
When a central bank expands its balance sheet by purchasing securities or making loans, it generates a corresponding increase in bank deposits at the central bank (a/k/a “reserves”). Those reserves, which are bank assets, cannot be created or destroyed by subsequent transactions between banks or between a bank and a non-bank. A bank’s leverage ratio is the ratio of its capital to its total assets, without weighting the assets for risks. Holding capital and all other bank assets equal, an increase in reserves therefore must reduce the leverage ratio of the banking system as a whole, and of each bank that receives them.

If a bank wishes to avoid a decrease in its leverage ratio or a capital raise, it must shed other assets (such as loans to businesses and households). Collectively, if a sufficient number of banks take such action, such a reduction in bank credit could reduce economic activity and reduce or even reverse the economic stimulus intended by the central bank when increasing its balance sheet. The problem is particularly acute for quantitative easing programs such as those conducted by the Bank of Japan, the Federal Reserve, and the European Central Bank because of the massive amount of reserves created.

Indeed, the Bank of England was sufficiently concerned that pressure on leverage requirements would undercut lending programs through which it was attempting to provide stimulus that it decided to exclude reserves from the denominator of its leverage ratio. As the BoE explained in its July 2016 financial stability report, “In circumstances where central bank balance sheets expand (for example, through increased use of liquidity facilities), regulatory leverage requirements can effectively tighten.” Similarly, a 2015 report on the impact of Basel II on monetary policy issued by the BIS’s Committee on the Global Financial System raised concerns that leverage ratio pressures could prevent banks from even participating in central bank operations –

In particular, the question is whether there are exceptional situations in which banks would refrain from subscribing to fund-supplying operations because concerns over the LR impact of the reserves that would be added to the banking system in aggregate outweigh the financial benefits accrued by participating in the operations. If so, this lack of participation could prevent a central bank whose operating framework entailed increasing the quantity of reserves from meeting its operating target.

While these concerns make intuitive sense, in another way they run contrary to the core Neo-Keynesian explanation for how monetary policy works. As described in Brainard and Tobin (1968) and Tobin (1969), interest rates fall when central banks add reserves because asset prices must adjust to make the banks willing to hold the reserves voluntarily. In particular, loan rates must fall. If leverage ratios make banks dislike holding reserves even more, loan rates must fall further.

That said, the Brainard-Tobin and Tobin analysis only consider a situation where central banks do not pay interest on reserve balances. In the current situation in the United States, the Federal Reserve raises and lowers interest rates by adjusting the interest rate it pays on excess reserves. The reduction in the ability of the central bank to lower rates considered in this note is only relevant when the central bank has lowered the interest it pays on excess reserves to its lower bound and is seeking to reduce other market interest rates through quantitative easing.
Unless the large majority of banks in the banking system are, in fact, bound by the leverage ratio, then the Brainard-Tobin intuition would seem the dominant one. As reserves go up, banks are increasingly eager to shed reserves, but in the equilibrium where they hold the reserves voluntarily, the interest rates on other bank assets, including bank loans, must fall by even more than they would without a leverage ratio requirement. If so, excluding reserves from the leverage ratio could make monetary policy less effective, in terms of the decline in interest rates associated with a given increase in reserves, than it would be if reserves were not excluded.

In this note, we present a simple model of banks, households, and the Fed that we then simulate. We use simulations to explore how interest rates and balance sheets behave when the Fed increases reserves and banks face balance sheet costs. To model the impact of a leverage ratio requirement, we simulate a situation in which those costs depend on total bank assets and another in which they depend on total bank assets minus reserves.

Our results indicate that, at least for this stylized model, both intuitions are correct. In the base case in which reserve balances increase, all interest rates decline and loans decline. When reserves are excluded from the leverage ratio, both interest rates and loans decline by less. In another case in which loans increase when reserves are added, excluding reserves from the leverage ratio again results in a lesser decline in interest rates, but in this case, loans increase by more. In general, excluding reserves from the leverage ratio lessens the tendency for QE to reduce credit availability, but it also dampens the interest rate reduction caused by QE.

A SIMPLE MODEL OF THE ECONOMY

The model has three participants, a bank, a household, and the Fed. The bank holds reserves $R$, Treasuries $T^B$, and loans $L$ as assets and its only liability is deposits $D$. There is no equity (as discussed below, adding equity would just add complexity without changing the analysis). The household holds Treasuries $T^H$ and deposits as assets funded with wealth $W$ and bank loans. The Fed holds Treasuries $T^F$ as assets and reserves as a liability. The total supply of Treasuries is fixed at $T$.

$Y^i$ is the bank’s demand for asset or liability item $i$. $X^i$ is the household’s demand for asset or liability item $i$. The interest rate on each liability and asset item $i$ is $r^i$. The spread of that interest rate over the interest rate the Fed pays on reserves is $s^i$. The Fed picks $T$, $R$, and $r^R$. The interest rate should be thought of as having been adjusted for risk as well as any addition services (such as payment services) provided by the financial instrument.

In the baseline case, the model is parameterized so that the following balance sheets are an equilibrium when all interest rates are equal.

<table>
<thead>
<tr>
<th><strong>Federal Reserve</strong></th>
<th><strong>Household</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assets</strong></td>
<td><strong>Liabilities</strong></td>
</tr>
<tr>
<td>Treasuries $100$</td>
<td>Reserves $100$</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Banks</strong></td>
<td><strong>Deposits $300$</strong></td>
</tr>
<tr>
<td><strong>Assets</strong></td>
<td><strong>Liabilities</strong></td>
</tr>
<tr>
<td>Reserves $100$</td>
<td>Deposits $300$</td>
</tr>
<tr>
<td>Loans $100$</td>
<td></td>
</tr>
<tr>
<td>Treasuries $100$</td>
<td></td>
</tr>
</tbody>
</table>

We assume that the bank’s demand for deposits increases in the spread between what the bank can earn on its assets, on average, and what it has to pay to get deposits. Hence the bank picks deposits to satisfy

\[
\log(Y^D) = (b_0 + b_D ((r^L + r^T + r^R)/3 - r^D))
\]

(1)
We set the bank’s starting demand for deposits (i.e., size) to $300, so we choose $b_0$ such that $Y^D = e^{b_0} = 300$. The bank’s sensitivity to the interest rate spread is determined by $b_D$, which we set to 5 in the base case. If a bank’s assets and liabilities offer a net interest margin that is 1 percentage point above zero, the bank would choose to be 5 percent bigger than its preferred size of $e^{b_0}$.

The bank divides the funds it raises as deposits between loans, Treasuries, and reserves. It prefers to have equal amounts of each ($Y^L = Y^T = Y^R = \frac{1}{3} D$), but it increases and decreases the shares of loans and Treasuries depending on the relative interest rates.

\[
Y^L = \left( \frac{1}{3} + b_L \left( r^L - \frac{r^T + r^R}{2} \right) \right) D \quad (2)
\]

\[
Y^T = \left( \frac{1}{3} + b_T \left( r^T - \frac{r^L + r^R}{2} \right) \right) D \quad (3)
\]

We set $b_L$ and $b_T$ equal to 5. If, for example, the interest rate on loans is 1 percentage point higher than the average yield on other bank assets, the bank sets the loan share of its balance sheets 5 percentage points above one third (so 0.38 instead of 0.33).

The bank’s demand for reserves is then what remains after subtracting the bank’s loans and treasuries from its deposits.

\[
Y^R = D - L - T^B \quad (4)
\]

Clearly, if interest rates are equal then the bank will also choose to hold one-third of its deposits as reserves.

The household adjusts its demand for loans in response to the difference between the average yield on the assets in which it can invest and the interest rate it pays on loans.

\[
\log(X^L) = \left( a_0 + a_L \left( \frac{r^D + r^T}{2} - r^L \right) \right) \quad (5)
\]

We set we set $a_0$ such that $X^L = e^{a_0} = 100$ so that in the baseline state the household borrows $100. Similar to the calibration of the equation for bank demand for deposits, we set $a_L$ to 5.

The household divides its wealth and loans between deposits and Treasuries. When all interest rates are equal it chooses to have equal amounts of each but it increases and decreases the shares depending on the relative interest rates. Specifically, the household chooses the share of its portfolio to invest in Treasury securities according to:

\[
X^T = \left( \frac{1}{2} + a_T (r^T - r^D) \right) (W + L) \quad (6)
\]

Note that when the interest rates on deposits and Treasuries are equal, the bank chooses to invest half its funds in Treasury securities. As for the bank equation, we set $a_T$ equal to 5.

Using the household balance sheet equation to solve for deposits yields

\[
X^D = W + L - T^H \quad (7)
\]

Note that equation (6) and (7) indicate that the household will choose to invest half its resources in deposits if the deposit and Treasury rates are equal.
Each of the equations is unchanged if all the interest rates are increased or decreased by the same amount. Consequently, each can be rewritten in terms of spreads over the interest rate the Fed pays on reserves.

\[
\log(Y^D) = \left( b_0 + b_D \left( \frac{s_L + s_T}{3} - s_D \right) \right) \quad (8)
\]

\[
Y^L = \left( \frac{1}{3} + b_L \left( s_L - \frac{s_T}{2} \right) \right) D \quad (9)
\]

\[
Y^T = \left( \frac{1}{3} + b_T \left( s_T - \frac{s_L}{2} \right) \right) D \quad (10)
\]

\[
\log(X^L) = \left( a_0 + a_L \left( \frac{s_D + s_T}{2} - s_L \right) \right) \quad (11)
\]

\[
X^T = \left( \frac{1}{2} + a_T (s_T - s_D) \right) (W + L) \quad (12)
\]

The Fed’s balance sheet identity is

\[
T^F = R \quad (13)
\]

And the fixed total quantity of Treasury securities is

\[
T = T^F + T^B + T^H \quad (14)
\]

Equations 4, 7, 13, and 14 imply that wealth and the total supply of Treasuries must be equal (and equal $500).

As described above, we have chosen \(b_0, a_0, R, \text{and } T\) so that, when all the spreads equal zero, deposits equal $300, loans equal $100, reserves equal $100, bank holdings of Treasuries equal $100, and household holdings of Treasuries equal $300.

In order to consider how different leverage ratio requirements change the effect of the central bank increasing the size of its balance sheet, we include an additional term that reduces the bank’s demand for leverage (that is, deposits) as the bank gets bigger. Put another way, the bank requires a larger profit inducement to be bigger than $300 than when the leverage ratio term is included than without the leverage requirement. We are assuming that the banking industry as a whole is not at a corner solution and so can get bigger.

\[
\log(Y^D) = \left( b_0 + b_D \left( \frac{s_L + s_T}{3} - s_D \right) \right) - b_C (\log(L + T^B + R) - \log 300) \quad (15)
\]

There is no equity in the model, but if there were and it were assumed to be constant, it would enter positively and negatively in the second term of equation (15) and drop out. That is, if equity is \(E\), then the “leverage” term in equation 15 can be written

\[
b_C \left( \log \left( \frac{E}{L + T^B + R} \right) - \log \left( \frac{E}{300} \right) \right) = b_C (\log(E) - \log(L + T^B + R) - \log(E) - \log(300)) \quad (16)
\]

and the \(\log(E)\) terms cancel. Intuitively, if equity is constant, then changes in the leverage ratio are perfectly explained by changes in assets.

Equation (15) indicates that a bank would be indifferent about a project that raises its net interest margin by \(b_C/b_D\) percent and increases its asset size by 1 percent. If equity is one tenth of assets, then a 1 percent increase in assets
reduces the leverage ratio by 10 basis points. If a bank would be willing to accept a 10 bp reduction in its leverage ratio for a 10 bp increase in its net interest margin, then \( b_C \) should be one-tenth of \( b_D \).\footnote{In the case where nothing is excluded from the denominator of the leverage ratio, equation (15) can be written \( \log(Y_D) = \log \frac{b_D}{(1 + b_C)}(s^L + s^T) - s^D \). The larger the coefficient on the leverage ratio \( b_C \), the less the bank chooses to borrow for any given net interest margin.}

When we exclude reserves from the leverage ratio, and when we exclude both reserves and Treasuries, we modify (15) accordingly by reducing \$300" to \$200" and \$100," respectively, thus holding the stringency of the requirement constant.

Lastly, we set supply and demand equal and derive three equations that depend only on the interest rate spreads on loans, Treasuries, and deposits.

First, banks must be willing to hold reserve balances in the amount the Fed provides

\[
R = Y^D - Y^L - Y^T. \tag{17}
\]

Second, deposit supply and deposit demand have to be equal

\[
Y^D = W + X^L - X^T. \tag{18}
\]

And third, loan supply has to equal loan demand

\[
Y^L = X^L. \tag{19}
\]

We then solve these equations numerically for different choices of the coefficients and different levels of reserves.

RESULTS

We simulate the model with reserves equal to 100 and reserves equal to 200; that is, the Fed buys \$100 in Treasuries, doubling its size. We consider three variants of the leverage ratio: one in which all assets are included, one in which we exclude reserves, and one in which we exclude both reserves and Treasuries. When reserves and Treasuries are both excluded, the situation corresponds to having a risk-weighted capital requirement be the binding constraint. The results are reported in Table 1.

<table>
<thead>
<tr>
<th>Row</th>
<th>Deposits Spread</th>
<th>Loans Spread</th>
<th>Treasuries Spread</th>
<th>Deposits</th>
<th>Loans</th>
<th>Bank Treasuries</th>
<th>Household Treasuries</th>
<th>Reserves</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full Leverage Ratio</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>300</td>
<td>100</td>
<td>100</td>
<td>300</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>-5.7%</td>
<td>-4.4%</td>
<td>-6.8%</td>
<td>326</td>
<td>91</td>
<td>35</td>
<td>265</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>-4.5%</td>
<td>-4.1%</td>
<td>-6.0%</td>
<td>341</td>
<td>94</td>
<td>46</td>
<td>254</td>
<td>200</td>
</tr>
<tr>
<td>4</td>
<td>-5.3%</td>
<td>-4.3%</td>
<td>-6.5%</td>
<td>332</td>
<td>93</td>
<td>39</td>
<td>261</td>
<td>200</td>
</tr>
</tbody>
</table>

Row 1 is the base case in which reserves are \$100. In that case, loan, Treasury, and deposit spreads are all equal to 0. The household borrows \$100 and splits its \$600 in loans and wealth evenly between investments in deposits and Treasuries. The bank splits the \$300 in deposits it receives from households evenly between loans, Treasuries,
and reserves. These are the base case results when reserves equal $100 for every specification of the leverage ratio.

Row 2 provides the results when the central bank purchases an additional $100 in Treasuries, doubling reserves to $200, and the leverage ratio is calculated using all bank assets in the denominator. In that case, as can be seen, all three interest rate spreads decline, with the largest decline in the Treasury spread. Bank loans decline as the bank makes room on its balance sheet for the additional reserves. Household and bank holdings of Treasuries both decline, but the decline is larger for the bank.

The results when reserves are excluded from the leverage ratio are provided in the third row. In this case, the declines in interest rate spreads are reduced. However, loans and bank holdings of Treasuries decline by less because the bank is under less pressure to resist the increase in its balance sheet caused by the growth in reserves.

Lastly, we consider the case when both reserves and Treasuries are excluded from the leverage ratio, essentially converting it into a risk-based capital requirement. In this case, with loans the only asset subject to a capital charge, loans again decline when reserve balances increase, although the decline is less than in the case with the full leverage ratio and only a little more than in the case when only reserves are excluded.

Exhibit 1 shows the balance sheet quantities and interest rate spreads in equilibrium for different levels of reserve balances, all simulated with the full leverage ratio. As can be seen, the results are qualitatively similar regardless of the size of the Treasury acquisition and resulting reserve injection by the Fed. Treasury holdings fall at both banks and households, loans are little changed, and deposits rise. All three interest rate spreads decline, with the Treasury spreads declining the most, loans spreads the least, and deposit spreads in between.
By judiciously choosing the model parameters, we can generate a case where loans actually increase when the central bank adds reserves and purchases Treasuries. In particular, we increase $b_D$, the banks sensitivity to interest rate spreads when choosing how much to hold in deposits, to 10, and we decrease $b_L$ and $b_T$, the bank’s sensitivity to spreads when choosing loans and treasuries, to 1. The household’s coefficients $a_L$ and $a_T$, as well as the coefficient on the leverage ratio, remain unchanged. Intuitively, the bank is more insistent that it maintain a well-diversified portfolio while the household is more willing to hold an unbalanced portfolio. In addition, the bank is more willing to get bigger.

The Case in Which Loans Increase

<table>
<thead>
<tr>
<th>Row</th>
<th>Deposits Spread</th>
<th>Loans Spread</th>
<th>Treasuries Spread</th>
<th>Deposits</th>
<th>Loans</th>
<th>Bank Treasuries</th>
<th>Household Treasuries</th>
<th>Reserves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Leverage Ratio</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
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<td>0%</td>
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<td>0%</td>
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<td>100</td>
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<tr>
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<td>-14.8%</td>
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<td>101</td>
<td>94</td>
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<td>200</td>
</tr>
<tr>
<td>Leverage Ratio Excludes Reserves</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>-14.0%</td>
<td>-16.2%</td>
<td>-17.3%</td>
<td>399</td>
<td>103</td>
<td>97</td>
<td>203</td>
<td>200</td>
</tr>
<tr>
<td>Leverage Ratio Excludes Reserves and Treasuries</td>
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<tr>
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<td>399</td>
<td>103</td>
<td>96</td>
<td>204</td>
<td>200</td>
</tr>
</tbody>
</table>

The results are presented in Table 2. As in the base case, excluding reserves lessens the decline in interest rate spreads when the central bank adds reserves and buys Treasuries, but in this case loans go up by more when reserves are excluded from the leverage ratio. The results illustrate that removing reserves from the leverage ratio doesn’t simply attenuate the impact of QE on the economy, it prevents the crowding out of loans on the bank’s balance sheet that would otherwise occur.
Sensitivity Analysis

Table 3

<table>
<thead>
<tr>
<th>Row</th>
<th>Deposits Spread</th>
<th>Loans Spread</th>
<th>Treasuries Spread</th>
<th>Deposits</th>
<th>Loans</th>
<th>Bank Treasuries</th>
<th>Household Treasuries</th>
<th>Reserves</th>
</tr>
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<tbody>
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<td>0.0%</td>
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<td>100</td>
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<tr>
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<td>Leverage Ratio Coefficient = 1/10</td>
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<td>Bank Loans and Treasuries Coefficients = 10</td>
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<td></td>
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<td>Bank Deposits and Household Loans = 10</td>
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<td>334</td>
<td>90</td>
<td>45</td>
<td>255</td>
<td>200</td>
</tr>
</tbody>
</table>

Table 3 presents the results for different choices of parameters. We have attempted a wide range of different parameterizations, but the results are all qualitatively similar. The first row reproduces the results when reserves are increased under the baseline parameterization and the full leverage ratio. The second row cuts the coefficient on the leverage ratio by half. In the third row, the sensitivity of the bank to interest rate differentials when choosing its portfolio distribution is doubled. In the fourth row, the sensitivity of the household to interest rates when choosing its portfolio is doubled. And in the fifth row, both the household and the bank are more willing to grow by borrowing in response to interest rate differentials. In all cases, the results are roughly the same. While not shown, it remains true that when reserves are excluded from the leverage ratio both interest rate spreads and the quantity of loans decline by less.

CONCLUSION

Overall, the results presented here support the proposition that excluding reserve balances from the leverage ratio would make extraordinary monetary policy actions that expand the central bank balance sheet and therefore the quantity of reserves more effective. While it is true that, in line with the standard Tobin model of monetary policy, excluding reserves would reduce the decline in interest rates that results from the expansion of reserves, such a decline is almost never the objective of the extraordinary policy action. In the United States, for example, the Federal Reserve’s QE programs were designed to lower longer-term interest rates by reducing the amount of longer-term securities in public hands.

The results reported here are merely simulations of a simple model but further investigation is warranted because the issue under consideration is serious. Low and declining levels of the neutral real overnight interest rate \( r^* \) have increased the likely frequency with which central banks will find themselves at the zero lower bound and so needing to use extraordinary policy actions to stimulate the economy. “Extraordinary” actions are not utilized in normal times because their effectiveness is less certain, but the circumstances under which they are utilized are dire.

We note that this research focuses only on the monetary policy effect of excluding reserves from the leverage ratio. There are other costs and benefits that might argue for or against such a policy. For example, such an exclusion might have adverse consequences for the repo market; also, if reserves are deducted and Treasuries are not, there might be an effect on Treasury demand; and if the deduction is offset by a recalibration calculated to return banks to their ex ante ratios and leave the leverage ratio as a binding constraint for at least some banks, then the effect is a de facto capital increase on all other assets, which would also come with costs.
REFERENCES


