabilities to those who value them most at the margin—i.e. money market funds in this case, as opposed to depository institutions.

This second point gets to the heart of our crowding-out approach. Recall that our main argument is that the consolidated government should supply more short-term safe claims because, with an expanded government supply of short-term safe claims, institutions like money market funds will not bid as aggressively for private-sector substitutes such as asset-backed commercial paper, thereby crowding out the amount of maturity transformation by private financial intermediaries. When the Fed expands the supply of RRP, this is almost like the Treasury issuing more T-bills, since it increases the supply of a government-provided short-term safe claim that can be held by money market funds. By contrast, when the Fed supplies reserves, it pays more interest but does not come as close to replicating T-bills, because the reserves cannot be held outside the regulated banking system. Hence, from our crowding-out perspective, one would not expect reserves to be as effective as RRP in reducing the incentives for private-sector maturity transformation.

Our contention that the RRP facility is likely to be a useful tool over the long run is at odds with the Fed's public statements on the topic, which have repeatedly expressed a desire to minimize the use of this facility. For example, the minutes of the January 2016 FOMC meeting mention that: "… participants reiterated that the Committee expects to phase out the [RRP] facility when it is no longer needed to help control the federal funds rate, and they unanimously expressed the view that it would be appropriate to reintroduce an aggregate cap on [overnight] RRP operations at some point."

One reason for this difference is that the Fed does not appear to be attaching much weight to the sorts of financial-stability considerations that we have been emphasizing. Rather, they seem to view the RRP facility more narrowly as an instrument of monetary control. That is, they see RRP primarily as a device for establishing a more reliable floor under the federal funds rate in light of the frictions in IOR arbitrage discussed above. Indeed, the January 2016 minutes went on to state that: "In making these judgements, most policymakers emphasized the primacy of maintaining monetary control in setting the appropriate capacity of the [overnight] RRP facility for the time being; participants indicated that the Committee's future decisions regarding the size and ultimate longevity of the facility should be largely driven by considerations of monetary control, although other factors, such as financial stability, should also be taken into account."

Beyond these differences in perspective, observers who have been skeptical of the RRP program have worried that if the Fed supplies a safe asset in elastic quantity at a fixed rate—as would be the case with a completely uncapped RRP facility—this could exacerbate flight-to-safety dynamics in a stressed crisis scenario. To be concrete, consider a money market fund whose portfolio is a mix of government securities and financial commercial paper. In a crisis situation, the fund is likely to try to shift towards safe government securities and away from risky commercial paper. If the quantity of government paper is in fixed supply, T-bill yields must decline in equilibrium. If, however, the Fed allows the supply of RRP to expand elastically at a fixed interest rate, the yields on government securities cannot fall, and the only remaining equilibrating mechanism must therefore be a sharper upwards spike in the yields on commercial paper, which might further destabilize markets.

This observation strikes us as valid. However, it is also straightforward to address. The solution is to cap the size of the RRP facility, but not at some arbitrary ex ante value. Rather, the cap should be made explicitly dynamic, so that the volume of RRP outstanding can find its natural level in normal times but cannot increase too much in a stressed scenario. Suppose that, per our earlier recommendation, the spread between the IOR and RRP rates is cut to 10 basis points, and—that during a calm market environment—the quantity of RRP supplied by the Fed is left uncapped, thereby finding its natural equilibrium level. Suppose further that this value has averaged $1 trillion over the past six months. The dynamic capping mechanism that we have in mind would then specify that the quantity of RRP on any given day cannot exceed (say) 120% of this trailing six-month average, or $1.2 trillion. This approach would help to dampen the sort of crisis dynamics described above, while still allowing the RRP facility to be far more responsive to the demand for short-term safe claims in normal times.[27]

Finally, we should note that the logic in Sections II and III suggests that the *ideal* crowding-out policy would be for the Fed to issue large quantities of short-term securities—i.e., "Fed bills"—that could be held by all investors.[28] Our proposal to significantly expand the Fed's RRP program

[27] The design of the capping mechanism has already been worked out by the Fed in its implementation of the RRP facility. At each auction, each participant submits a complete price-quantity demand curve. If, at the posted RRP rate, total demand lies below the cap, the posted rate prevails, and quantities are allocated accordingly. If, at the posted RRP rate, total demand is above the cap, the mechanism flips over into an auction for the fixed cap amount and the demand curves are used to set the market clearing rate. Relative to this established design, we are merely suggesting that the value of the cap be a function of past usage of the facility, rather than a pre-determined dollar value. See Frost et al (2015) for a detailed discussion of design issues related to the RRP facility.

[28] The Fed currently lacks the legal authority to issue securities, although many foreign central banks have this power. If granted this authority, the Fed could offer very short-term (e.g., one-day or one-week) bills using a fixed rate facility. Unlike an expansion in T-bill supply, an expansion in Fed bill supply would not increase auction risk because short-term fluctuations in the quantity of Fed bills would be perfectly offset by changes in bank reserves.

should be seen as a second-best approximation that takes as given the legal constraint that only the Treasury can issue short-term securities. However, one can imagine other ways that the Fed and Treasury could work together to increase the supply of short-term government claims, though these, too, bump up against existing institutional constraints. For example, if the debt ceiling were not binding, the Treasury could offer large amounts of one-day or one-week T-bills using a fixed rate facility similar to that currently used for RRP, deposit the proceeds in its account at the Fed, and have the Fed back these deposits with a portfolio of long-term Treasury securities (see Stella (2015) for a related proposal).[29] This arrangement is identical to an expansion of the Fed's RRP program from the perspective of consolidated fiscal risk and would yield similar financial stability benefits. However, it might better safeguard Fed independence as it would make it clear than the Fed was simply acting as the Treasury's agent, rather than taking on the fiscal risk of a large balance sheet in its own right.

IV.B. Using the Fed's Balance Sheet to Mitigate Regulatory Frictions

Our overarching theme in this paper has been that there is a complementarity between the Federal Reserve's balance sheet and its regulatory tools, and that by using its balance sheet intelligently, the Fed can achieve better financial stability outcomes than by relying on regulation alone. For much of the paper, the implicit model has been one in which regulation is generally helpful, but imperfectly effective in its coverage—say because some activity can always migrate from the more-regulated banking sector to the less-regulated shadow-banking sector. A related, but logically distinct case, is one in which regulation imposes costly side-effects on the more-regulated sector itself. We now discuss two leading examples of this point.

IV.B.i. The Supplementary Leverage Ratio

One way that the private sector performs maturity transformation is by engaging in Treasury repo. Specifically, when a hedge fund puts on a carry trade by buying a long-term Treasury bond and financing this purchase with short-term repo borrowing, it increases the supply of short-term safe assets available to the non-financial sector and reduces the supply of long-term

[29] The Treasury recently took some small steps in this direction. In May 2015, the Treasury announced that it planned to raise the size of its regular T-bill auctions and to hold larger deposits balances at the Fed. However, the Treasury's efforts to expand bill supply have been limited by maneuvering necessitated by the debt ceiling (Stella (2015))

safe assets. In other words, the hedge fund is effectively doing the same transaction—and bearing the same duration risk—that we have been arguing that the government should otherwise do more of, say, by shortening aggregate Treasury debt maturity. Moreover, as far as private-sector maturity-transformation activities go, this Treasury carry trade is at the benign end of the spectrum, as compared to, say, funding much more risky and illiquid assets (such as private-label securitizations) with runnable short-term funding.

However, recent regulatory changes have put a significant crimp in private-sector Treasury repo. The most important of these changes is the introduction of the Supplementary Leverage Ratio (SLR), which was finalized by the U.S. banking agencies in September of 2014. The SLR requires the largest U.S. bank holding companies to maintain a ratio of equity to total assets (irrespective of risk weights) of 5%, or 2% above the global standard. To the extent that the SLR is perceived to be a binding constraint on the activities of these firms, it will tend to discourage relatively low-risk activities that consume a lot of balance-sheet capacity. One example of such a low-risk activity that appears to have been noticeably impacted is so-called "matched-book repo". This is when a dealer bank acts as an intermediary to facilitate the type of carry trade by a hedge fund just described. For example, the dealer bank would borrow from a money fund in the tri-party repo market and then turn around and lend to the hedge fund in the bilateral repo market. Again, this type of matched-book activity on the part of the dealer is effectively taxed under a binding SLR, because the loan to the hedge fund increases the raw size of the dealer's balance sheet.

Figure 9 presents some evidence which suggests that the SLR has indeed increased intermediation frictions in the Treasury repo market. In Panel A, we plot the spread between the rate on 10-year plain-vanilla interest-rate swaps and 10-year Treasury yields. Because levered investors like hedge funds need to obtain dealer financing for their Treasury positions but not for their swap positions, the spread between swap rates and Treasury rates will, in part, reflect the shadow value of dealers' SLR constraint. As can be seen, the swap spread has declined significantly into negative territory over the past year, meaning that the Treasury yield has gone up sharply relative to the swap rate. This is indirect evidence, but it is consistent with the idea that it has become expensive for levered investors to finance their holdings of long-term Treasury securities.

More directly relevant for the hypothesis, Panel B of Figure 9 shows the spread between the tri-party repo rate (the rate at which dealer banks borrow) and the GC repo rate (the rate at which they lend). This spread is quite literally the intermediation spread in the repo market and should, in principle, be driven exactly the sort of regulatory frictions like those due to the SLR. As can be seen, this spread has widened considerably, from a range of five to seven basis points in late 2012 to over 20 basis points at the end of 2015. The figure also shows that this widening of the intermediation spread has happened at roughly the same time that the outstanding quantity of Treasury repo has declined.

To be clear, none of this evidence implies that a heightened SLR is a bad idea in any absolute sense. It may well create additional frictions in the Treasury repo market, but one might argue that its benefits outweigh the costs. However, the evidence does suggest that it is important to think about the complementarities between different policies. If one accepts that a side effect of the SLR is to inhibit the ability of private-sector intermediaries to convert long-term Treasuries into short-term safe claims, and if one also believes that such short-term safe claims are highly valued in the marketplace, it is natural to ask whether the SLR raises the burden on the public sector to take over some of the work that was previously being done by the private sector.

Thus, we believe that the frictions associated with the SLR—and the associated reduction in the vibrancy of the private-sector Treasury repo market—strengthen the general case for the Fed to step in and do essentially the same activity, by holding more Treasuries and financing these Treasuries with its own repo borrowing, via the RRP facility. This discussion also hints at one of the risks that may arise if the Fed chooses not take up this role. One might expect that the relative scarcity of Treasury repo, and the corresponding high returns to the Treasury carry trade, would lead private-sector actors to try to find a workaround. That is, eventually the function of doing matched-book repo intermediation might migrate from the balance sheets of regulated dealer banks, to some sort of entity that is not subject to the SLR. Perhaps this would involve a small number of very large hedge funds acting as a conduit between money funds and a larger number of other smaller hedge funds, much in the way that dealer banks do today. Or perhaps it would take some other form. But if an evolution like this does happen, it will be harder to say that overall systemic risk has been reduced by the SLR. So, if by maintaining a relatively large balance sheet, the Fed can help to reduce the incentives for this kind of regulatory arbitrage, it would be supporting the initial goals of the SLR regulation.

IV.B.ii. The Liquidity Coverage Ratio

Another important piece of the post-crisis regulatory framework is the Liquidity Coverage Ratio (LCR), which was also finalized in 2014. The LCR requires each large bank to hold enough high-quality liquid assets (HQLA) to meet its net cash outflows in a 30-day liquidity stress scenario, under specific assumptions about how different classes of liabilities and off-balance-sheet commitments behave in such a stress scenario. The LCR applies in full force to firms with $250 billion or more in assets, and in a less stringent form to those with between $50 billion and $250 billion in assets.

Key to the design of the LCR is the choice of what kinds of assets can be used to satisfy the HQLA requirement. In its current implementation, there are three categories of assets that can count as HQLA. Level 1 assets, the most pristine category, include Treasury securities and central bank reserves; each dollar of these counts as one dollar of HQLA, and they can be used without limit to satisfy the requirement. Next comes Level 2 assets, which include agency mortgage-backed securities. These are subject to a 15% "haircut," so a dollar of MBS only counts as 85 cents of HQLA; moreover, Level 2 assets can only be used to satisfy 40% of the HQLA requirement. Finally, there are Level 2B assets, including corporate stocks and bonds. These are subject to a 50% haircut and can only be used to satisfy 15% of the requirement.

For the purposes of what follows, it is useful to focus attention just on the Level 1 part of the requirement: that a given bank must hold a certain minimum level of Treasuries and reserves. Two points are worth noting here. First, as many observers have pointed out, the LCR may end up exacerbating an overall scarcity of safe assets, to the extent that the induced demands for Level 1 assets are quantitatively large (Hannoun, 2011; IMF Stability Report, 2012, p.100).[30]

Second, the Level 1 HQLA constraint is analogous to an expanded set of reserve requirements, but with a crucial difference. With traditional reserve requirements, and under the pre-crisis operating framework, if reserves became scarce—leading to an undesired increase in the federal funds rate—the Fed could choose to offset this scarcity with a standard open-market operation in which it purchased Treasuries with reserves, thereby increasing the supply of reserves. Thus, the level of the funds rate could be insulated from shocks to reserve demand. By contrast, the way the LCR is designed, if Level 1 assets become scarce, leading to unusually pronounced

[30] See BCBS (2010) and Elliott (2014) for more details of the LCR.

yield spreads between Treasuries and those near substitutes not classified as Level 1, the simplest open-market operation cannot loosen the constraint. This is because, by purchasing Treasuries with reserves, the Fed would leave *the sum of the two available to the public unchanged*, and it is the sum that is relevant for the Level 1 HQLA requirement.[31]

Thus, there is the risk that, given: (i) the rigidity of the regulation itself; (ii) unpredictable shocks to the supply and demand for Level 1 HQLA; and (iii) the Fed's inability to offset these shocks through open-market operations, the LCR could create undesirable volatility in various yield spreads relative to Treasuries, particularly in periods of market stress. One way to address this problem, and to introduce a "safety valve" role for the Fed, would be to tinker with the relative treatments of reserves and Treasury securities in the rule. For example, one could make it so that Treasuries—but not reserves—were haircut by, say, 10% in the computation of Level 1 HQLA. In this case, a dollar of reserves would buy more headroom under the rule than a dollar of Treasuries, and an open-market operation that purchased Treasuries with reserves would leave the financial system with more total available Level 1 HQLA. As a result, the Fed would be able to accommodate shocks to HQLA demand, much as it can accommodate shocks to reserve demand under a simple reserve-requirement regime.

If this avenue were to be pursued, it would be another reason to be open-minded about the Fed maintaining a relatively large balance sheet. In addition to ensuring an adequate supply of short-term safe claims, as we have been arguing all along, a larger balance sheet might also allow the Fed to vary the quantity of Level 1 HQLA in the financial system, and thereby temper some of the volatility that might otherwise be associated with the LCR.[32]

V. Looking Forward: Crowding Out as the Economy Leaves the ZLB

We have argued that the Federal Reserve should use its balance sheet to help reduce financial intermediaries' tendency to engage in excessive amounts of maturity transformation. As the economy returns to full employment in the years ahead, and the Fed begins raising the policy

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[31] Because agency MBS do not count as Level 1 assets, the Fed can ease a shortage of Level 1 HQLA by undertaking an open-market operation in which it purchases agency MBS instead of Treasuries. However such an operation might be unattractive because, say, it represents an explicit shift in the stance of monetary policy towards the housing market.

[32] See Pozsar (2016) for a similar argument. Pozsar does not raise the issue of differential regulatory haircuts for Treasuries and reserves. However, he suggests that some banks have an intrinsic preference for holding reserves relative to Treasuries to meet the LCR requirement. This has a similar effect, in that an increase in reserves matched one-for-one with a decrease in Treasuries may be perceived as easing the cost of the constraint for banks.

rate, will the need to crowd out maturity transformation subside, or will it instead become a more pressing consideration?

In this section, we argue that the crowding-out motive is likely to apply with even greater force as the Fed's policy rate moves away from the ZLB. Our argument is based on the observation that, as short-term interest rates rise, savings tend to flow out of stable retail deposit products offered by insured banks and into the more run-prone claims such as money market fund shares and wholesale deposits.

In recent decades, these cyclical outflows appear to stem from the fact that banks have considerable market power over retail depositors—either because deposit markets are concentrated or because some depositors face high search costs. As a result, banks choose to pass through only a small fraction of increases in short-term money-market rates (e.g., the fed funds rate) into the rates they pay to retail depositors; therefore the spread between money-market rates and retail deposit rates widens as money-market rates rise.[33] In response, more sophisticated households and nonfinancial firms tend to substitute away from stable retail bank deposits and towards more run-prone shadow banking liabilities, which pay rates that more closely track the fed funds rate. This logic suggests that maturity transformation migrates to the shadow banking sector as interest rates rise, strengthening the argument for increased provision of short-term claims by the Fed.

In Table V, we provide evidence that private money creation rises following increases in the fed funds rate. We present regressions of the four-quarter percentage change in money-like claims on the level as well as the four-quarter change in the fed funds rate. Formally, we estimate

$$\Delta_4 \log(Q_t) = a + b \cdot (r_t - r_{t-4}) + c \cdot r_{t-4} + \varepsilon_t, \tag{5}$$

where Q_t is the amount of money-like financial claims in quarter t expressed as a percentage of GDP. We show results for the 1960–2015 period, the 1960–1989 sub-period, and the 1990–2015 period. Our series on money-like claims—including checking deposits, Treasury bills, money market fund shares, and other private money-like debt (open market paper, repurchase agreements, and foreign deposits) are the same as those that we plotted earlier in Panel A of Figure 1.

We start by looking at increases in all forms of money-like financial claims. Column (1) shows that in aggregate, total demand for money-like claims rises modestly when short-term rates

[33] For studies linking the weak pass through to retail deposit rates to market concentration, see Hannan and Berger (1991) Neumark and Sharpe (1992), and Drechsler, Savov, and Schnabl (2016). See Sharpe (1997) and Hannan and Adam (2011), who show that consumer switching costs help explain the low rates on deposits, and Yankov (2014), who argues that heterogeneity in customer sophistication plays a key role in explaining deposit pricing dynamics.

are high. Columns (2) and (5) show that as rates rise, there is a significant substitution away from checking deposits and toward money market fund shares. As a result, columns (6) and (7) show that as a result, the *share* of money-like assets supplied by the shadow banking sector—defined as the sum of money market funds and other private money-like debt—responds strongly to the level of and changes in the fed funds rate.

Figure 10 displays this result graphically, showing for each year from 1990 to 2015 how money-like claims supplied by shadow banks have grown relative to total money-like claims. The regression, shown in column (6) of Panel C in Table V, is:

$$\Delta_4 \log\left(\frac{SHAD_t}{TOT_t}\right) = \underset{(t\,=\,-4.86)}{-0.04} + \underset{(t\,=\,3.59)}{3.27} \cdot (r_t - r_{t-4}) + \underset{(t\,=\,4.03)}{1.69} \cdot r_{t-4}, \qquad R^2 = 0.49. \tag{6}$$

As shown in Figure 10, the fitted values from this regression closely track a combination of the fed funds and recent changes in the fed funds rate.

Thus, money market funds and other shadow banking players are flush with funds when short rates are high. Consistent with this view, Nagel (2016) shows that the premiums on safe, short-term securities prized by these funds also tend to be high when short rates are high. As a result, financial intermediaries may find it increasingly attractive to finance themselves using uninsured forms of short-term debt as short rates rise.

Moreover, recent changes to the SEC's Rule 2a-7, which governs money market funds, may intensify the relationship between private maturity transformation and short-term interest rates that we have documented here. The SEC's 2010 amendments to Rule 2a-7 require money market funds to shorten the weighted average maturity of their assets.[34] As a result, a given dollar flow into money market funds during the next tightening cycle may create an even greater demand for the very shortest-maturity claims and, as a result, may elicit even more aggressive maturity transformation by the private sector.

A corollary of this observation is that the Fed should be willing to allow its balance sheet to adjust over time to accommodate the above-described changes in the demand for money-like claims. In particular, our analysis makes the following prediction: as short rates rise, if the Fed maintains a fixed spread between the IOR rate and the RRP rate, the take-up of the RRP facility

[34] The 2010 Amendments to Rule 2a7 require money market funds to maintain a weighted average asset maturity below 60 days (the prior requirement was 90 days); to hold 10% of their assets in cash, Treasury securities, or private claims that can be redeemed within a day; and to hold 30% of their assets in Treasuries, cash, or private claims that can be redeemed within five business days.

should be expected to increase, perhaps quite substantially, mirroring the inflows into money funds. From a normative perspective, our logic suggests that this change in the composition of the Fed's liabilities in a rising-rate environment—away from reserves and towards RRP—is a helpful stabilizing influence and should be welcomed, rather than resisted.[35]

VI. Conclusions

Our basic point is that even as the need for QE-style monetary accommodation wanes, the size and composition of the Federal Reserve's balance sheet will continue to be important policy tools that can be enlisted to help mitigate the financial-stability risks associated with excessive private-sector maturity transformation. Notably, our approach draws attention away from the asset side of the Fed's balance sheet and towards the liability side. In other words, while during the QE era much of the focus was on the allocation of the Fed's asset holdings between Treasuries and mortgage-backed securities, and on the duration of its investments in each of these categories, a financial-stability orientation leads one to ask instead about the nature of the claims that the Fed issues against these assets, and in particular about the appropriate mix of reserves and RRP.

A number of concrete policy recommendations flow from our framework.

First, the Fed should keep a large balance sheet indefinitely going forward, even as rates rise well above the ZLB. While we do not attempt to pin down an exact dollar number, the current size of approximately $4.5 trillion strikes us as a plausible baseline.

Second, in order to reduce its impact on the consolidated government's interest-rate exposure, the Fed can wind down its investment in mortgage-backed securities and reduce the weighted average maturity of its Treasury holdings. Our calculations suggest that by doing so, the Fed's contribution to the overall interest-rate risk position of the federal government can be reduced significantly, even at a nominal balance sheet size of $4.5 trillion. Moreover, once monetary policy has normalized, there will no longer be a quantitative-easing motive for the Fed to be overweight longer-maturity securities.

[35] As a logical matter, if the IOR-RRP spread were kept fixed at a narrow value, and if the demand for safe claims from money funds were to increase dramatically enough, it is possible that the Fed would have to expand its balance sheet beyond the current size of roughly $4.5 trillion in order to fully accommodate the demand for RRP. In other words, both the composition and size of its balance sheet might ultimately be in play if it were determined to both keep the IOR-RRP spread constant and small and to fix the funds rate at a given value. To be clear, this is just an articulation of constraints, not a policy recommendation: if a growing balance sheet became a cause for discomfort, the IOR-RRP spread could be widened, thereby tamping down the demand for Fed-provided safe claims.

And finally, the Fed should meaningfully reduce the spread—which currently stands at 25 basis points—between the interest rate it pays on reserves and the rate on its RRP facility. In addition to saving taxpayers billions of dollars a year, reducing this spread will lead to an expansion in the volume of RRP, which we argue is likely to be more effective than reserves at crowding out maturity transformation. Moreover, independent of the exact level of the spread, we expect that the RRP facility will have a more important role to play in the coming years as policy rates rise above the ZLB. We would urge the Fed to embrace this role, rather than seeking to phase out the RRP program.

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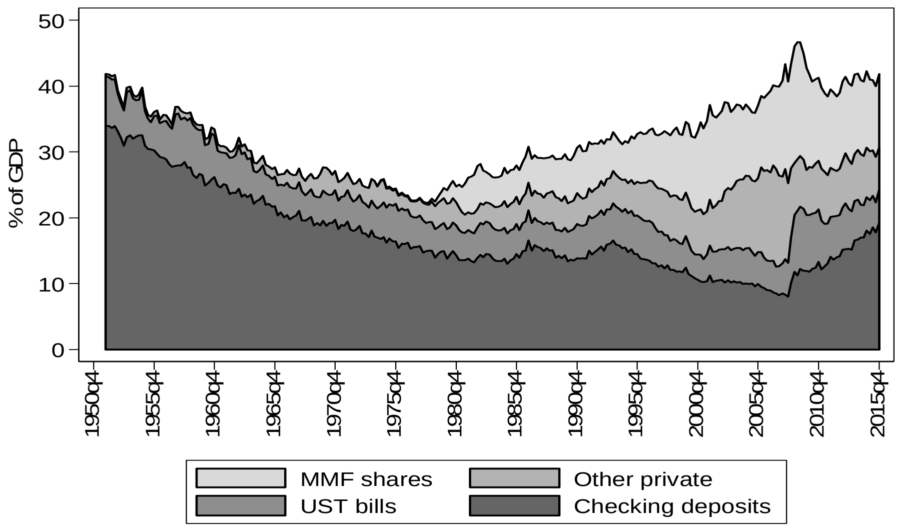
Figure 1
Money-like Claims

This figure plots money-like claims—i.e., short-term, safe, liquid claims—held by end-users in the nonfinancial sector as a percentage of U.S. GDP on a quarterly basis from 1951 to 2015. Panel A shows holdings broken out by instrument. Panel B shows holdings by holder type. All series are based on the Financial Accounts of the United States. Money-like claims consist of checkable deposits and currency, U.S. Treasury bills, money market fund shares, other uninsured short-term safe assets held directly by the nonfinancial sector (open market paper, repurchase agreements, and foreign deposits). Savings deposits are not included. The nonfinancial sector consists of households, nonfinancial businesses, the U.S. federal, state, and local government, and the rest of the world. Holdings of T-bills are estimated by taking the product of each sector's total holdings of U.S. Treasuries and the fraction of marketable Treasuries that are bills from Table L.210.

Panel A: Money-like instruments



Panel B: Nonfinancial holders of money-like claims

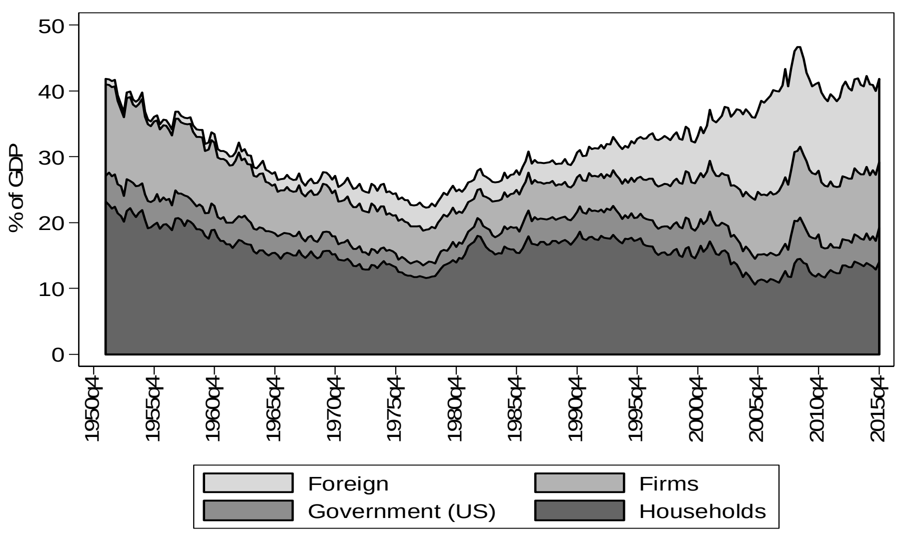


Figure 2
The Government Lengthens Debt Maturity as Debt/GDP Rises

The figure plots the weighted average maturity of Treasury debt versus the debt-to-GDP ratio. The average maturity of Treasury debt is based on authors' calculations using the CRSP government debt database.

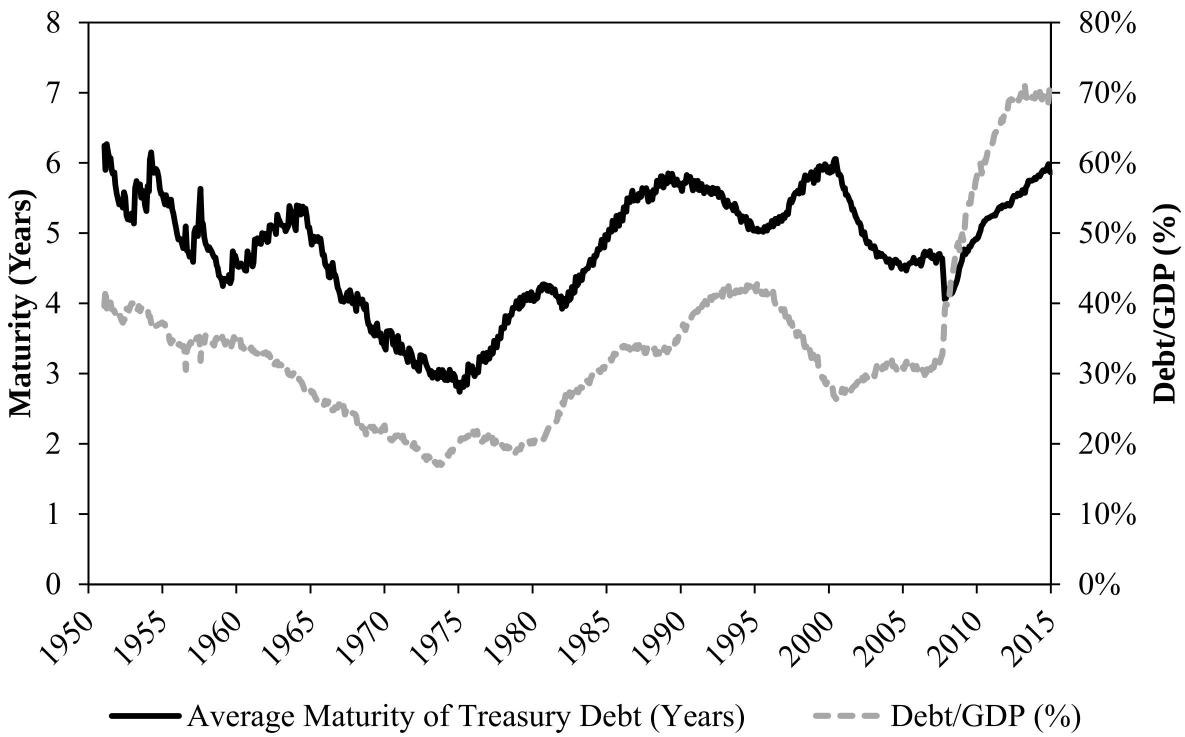
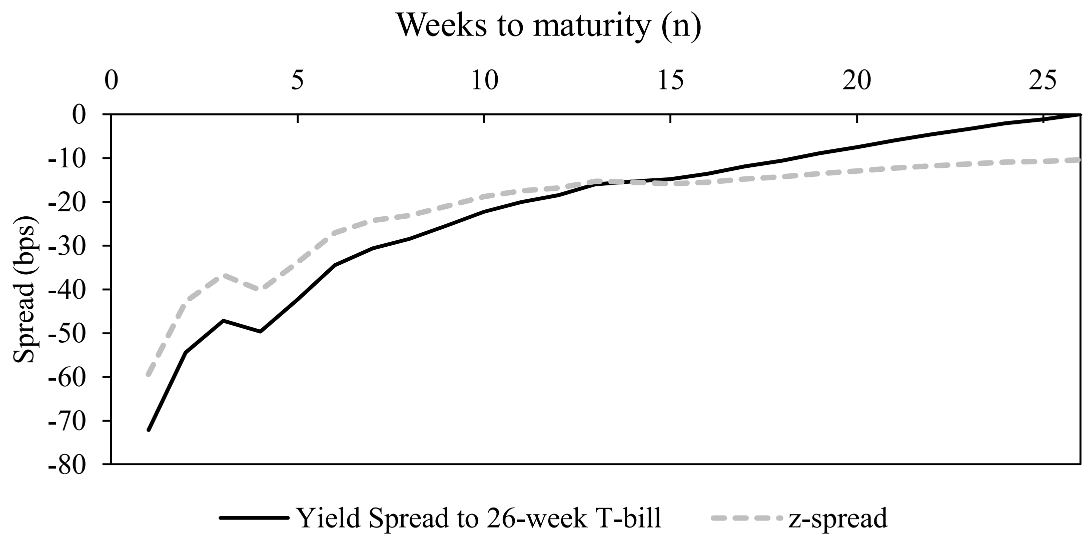


Figure 3
The Money Premium on Short-Term Treasury Bills

Panel A plots the average spread, over the period 1983 to 2009, between T-bill yields of maturities from 1 to 26 weeks and the yield on the 26-week bill. It also plots the *z*-spread, defined as the difference between T-bill yields and fitted yields, where fitted yields are based on the flexible extrapolation of the Treasury yield curve from Gürkaynak, Sack, and Wright (2007). Panel B shows average excess returns of *n*-week T-bills over the 1-week bill return over the same time period. Panel A follows Greenwood, Hanson and Stein (2015); Panel B follows Carlson, Duygan-Bump, Natalucci, Nelson, Ochoa, Stein, and Van den Heuvel (2016).

Panel A: Yield spreads on short-term Treasury bills



Panel B: Excess returns over 1-week Treasury bills

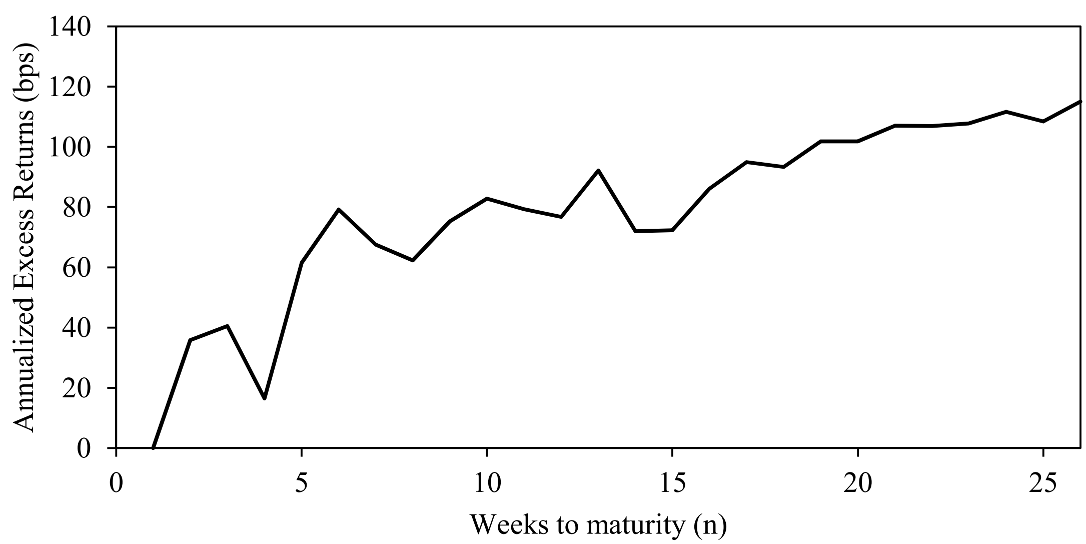


Figure 4
The Money Premium on T-bills and the Supply of T-bills, 1983 to 2009

The figure plots the 4-week *z*-spread against the ratio of T-bills to GDP. The *z*-spread is the difference between T-bill yields and fitted yields, where fitted yields are based on the flexible extrapolation of the Treasury yield curve from Gürkaynak, Sack, and Wright (2007).

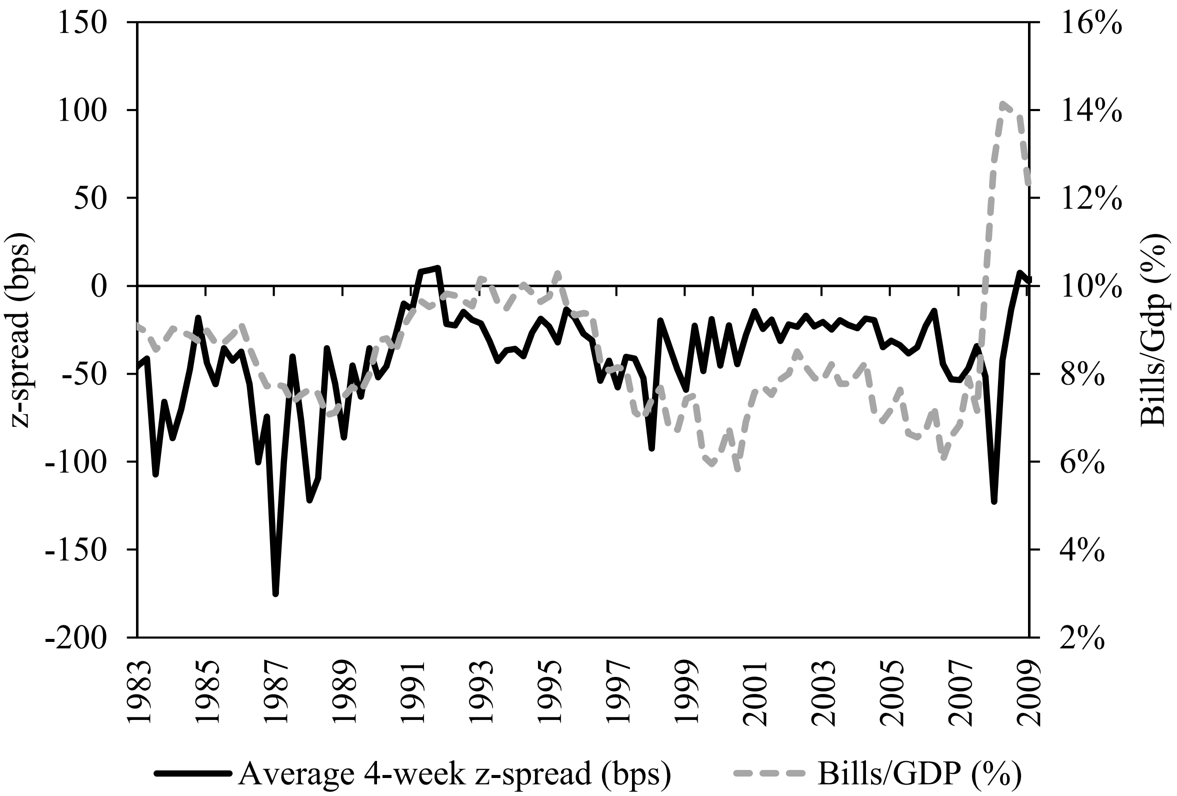


Figure 5
Comparing the Maturity Distribution of T-bills with that of Commercial Paper

The figure compares the maturity distribution of T-bills with that of commercial paper as of year-end 2015, and is based on data from CRSP and the Federal Reserve (https://www.federalreserve.gov/releases/cp/yrend.htm). The maturity breakdown for commercial paper is for all commercial paper and includes unsecured nonfinancial paper, unsecured financial paper, and asset-backed commercial paper.

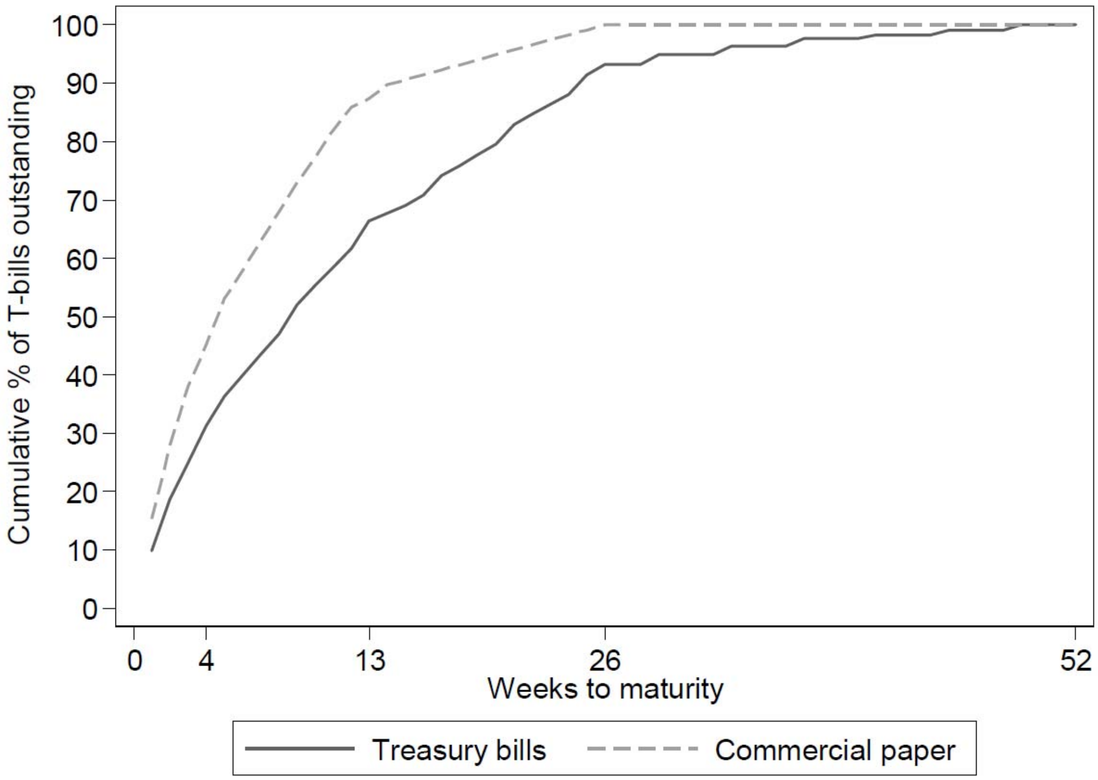


Figure 6
Yields on Treasury Floating Rate Notes

The figure compares the yield at issuance on Treasury Floating Rate Notes (FRNs) with the yield on 3-month Treasury bills. The Treasury first began issuing FRNs in January 2014. FRN issues are marked with squares on the chart. Data are from the Federal Reserve and Bloomberg.

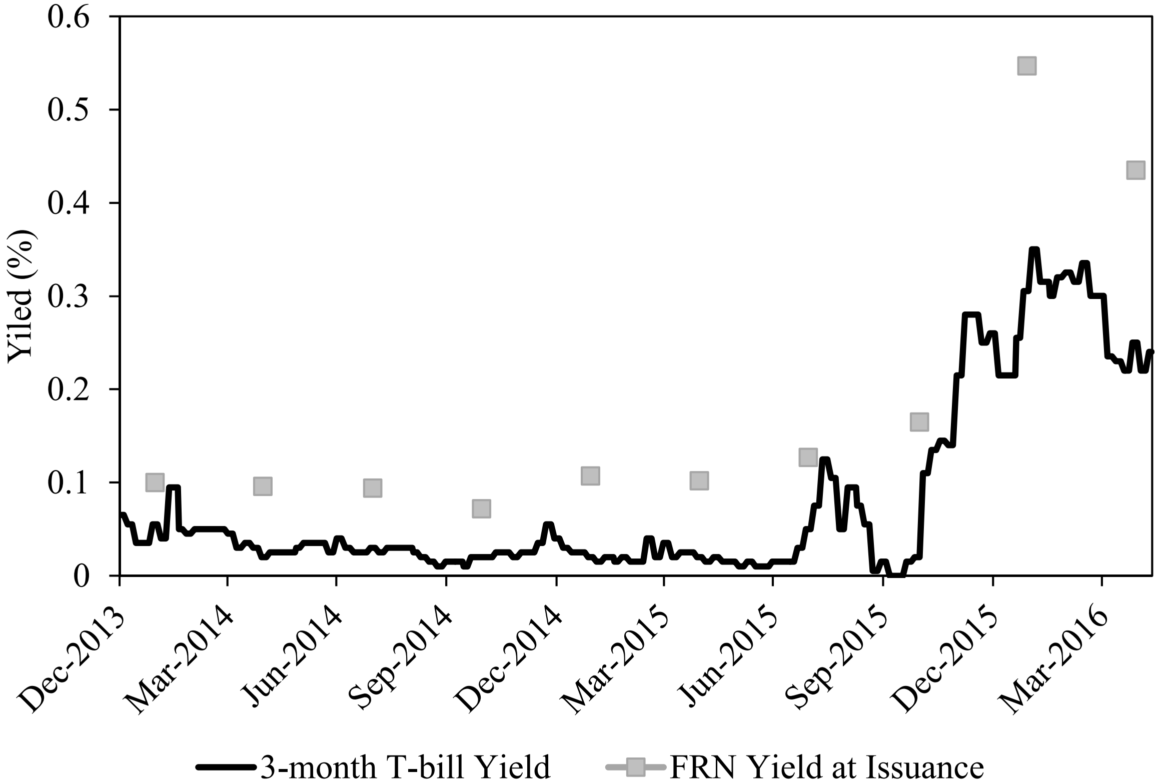


Figure 7
Government Supply of Money and Money-Like Claims

This figure plots the government supply of money and short-term, money-like debt claims as a fraction of GDP on a quarterly basis from 2003Q4 to 2015Q4. Data on currency in circulation and reserves held by depository institutions are from Table 5 of the H.4.1 Release. To smooth over the large seasonal swings in the mix between RRP and reserves, we take quarterly averages of the weekly quantities. Data on outstanding Treasury bills are quarterly averages of month-end quantities, net of month-end Federal Reserve holdings. Data on outstanding volumes for the overnight reverse repurchase agreement (ON RRP) program are available from the Federal Reserve Bank of New York; we plot quarterly averages of daily outstanding volumes in order to smooth out the large quarter-end spikes.

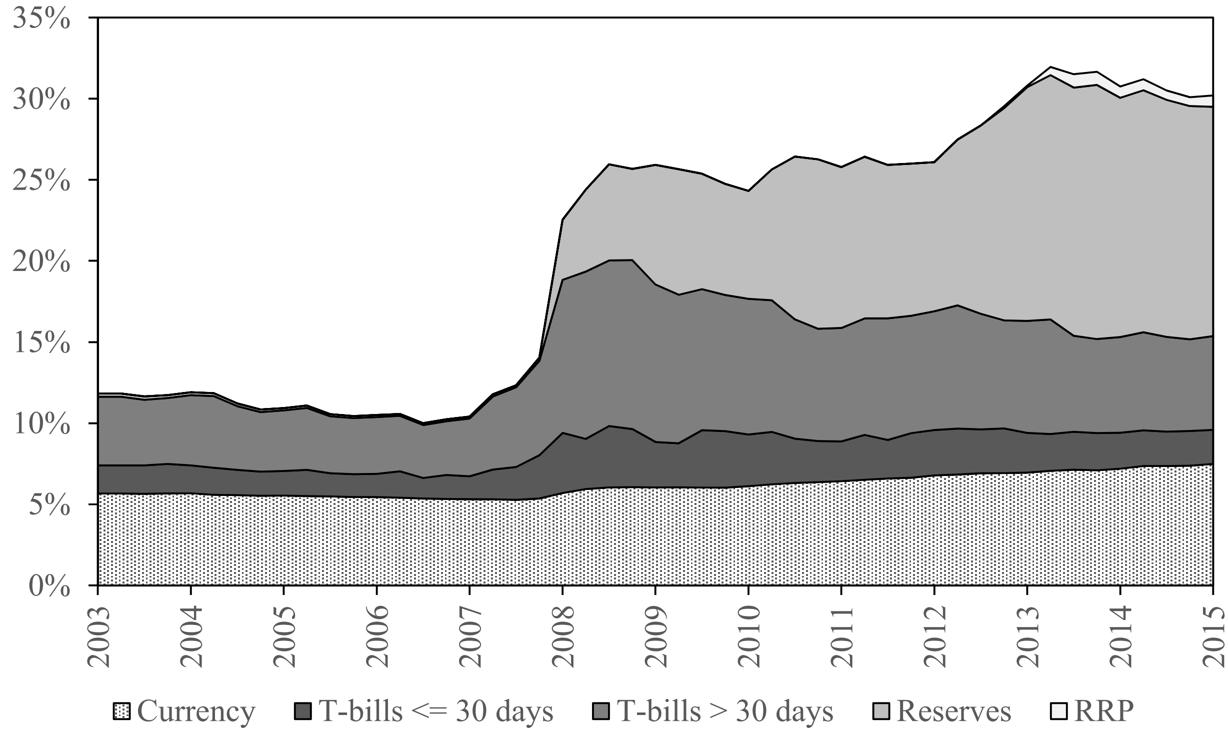
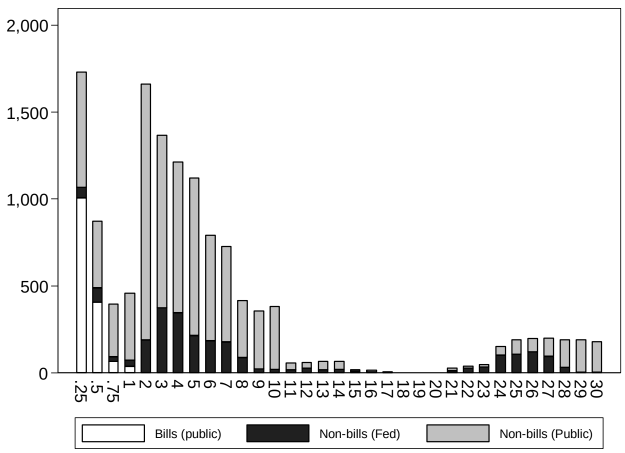


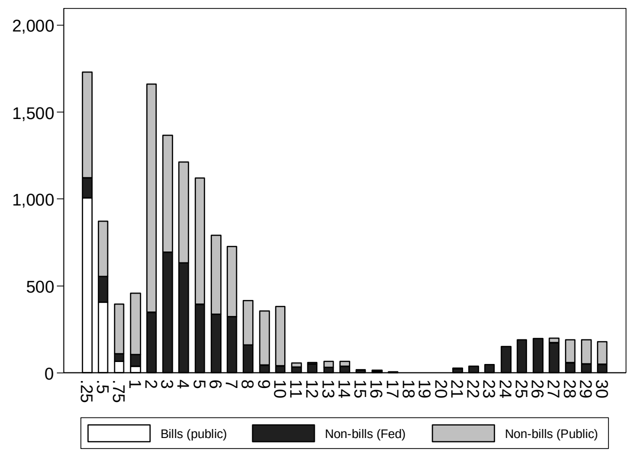
Figure 8
Marketable Treasury Debt under Different Federal Reserve Balance Sheet Scenarios

This figure provides a breakdown of marketable Treasury debt as of December 31, 2015 under different Federal Reserve balance sheet scenarios described in the text. Data are based on CRSP and Bloomberg. Since our attention is on the duration exposure of the Fed's portfolio, we classify FRNs based on their next quarterly interest rate reset even though they have an initial contractual maturity of two years. Panel A shows the Fed's actual Treasury holdings at year-end 2015 when the Fed held \$2.5 trillion in Treasuries. Panel B assumes that the Fed reinvests its roughly \$2 trillion of MBS holdings in Treasuries, bringing its Treasury holdings to \$4.5 trillion and maintaining the current maturity structure of its holdings. In Panel C, we assume that the Fed holds \$4.5 trillion of Treasury notes and bonds (holding no T-bills), with each bond or note held in proportion to total outstanding. In Panel D, we assume that the Fed holds \$4.5 trillion of Treasury notes and bonds but no T-bills, with maturities less than or equal to five years, in proportion to outstanding. For each scenario, we separately mark T-bills, non-bills held by the Fed, and non-bills held by the public.

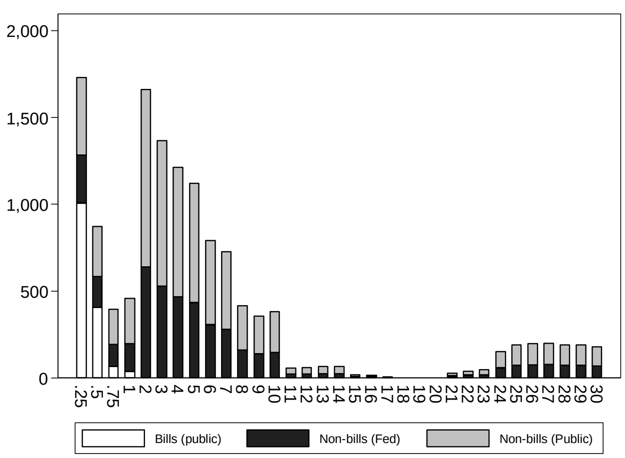
Panel A: Status Quo
\$2.5 trillion Treasury holdings
Fed portfolio WAM = 8.6 years



Panel B: Use MBS proceeds to expand
Treasury holdings to \$4.5 trillion
Fed portfolio WAM = 8.7 years



Panel C: \$4.5 trillion portfolio that holds all Treasuries
in proportion to total outstanding
Fed portfolio WAM = 6.4 years



Panel D: \$4.5 trillion portfolio that holds Treasuries maturing
in ≤ 5 years in proportion to outstanding
Fed portfolio WAM = 2.2

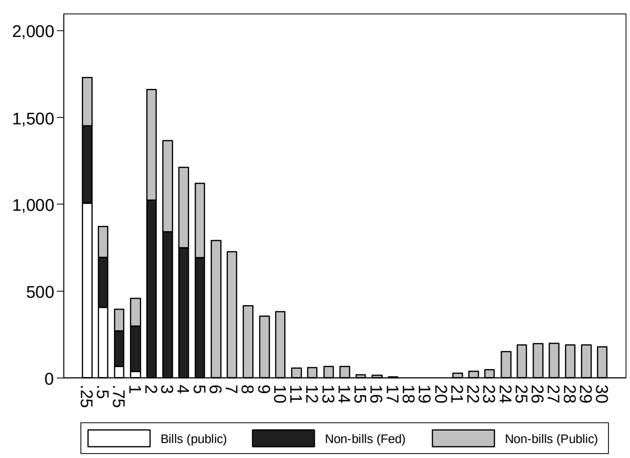
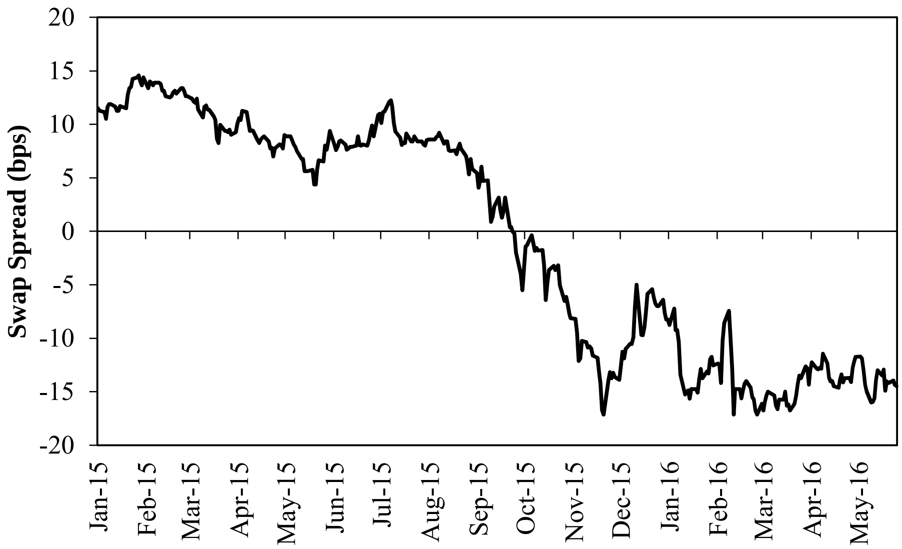


Figure 9
Selected Market Spreads

Panel A shows the 10-year swap-minus-Treasury spread. Panel B plots total repurchase agreements outstanding alongside the GCF-Triparty spread. Data are from Bloomberg, DTCC, and theNew York Fed Primary Dealer Survey.

Panel A: Swap Spread



Panel B: Repo Outstanding and the GCF-Triparty Repo Spread

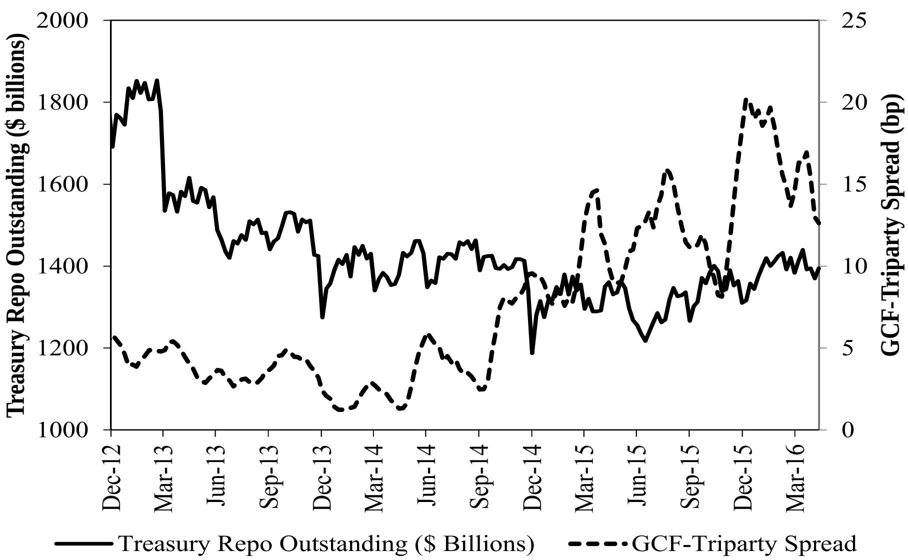


Figure 10
Growth of Money-like Claims and the Level of Short-term Nominal Interest Rates

The figure plots 4-quarter log changes in the ratio of shadow banking money-like claims—the sum of money market shares and other short-term safe private debt (open market paper, repurchase agreements, and foreign deposits)—to total money-like claims, which are the sum of shadow banking claims, Treasury bills, and checking deposits. The figure shows the actual 4-quarter changes from 1990Q1 to 2015QQ as well as the fitted change from estimating the specification shown in column (7) of Panel C of Table V:

$$\Delta_4 \log\left(\frac{SHAD_t}{TOT_t}\right) = \underset{(t\,=\,-4.86)}{-0.04} + \underset{(t\,=\,3.59)}{3.27} \cdot (r_t - r_{t-4}) + \underset{(t\,=\,4.03)}{1.69} \cdot r_{t-4}, \qquad R^2 = 0.49.$$

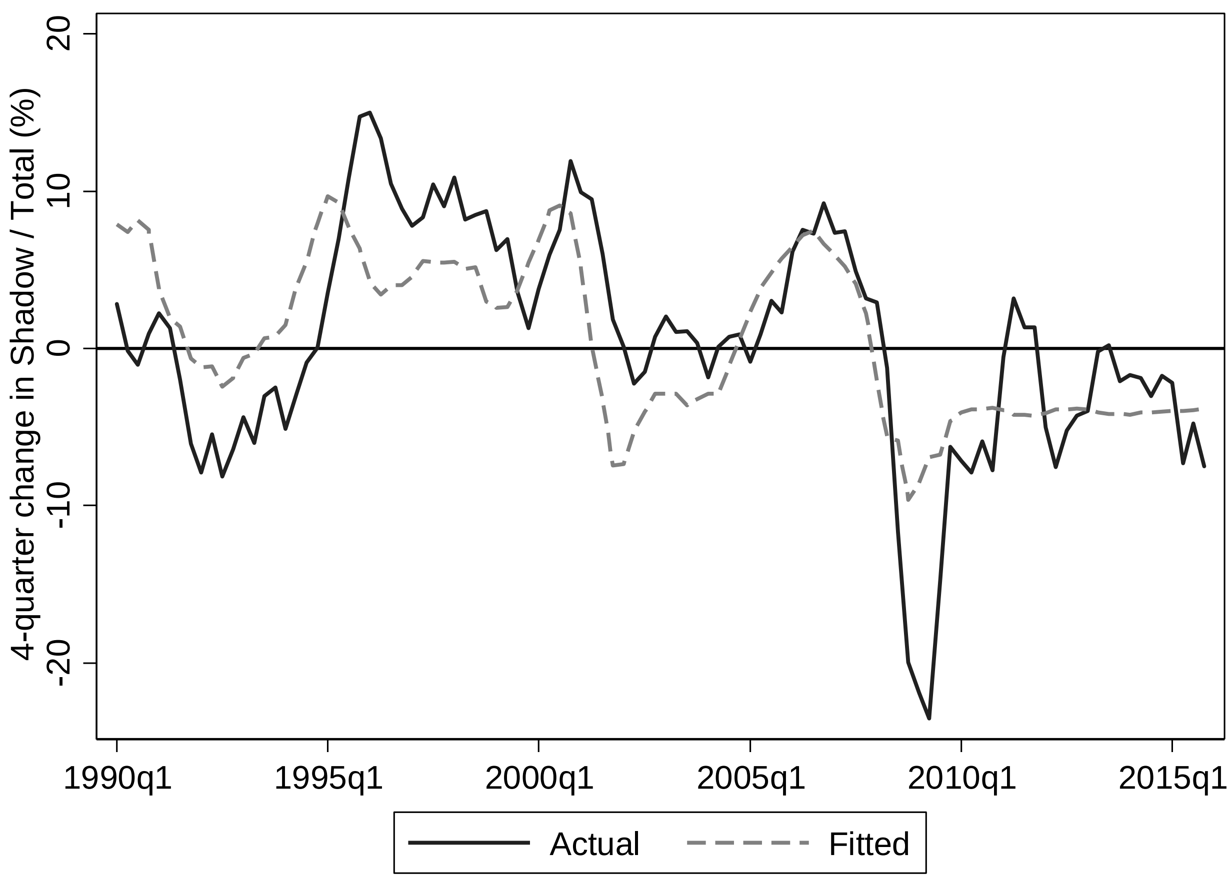


Table I
The Money Premium on T-bills and the Supply of T-bills, 1983 to 2009

The table reports weekly regressions of z-spreads on the supply on T-bills scaled by GDP. The n-week z-spread $z_t^{(n)} = y_t^{(n)} - \hat{y}_t^{(n)}$ is the difference between the actual yield on an n-week T-bill and the n-week fitted yield, based on the fitted Treasury yield curve in Gürkaynak, Sack, and Wright (2007). We estimate this specification in both levels and four-week differences:

$$z_t^{(n)} = a^{(n)} + b^{(n)} \cdot (BILLS / GDP)_t + c^{(n)} \cdot t + \varepsilon_t^{(n)} \text{ and } \Delta_4 z_t^{(n)} = a^{(n)} + b^{(n)} \cdot \Delta_4 (BILLS / GDP)_t + \varepsilon_t^{(n)} .$$

To compute the ratio of T-bills to GDP at the end of each week, we use data on the size and timing of Treasury auctions from http://www.treasurydirect.gov/. The units of the dependent variable are basis points and the units of the independent variables are percentage points. t-statistics are shown in brackets. For the levels regressions in columns (1) to (3), we compute standard errors assuming that the residuals follow an AR(1) process. For the changes regressions in columns (4) to (6), we compute Newey-West (1987) standard errors, allowing for serial correlation up to eight weeks. Additional related results are shown in Table I of Greenwood, Hanson and Stein (2015).

	Levels			Four-week Changes		
	2-week z	4-week z	10-week z	2-week z	4-week z	10-week z
	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A: 1983 to 2009 (N = 1,408)			
$b^{(n)}$	5.78	4.17	1.96	15.75	7.59	0.65
[t]	[2.30]	[1.74]	[1.19]	[1.55]	[1.20]	[0.22]
$c^{(n)}$	28.06	33.62	-13.13			
[t]	[3.36]	[3.66]	[-2.20]			
R^2	0.05	0.08	0.06	0.01	0.00	0.00
			Panel B: 1983 to 2007 (N = 1,303)			
$b^{(n)}$	16.73	13.80	6.21	34.89	20.29	7.41
[t]	[7.73]	[7.17]	[6.59]	[6.35]	[5.04]	[3.67]
$c^{(n)}$	60.22	61.52	2.62			
[t]	[7.49]	[7.58]	[0.61]			
R^2	0.11	0.17	0.15	0.03	0.02	0.02

Table II
Financial Commercial Paper and the Supply of Short-Term Treasuries

The table reports regressions of financial commercial paper supply on the supply on T-bills scaled by GDP: $(FINCP/GDP)_t = a + b \cdot (BILLS/GDP)_t + c \cdot t + u_t$ and $\Delta_k (FINCP/GDP)_t = a + b \cdot \Delta_k (BILLS/GDP)_t + \Delta_k u_t$. Weekly data on outstanding unsecured financial commercial paper are available from the Federal Reserve starting in 2001, monthly data are available from the Federal Reserve starting in 1992, and quarterly data are available from Table 209 of the Financial Accounts of the United States starting in 1952. (To maintain comparability with the recent weekly and monthly data, we use open market paper issued by "financial businesses" less open market paper issued by "ABS issuers" in Table 209.) Data on T-bills outstanding are constructed using data on Treasury auctions and from the Monthly Statement of the Public Debt. We include marketable Treasury certificates (interest-bearing issues with original maturities less than one year) that the Treasury issued until 1967 in our T-bills measure. *t*-statistics are shown in brackets. For the levels regressions, we compute standard errors assuming that the residuals follow an AR(1) process. For the changes regressions, we compute Newey-West (1987) standard errors. For each specification, the table lists the number of lags used in computing Newey-West standard errors. Panel A shows results for samples ending in 2009; Panel B shows results for samples ending in 2007. Additional related results are in Table II of Greenwood, Hanson and Stein (2015).

	Weekly (2001+)		Monthly (1992+)				Quarterly (1952+)	
	Levels	4-week Changes	Levels	1-mo Changes	3-mo Changes	12-mo Changes	Levels	4-qtr Changes
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Samples ending in 2009								
b	-0.174	-0.139	-0.165	-0.060	-0.115	-0.210	-0.116	-0.087
[*t*]	[-2.79]	[-3.21]	[-2.20]	[-1.39]	[-6.43]	[-5.34]	[-0.14]	[-3.22]
c	0.197		-0.018				0.051	
[*t*]	[0.35]		[-3.12]				[1.84]	
N	469	465	214	213	211	202	232	228
SEs	AR1	NW 8	AR1	NW 0	NW 6	NW 24	AR1	NW 8
R^2	0.42	0.14	0.56	0.03	0.12	0.45	0.74	0.11
Panel B: Samples ending in 2007								
b	-0.592	-0.082	-0.528	-0.043	-0.081	-0.527	0.017	-0.073
[*t*]	[-7.18]	[-2.28]	[-6.07]	[-1.24]	[-1.56]	[-8.32]	[0.13]	[-1.98]
c	-0.549		-0.032				0.055	
[*t*]	[-2.51]		[-6.90]				[2.03]	
N	364	360	190	189	187	178	224	220
SEs	AR1	NW 8	AR1	NW 0	NW 6	NW 24	AR1	NW 8
R^2	0.70	0.04	0.72	0.01	0.02	0.54	0.78	0.06

Table III
Long-run Volatility of Consolidated Federal Interest Expense and Federal Reserve Remittances under Different Fed Balance Sheet Profiles

The table presents estimates of how different configurations of the Fed's balance sheet might impact long-run fiscal risk. The consolidated federal interest expense is defined as the interest on Treasury debt minus the net interest income the Federal Reserve remits to the Treasury. The Federal Reserve's remittances are defined as the interest income the Fed earns on its assets minus the interest that it pays on interest-bearing liabilities. In this table, we assume total Treasury debt of $13 trillion with a weighted average maturity 5.75 years; we assume non-interest bearing currency in circulation of $1.5 trillion. To compute our long-run volatility measures, we simulate the term structure of interest rates using 100,000 years of monthly term structure data, compute the consolidated federal interest expense and remittances using equations (3), (4), and (5), and then take the standard deviation of these series. Term structure data is based on simulations of the model in Greenwood, Hanson, and Vayanos (2015) (GHV). We simulate paths of interest rates using the parameters that GHV list in Table 1of their paper. Their key parameters are chosen to match the time-series volatility and persistence of nominal short rates from 1961 to 2015. Our simulation methodology and the GHV model are described in the Internet Appendix. The table reports long-run volatilities both in $ billion and as a percentage of the $13 trillion debt (for the consolidated interest expense) and as a percentage of Fed assets (for Fed remittances).

	Volatility of Consolidated Federal Interest Expense			Volatility of Federal Reserve Remittances		
	WAM_{FED} = 2.2 yrs	WAM_{FED} = 6.4 yrs	WAM_{FED} = 8.7 yrs	WAM_{FED} = 2.2 yrs	WAM_{FED} = 6.4 yrs	WAM_{FED} = 8.7 yrs
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: $4.5 trillion Fed balance sheet (financed with 1/3 non-interest bearing currency, 2/3 interest bearing reserves)					
St Dev (% of Treasury debt or % of Fed assets)	1.09%	1.42%	1.54%	1.28%	1.87%	2.00%
St Dev ($ billion)	$ 141.2	$ 185.0	$ 200.1	$ 57.4	$ 84.3	$ 90.1
	Panel B: $3.0 trillion Fed balance sheet (financed with 1/2 non-interest bearing currency, 1/2 interest bearing reserves)					
St Dev (% of Treasury debt or % of Fed assets)	1.01%	1.20%	1.29%	1.23%	1.40%	1.48%
St Dev ($ billion)	$ 130.8	$ 156.5	$ 167.1	$ 37.0	$ 42.0	$ 44.5
	Panel C: $1.5 trillion Fed balance sheet (financed with 100% non-interest bearing currency)					
St Dev (% of Treasury debt or % of Fed assets)	0.97%	1.05%	1.09%	2.24%	1.05%	0.76%
St Dev ($ billion)	$ 126.4	$ 136.4	$ 141.7	$ 33.6	$ 15.8	$ 11.4

Table IV
Federal Reserve Balance Sheet as of 2015Q4

This table presents data on the Fed's Balance sheet as 2015Q4. To smooth over the large seasonal swings in the mix between RRP and reserves, we take quarterly averages of the weekly quantities from Table 5 of the H.4.1 Release, "Factors Affecting Reserve Balances." For the overnight RRP facility, we take quarterly averages of the daily outstanding amount based on data from the Federal Reserve Bank of New York available at https://www.newyorkfed.org/ markets/omo/dmm/temp/file/Reverse Repo Data by Counterparty Type.xlsx.

Assets ($ billion)		Liabilities ($ billion)	
Treasury Securities	2,462	Currency (Federal Reserve Notes)	1,361
GSE debt and GSE-backed MBS	1,782	Depository institution reserves	2,566
Other Assets	245	ON RRP Facility	127
		Other Liabilities and Capital	435
TOTAL	4,489	TOTAL	4,489

Table V
Growth of Money-like Claims and the Nominal Interest Rate.

This table reports quarterly time-series regressions relating 4-quarter growth in short-term, safe, and liquid claims to 4-quarter changes in the Federal funds rates and the 4-quarter lagged level of the Federal funds rate:

$$\Delta_4 \log(Q_t) = a + b \cdot (r_t - r_{t-4}) + c \cdot r_{t-4} + \varepsilon_t$$

where r_t denotes the average federal funds effective rate during the quarter. Columns (1) to (5) examine percentage changes in quantities (expressed as percentage of GDP) of money-like claims. The series in column (1) to (5) are shown in Panel A of Figure 1. Column (1) shows total money-like claims, column (2) shows checkable deposits, column (3) shows Treasury bills, column (4) shows other money-like claims (open market paper, repurchase agreements, and foreign deposits), and column (5) shows money market fund shares. Columns (6) and (7) show the changes in shadow money claims relative to private money-like claims (all claims except Treasury bills) and total money-like claims. *t*-statistics are based on Newey-West (1987) standard errors, allowing for serial correlation at up to 8 quarterly leads and lags.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Changes in Quantities of Money-Like Claims					*Relative* Changes in Shadow Money Claims	
	$\Delta_4\log\left(\frac{TOT_t}{GDP_t}\right)$	$\Delta_4\log\left(\frac{CHECK_t}{GDP_t}\right)$	$\Delta_4\log\left(\frac{TBILL_t}{GDP_t}\right)$	$\Delta_4\log\left(\frac{OTH_t}{GDP_t}\right)$	$\Delta_4\log\left(\frac{MMF_t}{GDP_t}\right)$	$\Delta_4\log\left(\frac{SHAD_t}{PRIV_t}\right)$	$\Delta_4\log\left(\frac{SHAD_t}{TOT_t}\right)$
	Panel A: Full Sample 1960Q1 – 2015Q4						
$r_t - r_{t-4}$	-0.239	-1.522	-1.642	3.582	3.616	3.974	4.242
	(-0.84)	(-3.15)	(-1.69)	(2.28)	(0.93)	(4.69)	(4.71)
r_{t-4}	0.319	-0.570	0.466	-0.130	4.573	1.006	0.973
	(2.41)	(-2.13)	(1.13)	(-0.19)	(3.29)	(3.55)	(3.33)
T	224	224	224	224	164	224	224
R^2	0.10	0.22	0.09	0.21	0.22	0.38	0.39
	Panel B: 1960Q1 – 1989Q4						
$r_t - r_{t-4}$	0.316	-0.684	-0.003	2.879	4.595	3.952	4.046
	(1.16)	(-3.12)	(-0.01)	(1.56)	(0.83)	(3.61)	(3.50)
r_{t-4}	0.716	0.150	0.919	-1.057	5.124	0.088	0.039
	(6.81)	(1.46)	(2.29)	(-1.33)	(2.47)	(0.18)	(0.07)
T	120	120	120	120	60	120	120
R^2	0.31	0.25	0.09	0.26	0.08	0.37	0.37
	Panel C: 1990Q1 – 2015Q4						
$r_t - r_{t-4}$	-0.991	-4.194	-6.144	4.445	0.648	2.426	3.266
	(-2.04)	(-3.71)	(-2.18)	(1.54)	(0.51)	(4.08)	(3.59)
r_{t-4}	0.360	-2.123	0.250	0.708	2.958	1.697	1.693
	(1.18)	(-5.34)	(0.26)	(0.75)	(4.24)	(5.06)	(4.03)
T	104	104	104	104	104	104	104
R^2	0.22	0.50	0.32	0.17	0.41	0.55	0.49