The Great Divorce: The Federal Reserve's Move to a Floor System and the Implications for Bank Portfolios

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ABSTRACT

The Federal Reserve (Fed) switched from using a corridor operating system to using a floor operating system in late 2008. By design, a floor system eliminates the opportunity cost to a bank of holding reserves, allowing a central bank to use its balance sheet as an independent tool of monetary policy. Making the demand for bank reserves perfectly elastic is therefore a feature, not a bug, of a floor system. Some observers worry, however, that this feature may adversely affect asset allocation in bank portfolios such that banks underinvest in loans. If this is the case, broader money and credit creation may be less under the Fed's floor system than they would have been otherwise. This paper investigates this possibility by taking a close look at bank portfolios and assessing whether any changes since 2008 can be attributed to the Fed's floor system. The paper does find significant changes in bank portfolio allocations over the past decade and is able to trace much of the shift to the Fed's floor system.

JEL codes: E5

Keywords: IOER, Federal Reserve, floor system, corridor system, bank portfolio

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US monetary policy has undergone a lot of change over the past decade. Some of it was highly publicized, such as the arrival of large-scale asset purchases (LSAPs), the elevated use of forward guidance, and the adoption of an official inflation target. A less publicized change was the move by the Federal Reserve (Fed) from a corridor operating system to a floor operating system, a development made possible by the advent of interest payments on excess reserves (IOER) in late 2008.

This transformation, though often overlooked, may prove to be one of the more important developments in US monetary policy during this time. It has cut the last link between money and monetary policy and, as a result, has fundamentally altered the transmission mechanism of monetary policy.

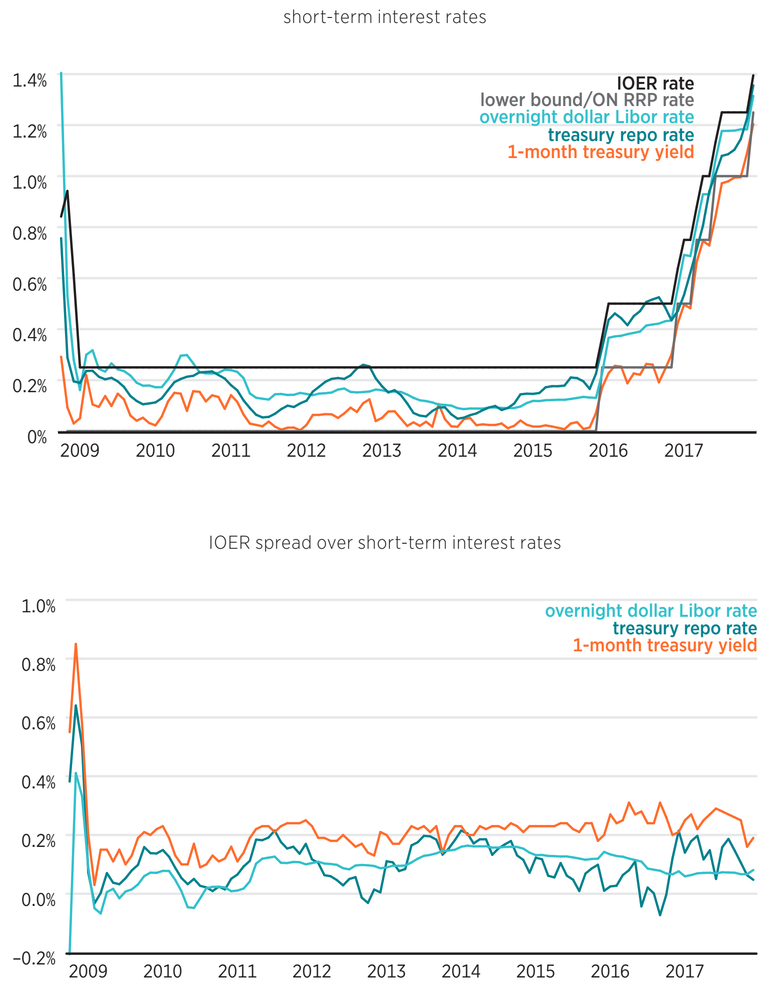
This change has been championed by some observers. They see it as empowering the Fed by giving it an extra, independent tool with which to work: its balance sheet. Others worry that this change has impaired US monetary policy. They see it as removing the one thing, money, that makes monetary policy special. For them, this change amounts to a Great Divorce from money that will reduce the efficacy of Fed policy. Who is right?

CREATING THE DIVORCE

To begin answering this question, recall that the Fed's operating system before the financial crisis was based on the buying and selling of securities in open market operations. The Fed used open market operations to adjust the supply of bank reserves in order to hit an interest rate target.[1] As a result, the supply of bank reserves was closely tied to the stance of monetary policy. This operating system was called a corridor system because there were upper and lower bounds on

1. Technically, the Fed would adjust the supply of reserves in response to changes in demand for them so as to hit a given interest rate target. The supply of reserves, in other words, was endogenous in the short run.

FIGURE 1. SHORT-TERM INTEREST RATES AND SPREADS



Sources: The treasury repo rate is from "Depository Trust & Clearing Corporation," accessed October 25, 2018, http://www.dtcc.com. All other series are from Federal Reserve Bank of St. Louis, Federal Reserve Economic Data (database), accessed October 25, 2018, https://fred.stlouisfed.org.

where short-term interest rates could go. The upper bound was set by the interest rate at which banks could borrow from the Fed, and the lower bound was set by the zero lower bound.[2]

2. If short-term market interest rates were to go above the upper bound, banks could always borrow at the Fed and lend at the higher market interest rate. Arbitrage would therefore bring these interest rates down to the borrowing rate at the Fed. The lower bound would be binding, since banks would

In November 2008, this corridor system came to an abrupt end. In that month US monetary authorities raised the IOER rate above short-term market interest rates and triggered the shift to a floor system.[3] As shown in figure 1, the IOER rate in late 2008 got almost 90 basis points over the 1-month treasury yield, around 60 basis points over the treasury repurchase (repo) rate, and 40 basis points over the overnight dollar Libor rate. Thereafter, the IOER-1-month treasury spread settled down to about 20 basis points on average, and the IOER-treasury repo and IOER-Libor spreads settled to near 10 basis points on average through 2017.

The central idea behind this move was to remove the opportunity cost to banks of holding excess reserves by offering the banks a deposit rate at the Fed—the IOER rate—that was equal to or above short-term market interest rates. This favorable return was to sever banks' incentive to rebalance their portfolios away from excess reserves toward other assets. The IOER rate was also to put a floor under short-term interest rates so as to align them with the Fed's desired interest rate target.[4] Together, these two facets of the floor system would allow the Fed to use its balance sheet as a tool of monetary policy while still maintaining interest rate control.

In this new operating system, the stance of monetary policy was no longer set by a market interest rate but by an administrative interest rate: the IOER rate. The stance of monetary policy also was no longer tied to the supply of reserves. Instead, it was linked to the quantity of reserves demanded by banks, which the Fed influenced through changes to IOER. Specifically, the Fed set the IOER rate high enough that banks' demand for reserves became perfectly elastic with respect to the federal funds rate. As a result, changes in the quantity of reserves supplied led to identical changes in the quantity demanded, other things being equal.

The Federal Reserve, in short, went from an operating system in which monetary policy was transmitted through open market operations to one in

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rather earn 0 percent holding reserves than a negative return from lending. The corridor, however, was asymmetric, because short-term interest rates generally were closer to the upper bound.

3. The IOER rate had been above the 1-month treasury rate in October as well, the month IOER were introduced, but interbank interest rates had risen above the IOER rate that month. Only in November did the IOER rate rise above interbank rates. So, defining a floor system as a system in which the opportunity cost of holding reserves is eliminated, the floor system only began in November. (This is the definition used in Marvin Goodfriend, "Interest on Reserves and Monetary Policy," *Federal Reserve Bank of New York Economic Policy Review*, May 2002; and in Todd Keister, Antoine Martin, and James McAndrews, "Divorcing Money from Monetary Policy," *Federal Reserve Bank of New York Economic Policy Review*, September 2008.)

4. If short-term interest rates were to fall below the IOER rate, then banks could borrow at those lower yields and park the funds at the Fed. Arbitrage, then, should in theory cause short-term interest rates to converge to the IOER rate.

which it is transmitted through the IOER rate. The Fed's operating system changed from one in which money, in the form of reserves, mattered for monetary policy to one in which money has been "divorced" from monetary policy (a term coined by Keister and his coauthors).[5]

A FRAGILE DIVORCE

This divorce from money is seen by many observers as the key advantage of the floor system, because it gives the Fed the freedom to use its balance sheet independently of its desired interest rate target.[6] The Fed, for example, can now sharply increase the supply of reserves in response to a liquidity crisis without causing a decline in its targeted interest rate.

Others, however, see this divorce as creating an operating system that impairs the transmission mechanism of monetary policy. It impairs the transmission mechanism because the Fed has an incentive to set the IOER rate above short-term interest rates, owing to the fragility of its floor system. Creating this interest rate spread, however, may spawn a new set of problems that can adversely affect economic growth.[7] Consequently, according to these observers, this divorce is not benign and amounts to what this paper calls a Great Divorce.

These observers' understanding starts with the standard assumptions of a floor system. First, a floor system requires the IOER rate to be set at least equal to short-term interest rates. This removes the opportunity costs to banks of holding reserves and thereby keeps their demand perfectly elastic with respect to other

5. Keister, Martin, and McAndrews, "Divorcing Money from Monetary Policy." Another way to frame this change in the Fed's operating system is to see the operating system as changing from one in which the quantity of reserves supplied was endogenous in the short run to one in which the quantity of reserves demanded is endogenous in the short run.
6. Goodfriend, "Interest on Reserves and Monetary Policy"; Keister, Martin, and McAndrews, "Divorcing Money from Monetary Policy"; Ben S. Bernanke and Donald Kohn, "The Fed's Interest Payments to Banks," *Ben Bernanke's Blog* (Brookings Institution), February 16, 2016; Robin Greenwood, Samuel Hanson, and Jeremy Stein, "The Federal Reserve's Balance Sheet as a Financial-Stability Tool" (paper presented at Federal Reserve Bank of Kansas City's annual economic policy symposium, "Designing Resilient Monetary Policy Frameworks for the Future," Jackson Hole, WY, August 25–27, 2016).
7. Joshua Hendrickson, "Interest on Reserves, Settlement, and the Effectiveness of Monetary Policy," *Journal of Macroeconomics* 54, part B (2017); Donald Dutkowsky and David VanHoose, "Interest on Reserves, Regime Shifts, and Bank Behavior," *Journal of Economics and Business* 91 (2017); Thomas L. Hogan, "Bank Lending and Interest on Excess Reserves" (working paper, Baker Institute for Public Policy, Rice University, Houston, TX, 2018); George Selgin, *Floored! How a Misguided Fed Experiment Deepened and Prolonged the Great Recession* (Washington, DC: Cato Institute, 2018).

short-term interest rates.[8] Second, a floor system assumes that once said system is in place, arbitrage will keep other short-term interest rates from deviating from the IOER rate.[9]

If, however, the Fed were to set the IOER rate exactly equal to short-term interest rates, the latter could still deviate at a later date. Specifically, if short-term interest rates were to rise above the IOER rate for a sustained period, there would again be an opportunity cost to banks of holding reserves. In that case, the demand for reserves would no longer be perfectly elastic, causing the floor system to end. Money, in that case, would be reunited with monetary policy and their divorce would come to an end.

The Fed's floor system, accordingly, is *fragile* unless the central bank sets the IOER rate high enough above short-term interest rates that there is an ample buffer to handle fluctuations in short-term interest rates. To the extent, then, that the Federal Reserve desires to run a robust floor system, it needs to keep the IOER rate above short-term market interest rates.

Fortunately for the Fed, financial frictions have weakened the arbitrage process and kept the IOER rate above short-term interest rates. The most important of these financial frictions is the limited access to the Fed's balance sheet.[10] Only commercial banks can earn IOER, and—owing to regulations and risk management—there is a limit to how much they can leverage their balance sheets to arbitrage away short-term interest rate spreads.[11] Limited access to the Fed's

8. Keister and his coauthors put it this way: "If the market interest rate were exactly zero . . . there would be no opportunity cost of holding reserves. In this limiting case, there is no cost at all to a bank of holding additional reserves. . . . The demand curve is therefore flat along the horizontal axis after this point." Keister, Martin, and McAndrews, "Divorcing Money from Monetary Policy," 44. Peter Ireland formally demonstrates this understanding in a New Keynesian model. Peter Ireland, "The Macroeconomic Effects of Interest on Excess Reserves," *Macroeconomic Dynamics* 18 (2014).

9. Again, here is what Keister and his coauthors have to say: "If the market rate were below the deposit rate, an arbitrage opportunity would exist—a bank could borrow at the (low) market rate and earn the (higher) deposit rate on these funds, making a pure profit. The demand for reserves would be unbounded in this case; such arbitrage activity would quickly drive up the market rate until it at least equals the deposit rate." Keister, Martin, and McAndrews, "Divorcing Money from Monetary Policy," 46. Michael Woodford makes a similar argument for why arbitrage would keep short-term interest rates equal to the deposit rate at the central bank. Michael Woodford, *Interest and Prices: Foundations of a Theory of Monetary Policy* (Princeton, NJ: Princeton University Press, 2003).

10. Another friction is market power over deposit accounts. Darrell Duffie and Arvind Krishnamurthy, "Pass-Through Efficiency in the Fed's New Monetary Policy Setting" (paper presented at the Federal Reserve Bank of Kansas City Economic Policy Symposium, Jackson Hole, WY, August 2016).

11. The Fed adopted a target range for short-term interest rates as a partial fix for this problem, but even this solution has not been foolproof, as seen by the occasional drift of the 1-month treasury bill rate outside the targeted range (figure 1). The lower range was bounded by the Fed's overnight

balance sheet, then, has been a key friction that has weakened the arbitraging away of short-term interest rate spreads.[12]

This lack of complete arbitrage has served the Fed's floor system well during most of the past decade by keeping the IOER rate above other short-term interest rates. Starting in 2018, however, the IOER spread began to shrink owing to developments that illustrate the inherent fragility of the Fed's floor system. First, the Fed's planned reduction of its balance sheet has been reducing the supply of reserves, making them scarcer. Second, President Trump's large budget deficits have been financed mainly with treasury bills, and this increase in supply has pushed up overnight repo interest rates. Finally, ongoing currency demand growth and new regulatory requirements are putting additional demand on bank reserves. Collectively, these forces began narrowing the IOER spread in 2018 and have the potential to turn it negative. If this happens, the floor system will collapse back into a corridor system. The Fed, consequently, has an incentive to keep the IOER rate higher than other short-term interest rates if it desires to keep the floor system running smoothly.

POTENTIAL CONSEQUENCES

Maintaining this IOER buffer, however, can create its own problems. First, there is the danger that in setting the IOER rate above short-term interest rates, the Fed may also set the IOER rate above the natural interest rate and inadvertently tighten the stance of monetary policy. Short-term market interest rates automatically gravitate toward the natural rate level, so it is a real possibility that an administered interest rate like the IOER rate could be set too high.

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reverse repurchase agreements rate in 2014, which further opened up the Fed's balance sheet to nonbank financial firms.

12. Morgan Ricks, "Money as Infrastructure" (working paper, Vanderbilt University Law School, 2018). Along these lines, Marvin Goodfriend argues that the Fed should either allow the government-sponsored enterprises (GSEs) to earn IOER or completely remove their access to the Fed's balance sheet. Marvin Goodfriend, "The Fed Should Fix the Fed's Interest on Reserves Floor" (paper presented at the Shadow Open Market Committee Meeting, New York, 2015). Currently, GSEs use their balance sheet access to lend reserves to banks, which then can earn the IOER rate. GSEs charge the banks a federal funds rate slightly lower than the IOER rate so that it is worthwhile for banks to borrow from the GSEs. This difference keeps the federal funds rate below the IOER rate. Note, though, that even if the GSEs had full access to IOER, there would still be incomplete arbitrage of short-term interest rates because there would still be many nonbank financial firms and treasury bill holders that lacked access to the Fed's balance sheet. See also Joseph E. Gagnon and Brian Sack, "Monetary Policy with Abundant Liquidity: A New Operating Framework for the Federal Reserve" (Policy Brief No. PB14-4, Peterson Institute for International Economics, Washington, DC, January 2014).

Second, the IOER buffer can lead to a rebalancing of bank portfolios that causes the supply of loans to be lower than it would have been otherwise. Banks lend as long as the marginal cost of funding is less than the risk-free marginal return on bank lending. In the Fed's floor system, the IOER rate sets the marginal funding cost. Consequently, by setting the IOER rate higher than other short-term interest rates, the Fed has raised the marginal costs of funding and narrowed the gap between these costs and the risk-free marginal return on bank lending. All else being equal, the narrowing of this gap implies a relative reduction in the supply of loans and therefore a relative decline in the money supply.[13]

Put differently, the Fed's floor system with its positive IOER spread over most of the past decade has weakened the monetary "hot potato" effect that existed in the corridor system, whereby banks in their attemps to maximize their portfolio returns would invest in loans and, in the process, turn excess reserves into required reserves and expand the broader money supply.[14] This is a central claim of Joshua Hendrickson's and George Selgin's and has been theoretically demonstrated by Donald Dutkowsky and David VanHoose.[15]

The Fed's floor system, then, may be a drag on economic growth for two reasons. First, it may weaken aggregate demand growth by setting the target interest rate above the natural interest rate. Second, it may inhibit credit and money creation by removing banks' incentives to rebalance their portfolios away from excess reserves. If so, the critics are right to be worried about the Fed's floor system, because it would constitute a Great Divorce for monetary policy.

ASSESSING THE CRITIQUE

So, are these worries about the Fed's floor system merited? This paper attempts to answer this question, in part, by taking a closer look at the second concern. Specifically, this paper empirically assesses the claim that by making bank reserve demand perfectly elastic, the Fed's floor system has caused a structural shift in bank portfolios that has made the supply of loans lower than it would be otherwise.

13. Antoine Martin, James McAndrews, and David Skeie, "Bank Lending in Times of Large Reserves," *International Journal of Central Banking* 12, no. 4 (2016).

14. In other words, since banks can earn a risk-free return on excess reserves, they will expand their balance sheets through loans only as long as the risk-free marginal return on loans exceeds the risk-free marginal return on excess reserves. By raising the IOER rate, the Fed has raised the return on excess reserves and lowered the quantity of loans demanded.

15. Hendrickson, "Interest on Reserves"; Selgin, *Floored!*; Dutkowsky and VanHoose, "Interest on Reserves."

The paper accomplishes this task in three steps. First, it looks at the composition of commercial bank portfolios before and after the introduction of the Fed's floor system. If the rebalancing concern has merit, then one would expect to see significant structural changes in bank asset allocation between reserves and loans. Second, the paper examines whether any of the observed changes in bank portfolio allocations can be tied to exogenous changes in the spread between the IOER rate and other short-term interest rates. Third, the paper shows what the estimated changes in bank portfolios due to the IOER spread imply for counterfactual cash asset and loan asset shares.

As the paper will demonstrate, there has been a significant reallocation within bank portfolios away from loans and toward reserves, and most of this change can be explained by the IOER interest rate buffer. These results complement those of Thomas Hogan, who, using a different dataset and approach, similarly finds that the IOER spread over short-term interest rates is an important predictor of bank asset allocation.[16] These findings suggest that the level of loans has been adversely affected by the Fed's floor system. Consequently, the critics appear to be right when they worry that the Fed's floor system is impairing broad money and credit creation.

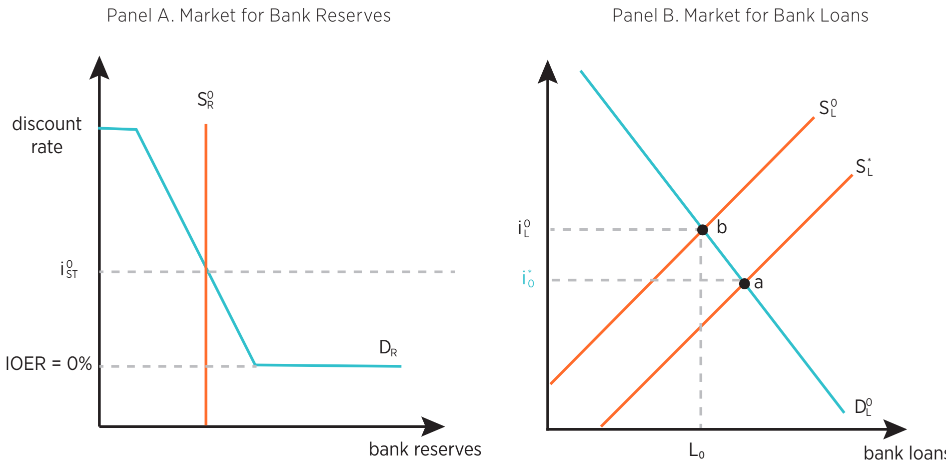
In the sections that follow, this paper first lays out a simple supply-and-demand model to illustrate the corridor and floor operating systems. It does so by providing a stylized history of the transition that occurred between the two systems in late 2008. This theoretical section aims to further clarify the link between the market for bank reserves and the market for bank loans. Readers who already understand these two operating systems can skip ahead to the following section of the paper that provides the empirical analysis. The paper closes with some policy implications for the Fed's operating system.

A STYLIZED HISTORY OF THE FED'S FLOOR SYSTEM

In order to illustrate the precrisis corridor system and the current floor system, this section provides a stylized history of the Fed's transition from the first system to the second. It tells the story by using and building on the model devised by

16. Hogan uses Call Report data from the Federal Deposit Insurance Corporation and looks at US commercial banks at the bank holding company level (Hogan, "Bank Lending and Interest on Excess Reserves"). By contrast, this study uses the Federal Reserve's H.8 dataset, which provides aggregated bank data based on bank size. Board of Governors of the Federal Reserve System, "Assets and Liabilities of Commercial Banks in the United States - H.8," October 19, 2018, https://www.federalreserve.gov/releases/h8/current/default.htm.

FIGURE 2. THE PRECRISIS CORRIDOR SYSTEM



Keister and his coauthors. Their framework shows how central banks implement monetary policy by using a simple supply-and-demand model for bank reserves. Their framework assumes banks are price takers and therefore provides a benchmark case for thinking through the Fed's operating systems. Their model is expanded here by adding the supply and demand for bank loans so that banks are equating the margins on bank reserves and bank loans. This framework, though it abstracts from other bank assets, provides an accessible way to demonstrate how the Fed's operating systems interact with the market for loans.[17]

The Precrisis Corridor System

Figure 2 shows this framework for the Fed's precrisis corridor system. Consider first the market for bank loans, in panel B. The horizontal axis shows the total quantity of bank loans while the vertical axis shows the interest rates on loans. The supply of loans is reflected by two supply curves, S_L^* and S_L^0. S_L^* is the loan supply schedule based on bank fundamentals like funding costs, capital levels, regulatory requirements, and bank culture. The intersection of this "fundamental" supply curve and the demand curve for loans determines the risk-free short-run interest rate on loans, i_0^*.

17. Keister, Martin, and McAndrews, "Divorcing Money from Monetary Policy."

The second loan supply schedule, S_L^0, is the one where the actual quantity of loans supplied is determined. Banks must account for the riskiness of borrowers when making loans. This risk premium creates a wedge between S_L^* and S_L^0. For the sake of simplicity, this wedge is assumed to be constant. Allowing it to vary would not change the key implications of this model.[18]

The intersection of the S_L^0 supply curve and the demand for loans determines the observable loan interest rate, i_L^0. The spread between i_L^0 and i_0^* can be roughly viewed as the net interest margin. Both loan supply curves are upward sloping for the usual reason: as the marginal return on loans increases, banks are willing to increase the quantity of loans supplied, all else held constant. When all else is not held constant—funding costs, capital levels, regulatory requirements, and bank culture can change—the supply curves shift.

The demand curve for bank loans is downward sloping. This reflects the standard notion that, as the cost of financing bank loans falls, the quantity of bank loans demanded will rise, all else held constant. Of course, all else is often not constant—wealth, incomes, and preferences can change—and that will be reflected in shifts of the loan demand curve.

Consider now the market for the bank reserves in panel A of figure 2. The horizontal axis shows the total quantity of reserves held by banks, while the vertical axis shows the opportunity costs to banks of holding reserves. The quantity of reserves—S_R^0—is supplied and therefore determined by the Federal Reserve.

The demand for reserves by banks—D_R—is generated by two factors. First, banks face a reserve requirement on deposits; it must be met or they will pay a penalty to the central bank for their shortfall. Second, there is some uncertainty surrounding the flow of funds into and out of each bank. This uncertainty creates a precautionary motive to hold reserves, so that there are sufficient funds available to make payments. Both of these factors, in turn, are positively related to the volume of loans. As the number of loans issued rises, the number of deposits created will also rise—and so, in turn, will the level of required and precautionary reserves needed by banks.

While these two factors create a positive demand for reserves, the actual shape of the demand curve for reserves is defined by the opportunity costs of banks holding reserves. On the downward-sloping portion of the demand curve, reserves earn nothing, and therefore banks holding them face an opportunity cost. That opportunity cost is defined by the return banks could earn by lending their reserves on the interbank market. Consequently, banks will only increase

18. The Fed's LSAPs, for example, were intended to shrink risk premiums like this one.

the quantity of bank reserves they demand as their cost (that is, the interbank interest rate) declines. Owing to arbitrage, the interbank rate is equal to the interest rate on overnight assets, such as treasury bills. The overnight interest, i^0_{ST}, is therefore used interchangeably with the interbank rate in the context of the corridor operating system.

The upper portion of the reserve demand curve is flat—perfectly elastic. This is the case because, should the supply of reserves fall far enough, the interbank interest rate would rise above the rate at which banks could borrow from the Fed.[19] This interest rate spread would cause interbank lending to cease as banks began borrowing solely from the Fed. Interbank interest rates would quickly fall back to the Fed's lending rate, the discount rate.[20] The interbank demand for reserves is therefore perfectly elastic once the interbank interest rate rises to the Fed's lending rate.[21]

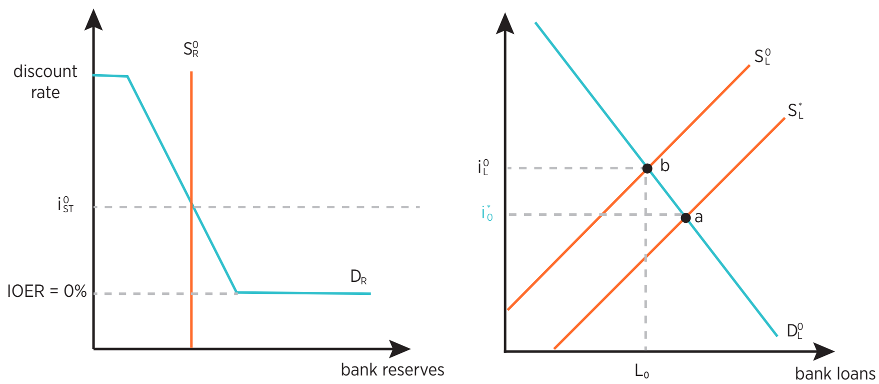
The lower portion of the reserve demand curve is also flat. Here, too, reserve demand for interbank lending becomes perfectly elastic with respect to short-term interest rates. Here the opportunity costs of holding reserves have been eliminated, so banks are willing to hold any amount of reserves supplied by the Fed. For the precrisis floor system, this lower portion was bounded by an interest rate of zero.[22] Expressed differently, this is the place where the liquidity trap occurs in the portfolios of banks. Zero percent was also the implicit IOER rate in the corridor system.

The intersection of the demand and supply curves for bank reserves determines the interbank interest rate, i^0_{ST}. In equilibrium, this overnight interest rate is equal to the risk-free short-term interest rate, i^*_0, that is determined in the market for bank loans. Expressed differently, the marginal risk-free return on loans is equal to the marginal cost of funding in equilibrium ($i^*_0 = i^0_{ST}$). To illustrate how these interest rates converge to this equilibrium, figures 3 and 4 provide two scenarios.

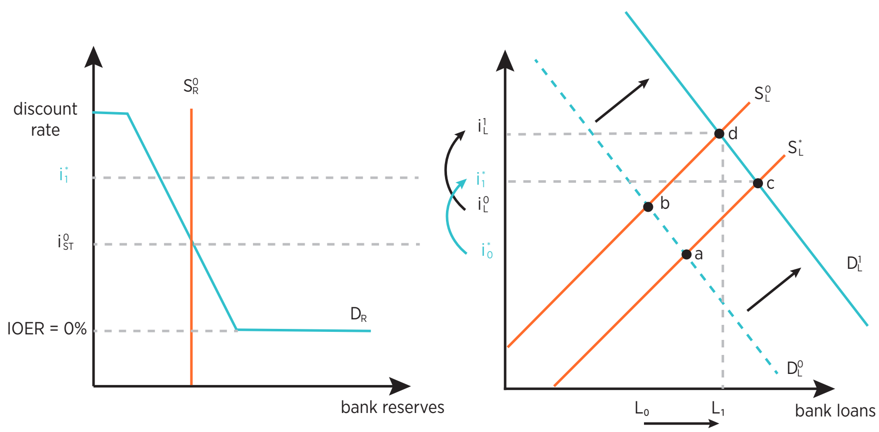
19. A similar situation could arise if the demand for bank reserves shifted far enough out to the right that the flat part of the demand curve hit the reserve supply curve. In this case, the supply curve would become flat too, and the Fed would perfectly accommodate the growth in reserve demand through discount lending (assuming no open market operations).
20. This assumes there is no stigma in borrowing from the Fed.
21. Technically, the supply of bank reserves also becomes perfectly elastic, because the Fed would accommodate all the demand for reserves. Some observers, therefore, draw the reserve supply horizontal at this point. This paper, however, follows Keister and his coauthors, who draw the demand curve as described above. Keister, Martin, and McAndrews, "Divorcing Money from Monetary Policy."
22. As shown later in this paper, the lower bound in a corridor system could also be determined by the IOER rate set a level below short-term market interest rates but above 0 percent. So it need not be the case that the lower bound is set by zero.

FIGURE 3. A POSITIVE SHOCK TO LOAN DEMAND

Panel A. Equilibrium in Both Markets



Panel B. Loan Demand Suddenly Increases



Panel C. Reserve Demand Adjusts to Restore Equilibrium

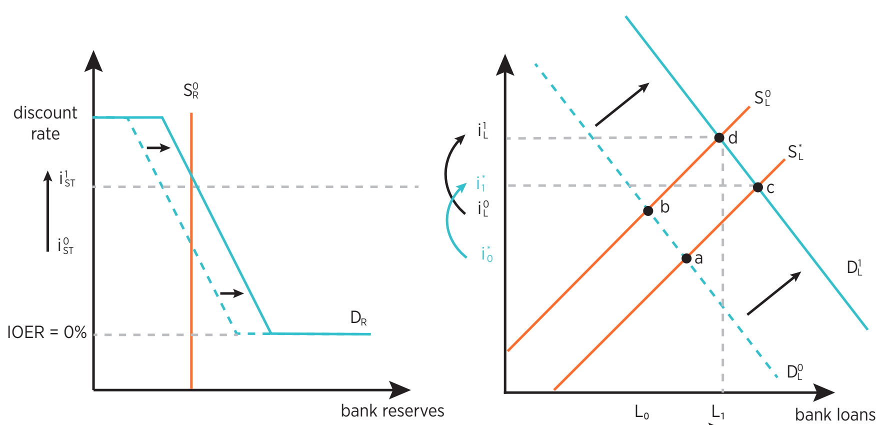


Figure 3 shows what happens when there is an unexpected increase in the demand for loans. Starting in panel A, where both markets are in equilibrium, the demand for bank loans suddenly rises, as shown in panel B. Panel B shows how the loan demand curve shifts right, from D_L^0 to D_L^1.

Banks realize that at this higher demand the marginal risk-free return on loans (or the risk-free short-run interest rate) will rise from i_0^* to i_1^* and, assuming constant risk premiums, the loan interest rate will proportionally rise from i_L^0 to i_L^1. As a result, the marginal risk-free return on loans will exceed the marginal cost of funding those loans ($i_1^* > i_{ST}^0$). Consequently, banks will respond by increasing the quantity of loans supplied from L_0 to L_1.

Doing this, however, raises the demand for bank reserves to meet the now-higher required and precautionary reserve amounts. As seen in panel C, this causes the demand curve for bank reserves to shift right until the marginal cost of funding the loans just equals their marginal risk-free return ($i_{ST}^1 = i_1^*$). At that point, there is no longer an incentive for banks to provide more loans. Once again, both markets are in joint equilibrium.

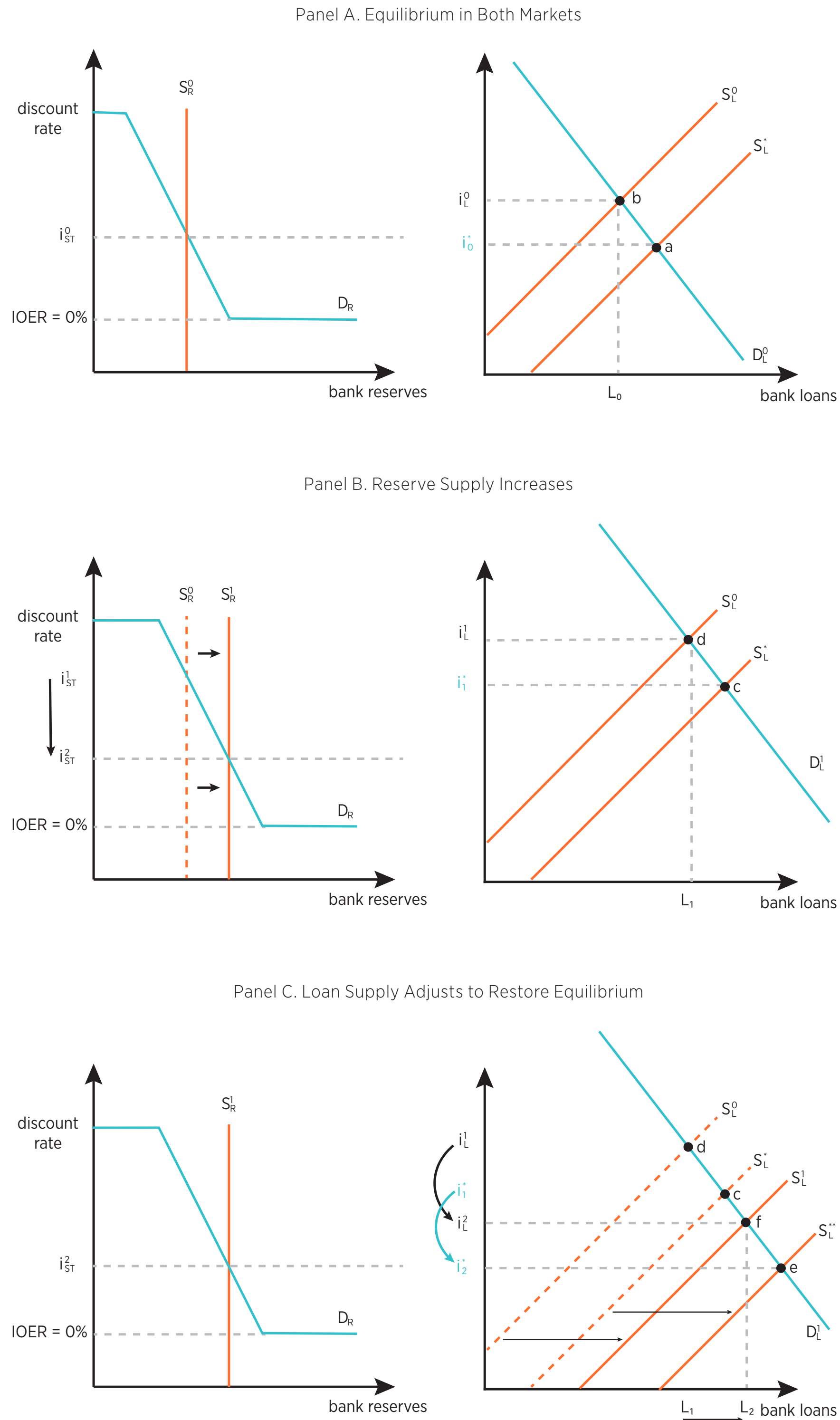
A couple of observations are in order. First, note that while the supply of reserves is unchanged in this scenario, the composition of reserves does change. As the quantity of loans supplied increases, excess reserves get turned into required reserves. Additionally, some reserves get transformed into currency as currency demand grows with the economy. In this case, the Fed would have to add to the stock of bank reserves via open market operations to keep the supply curve constant, as depicted in figure 1. In general, the Fed determines the supply of reserves, while the market determines composition of reserves.

Second, if there were a sudden drop in loan demand, the exact opposite of the situation depicted in figure 3 would happen. This is illustrated later, but for now note that this development would initially cause the marginal risk-free return on loans to fall beneath the marginal cost of funding them ($i_1^* < i_{ST}^1$). As a result, the quantity of loans supplied would fall and the demand for bank reserves would shift inward until the marginal conditions were once again equalized.

Continuing with the story, assume that now the Fed suddenly decides it wants to lower the overnight interest rate back to its original value, i_{ST}^0. Figure 4 shows how this would happen in the corridor system, starting in panel A, where both markets are in equilibrium.

First, via open-market operations, the Fed would increase the supply of bank reserves from S_R^0 to S_R^1. As seen in panel B, this shift in reserve supply creates a liquidity effect that causes a decline in the interbank interest rate, from i_{ST}^1 to i_{ST}^2. The Fed has now returned the overnight interest rate to its original value ($i_{ST}^2 = i_{ST}^0$).

FIGURE 4. A POSITIVE SHOCK TO RESERVE SUPPLY



Consequently, banks now find that their marginal risk-free return on loans is higher than the marginal funding cost ($i_1^* > i_{ST}^2$). This gives them an incentive to increase the supply of loans—a shift to the right for the loan supply curve—until the marginal conditions are again equalized. Again, assuming fixed risk premiums, both loan supply curves shift right proportionally. For a given loan demand curve, this loan supply shift results in an increase in the quantity of loans demanded as interest rates fall.

In short, when the Fed independently increases the supply of bank reserves this results in an increase in loan supply. The opposite would happen in the corridor system if the Fed were to decrease the supply of bank reserves (not shown in these figures). That is, a sudden reduction in bank reserves would cause the marginal risk-free return on loans to be lower than the marginal funding cost ($i_1^* < i_{ST}^2$). This would incentivize banks to decrease the supply of loans—a shift leftward of the loan supply curve—until the marginal conditions were once again equalized.

Note that the increase in the supply of reserves depicted in figure 3 initially results in an increase in excess reserves. But as more loans are supplied, some of these excess reserves get turned into required reserves. This, again, highlights the fact that the Fed determines the supply of reserves while the market determines composition of reserves.

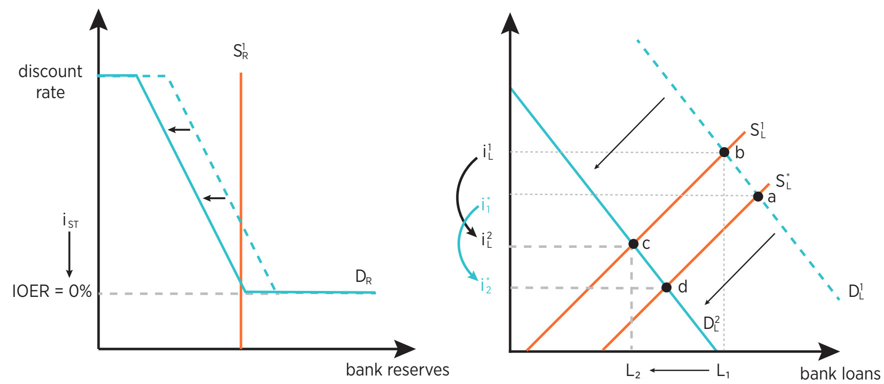
These two scenarios illustrate how bank reserves and bank loans were closely linked in the Fed's precrisis corridor system. As noted earlier, however, the Fed conducted monetary policy by setting a target rate for i_{ST}^0 according to a Taylor rule–like reaction function. This meant that the Fed had to endogenously adjust the supply of bank reserves to changes in the demand for bank reserves in order to maintain a given interest rate target.

Expressed differently, over the short term when the target interest rate was fixed, changes in the market for bank loans drove activity in the market for bank reserves. This pattern is similar to what was shown in figure 3, with the only difference being that the Fed would adjust the reserve supply curve to offset shifts in reserve demand so as to maintain a fixed interest rate target. Eventually, though, the Fed would change its target interest rate as prescribed by the Taylor rule. This change would be more like the development in figure 4. Here, the change in reserves is more exogenous. Causality, in this case, is running from changes in the market for bank reserves to changes in the market for bank loans.

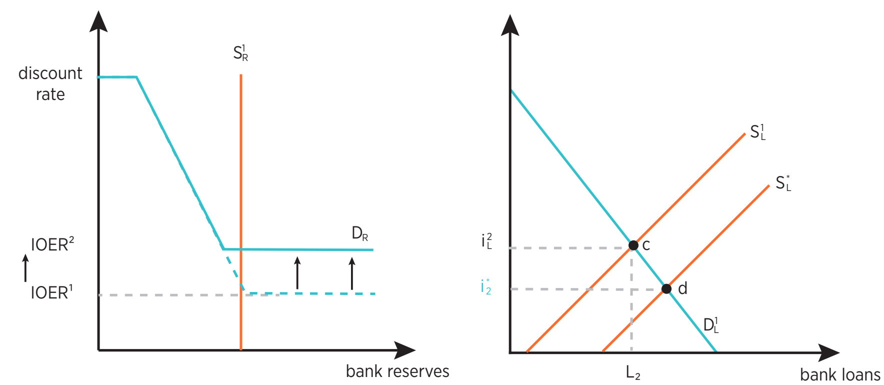
To be clear, this analysis holds constant the other shift factors mentioned earlier, and it also assumes away other assets on the banks' balance sheets. These simplifications do not change the implications of the Fed operating systems, but they do add clarity to the analysis. In the case of the precrisis corridor system,

FIGURE 5. MOVING TO THE FED'S FLOOR SYSTEM IN THREE STEPS

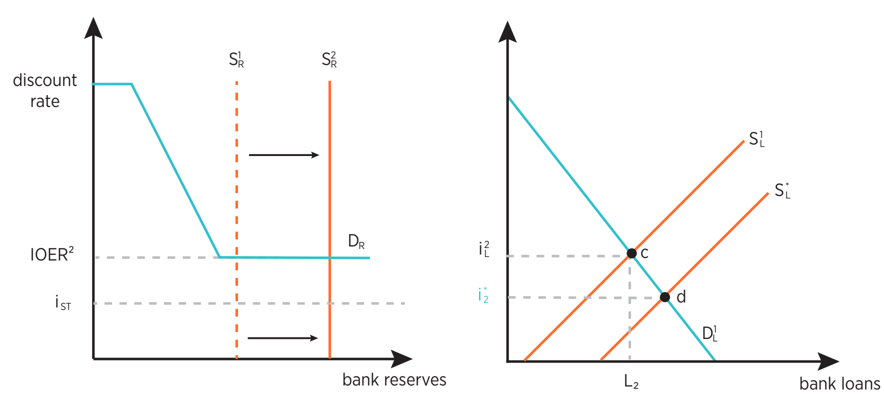
Panel A. Step 1—A Collapse in Loan Demand



Panel B. Step 2—Raising IOER above Overnight Market Rates



Panel C. Step 3—An Increase in Bank Reserves



the model shows how money—in the form of bank reserves—was still tied to the stance of monetary policy. The Fed adjusted the supply of reserves so as to maintain a given interest rate target or move to a new one. Money still mattered to monetary policy. That changed in late 2008, when this last vestige of money was severed from monetary policy.

Moving to the Fed's Floor System in Three Steps

The transition from the Fed's corridor system to its new floor system in late 2008 is thoroughly documented by George Selgin.[23] Here, a summary of this process is illustrated in figure 5, which shows the three key steps in this transition.

First, the recession itself caused a sharp decline in loan demand in 2008. As seen in panel A, this development caused the loan demand curve to fall from D_L^1 to D_L^2. This caused the marginal risk-free return on loans to fall from i_1^* to i_2^* and the loan interest rate to fall from i_L^1 to i_L^2.[24] As a result, the marginal cost of funding loans exceeded the marginal risk-free return ($i_{ST} > i_2^*$), and banks responded by reducing the quantity of loans supplied from L_1 to L_2.[25] In turn, there was less demand for bank reserves, and the demand curve for such reserves shifted left, causing i_{ST} to start declining. As seen in panel A, this first step alone brought i_{ST} close to the zero lower bound and, therefore, close to the lower horizontal position of the reserve demand curve.

Second, in October 2008, the Fed began paying IOER at a rate that was higher than comparable short-term interest rates (IOER > i_{ST}). As noted earlier, the IOER rate in late 2008 got almost 90 basis points over the 1-month treasury bill yield, 60 basis points over the treasury repo rate, and 40 basis points over the overnight dollar Libor rate. The interest rate on bank reserves, therefore, was no longer equal to comparable yields, including overnight interest rates. This development is depicted in panel B, with the shift up of the lower flat portion of the reserve demand curve, D_R, to the level of the new IOER rate.

Third, about two months later, the Fed began expanding the supply of bank reserves via its large-scale asset purchases. This is depicted in panel C. This

23. Selgin, *Floored!*

24. This depiction has the risk-free short-run interest rate, i_2^*, falling to only 0 percent. In reality, this rate probably fell well below 0 percent, but for the sake of easy exposition it is drawn here as only falling to 0 percent. This simplification, however, does not change the implications.

25. Though not depicted here (for simplicity's sake), the risk premium also increased during this time, creating a larger wedge between S_L^* and S_L^1. This larger wedge implies a shift in S_L^1 and therefore a reduction in the supply of loans. This reduction in loan supply was above and beyond the reduction in quantity supplied that was discussed above.

third step put the supply of reserves far out on the elastic region of the reserve demand curve. Recall that here banks will hold all the reserves created by the Fed, because the opportunity cost of holding them has vanished.

It is worth noting that the collapse in demand and the increase in bank reserves from the LSAPs would have been sufficient to get short-term interest rates to the zero lower bound. Once rates are there, the opportunity costs of reserves disappear, which would have put the Fed on the perfectly elastic (flat) portion of the reserve demand curve, the standard requirement for a floor system.[26]

The Fed, however, went above and beyond that requirement by initially raising the IOER rate higher than comparable short-term interest rates. This can be seen in panel C, with $IOER^2 > i_{\mathrm{ST}}$. This step created a buffer so that if i_{ST} were to suddenly rise, the Fed would have some wiggle room to maintain its floor system. The Fed's floor system, consequently, would not be as susceptible to the whims of the market with this IOER buffer. The IOER buffer did narrow somewhat over time, so that the spread averaged 20 basis points over the 1-month treasury yield and about 10 basis points over the treasury repo rate and Libor rate through the end of 2017. Still, these spreads have been large enough to keep the Fed's floor system operational since then.[27]

While the IOER rate buffer solidified the Fed's floor system, it may have come at a cost. First, by setting the IOER rate above other short-term interest rates, the Fed might also have set the IOER rate above the natural interest rate and inadvertently tightened the stance of monetary policy.

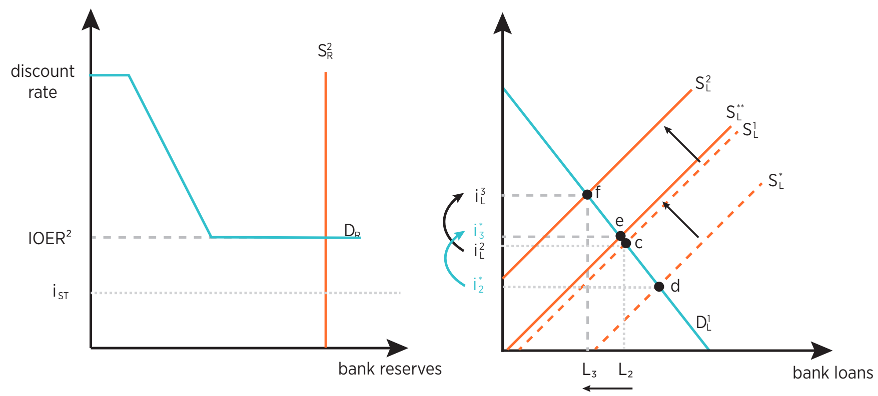
Another potential cost, and one that is the focus of this paper, is that the Fed's floor system may have reshaped banks' portfolios in a way that has affected the supply of loans. Recall that a floor system requires banks to be willing to hold unlimited amounts of reserves supplied by the central bank. The Fed incentivizes this willingness by eliminating the opportunity costs to banks of holding reserves. So, by design, a floor system changes the asset composition of a bank's portfolio.

The Fed's floor system, however, goes beyond eliminating the opportunity costs of bank reserves. As noted above, it offers a higher return on reserves than what is earned on comparable short-term assets. The Fed's floor system, consequently, may not only change bank portfolios but do so in a manner that causes banks to overinvest in bank reserves at the expense of other assets. Expressed differently, the IOER rate spread effectively creates a quasi–liquidity trap in bank

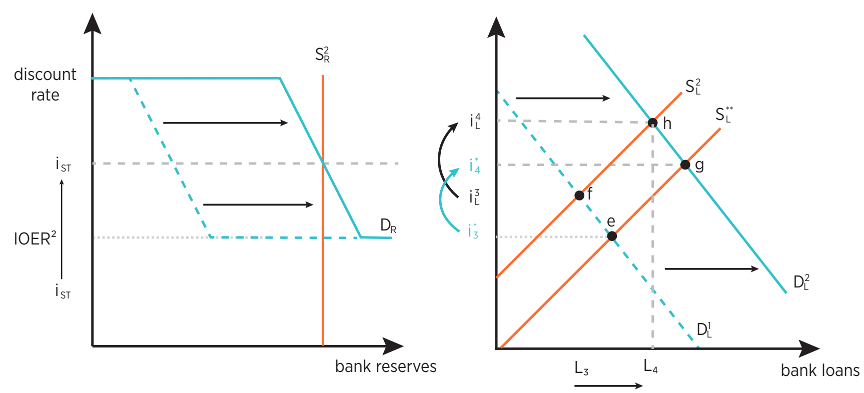
26. Goodfriend, "Interest on Reserves and Monetary Policy"; Keister, Martin, and McAndrews, "Divorcing Money from Monetary Policy."
27. As noted later in this paper, these spreads began to narrow in 2018 with burgeoning federal budget deficits. This narrowing of spreads arguably is already putting a strain on the Fed's floor system.

FIGURE 6. POTENTIAL DANGER AND FRAGILITY OF THE FED'S FLOOR SYSTEM

Panel A. Potential Danger of the Fed's Floor System



Panel B. Fragility of the Fed's Floor System



portfolios that can persist above the zero lower bound. Dutkowsky and Van-Hoose formally demonstrate this possibility in an optimizing bank model with multiple asset classes.[28]

The model used in this paper (as previously noted, a modified version of Keister and his coauthors' model)[29] is much simpler, but illustrates this cost in figures 5 and 6. In panel C of figure 5, the IOER rate ended up being higher than the overnight interest rate and the risk-free short-term interest rate on loans ($IOER^2 > i_{ST} = i_2^*$). The marginal cost of funding in panel C is now higher than

28. Dutkowsky and VanHoose, "Interest on Reserves."
29. Keister, Martin, and McAndrews, "Divorcing Money from Monetary Policy."

the risk-free marginal return on bank lending. Stated differently, the production costs of loans have risen, and this incentivizes banks to reduce the supply of loans they provide. Graphically, this is illustrated in panel A of figure 6, with the leftward shift of the loan supply curve until the marginal cost of funding equals the risk-free marginal return on loans ($IOER^2 = i_3^*$). This shift causes the quantity of loans demanded to decline from L_2 to L_3.

Note that in panel A of figure 6 the overnight interest rate, i_{ST}, does not converge to the IOER rate in the floor operating system. The overnight interest rate is therefore no longer equal to the risk-free short-term interest rate on loans ($i_{\mathrm{ST}} < IOER^2 = i_3^*$). The reasons for this divergence are twofold: first, only banks have access to the managed IOER rate, and second, expanding bank balance sheets is an increasingly costly endeavor, owing to regulations and risk management of bank portfolios. As a result, banks cannot arbitrage away the IOER interest rate spread and remain a relatively small part of the overnight market.[30] Banks are price-takers rather than price-makers in this market.

To be clear, the Fed did try to manage the IOER spread over overnight interest rates by setting a lower bound on short-term interest rates in late 2008. This lower bound was further reinforced by the Fed's overnight reverse repurchase agreements, introduced in 2014. As figure 1 shows, however, even this lower bound was occasionally breached by the 1-month treasury bill yield. Moreover, even if it had not been breached, the lower bound established a 25-basis-point space in which the IOER spread could freely operate. The Fed, in other words, allowed bank reserves to earn a return that was greater than the return required to operate the floor system.

Banks cannot eliminate the IOER spread over overnight interest rates, but other forces can. First, changes in the overnight market can narrow the IOER spread. For example, as noted by the Federal Open Market Committee, President Trump's budget deficits are increasing the issuance of treasury bills and appear to be driving up overnight repo interest rates.[31] Via arbitrage, the rise in repo

30. The Fed's H.8 measure "Fed Funds and Reverse Repos with Non-banks" for all commercial banks provides a measure of bank activity in the overnight market (Board of Governors of the Federal Reserve System, "Assets and Liabilities of Commercial Banks in the United States - H.8," October 19, 2018, https://www.federalreserve.gov/releases/h8/current/default.htm). Dividing this measure by the measure of the repo market used by Adam Copeland and his coauthors indicates that banks comprised on average about 12 percent of overnight market activity from 2008 to 2017. Adam Copeland et al., "Mapping and Sizing the U.S. Repo Market," *Liberty Street Economics* (New York Federal Reserve Bank), June 25, 2012.
31. Minutes of the Federal Open Market Committee, June 2018. See also David Beckworth, "Donald Trump's Real Influence on Fed Policy," *Alt-M (Cato Institute)*, August 15, 2018.

interest rates has driven up other short-term interest rates, such as the overnight dollar rate. This is shown later in this paper.

Second, a sudden increase in loan demand that raised the marginal risk-free return on loans above the IOER rate would also pull the overnight interest rate up to the same level ($i_{ST} = i_4^*$) via arbitrage. This scenario is illustrated in panel B of figure 6. Short-term interest rates are now above the IOER rate, and the interbank interest rate is back on the downward-sloping portion of the reserve demand curve. The quantity of loans supplied increases from L_3 to L_4. Not only does this scenario illustrate how the IOER spread can change, but it also demonstrates the fragility of the Fed's floor system: the demand for reserves is no longer perfectly elastic with respect to short-term interest rates, because there is now an opportunity cost of holding reserves.

A final takeaway from figure 6 is its implications for the allocation of assets in bank portfolios. Specifically, both panels imply that an increase in the IOER spread on the overnight interest rate increases the share of bank assets allocated to reserves and decreases the share of bank assets allocated to loans. Conversely, the figure also implies that anything that causes loan demand to rise will decrease the share of bank assets going to reserves and increase the share of bank assets going to loans. Equations (1) and (2) summarize these relationships:

$$\frac{R}{A} = f\left(\overbrace{IOER - i_{ST}}^{+}, \overbrace{L^D}^{-}\right), \tag{1}$$

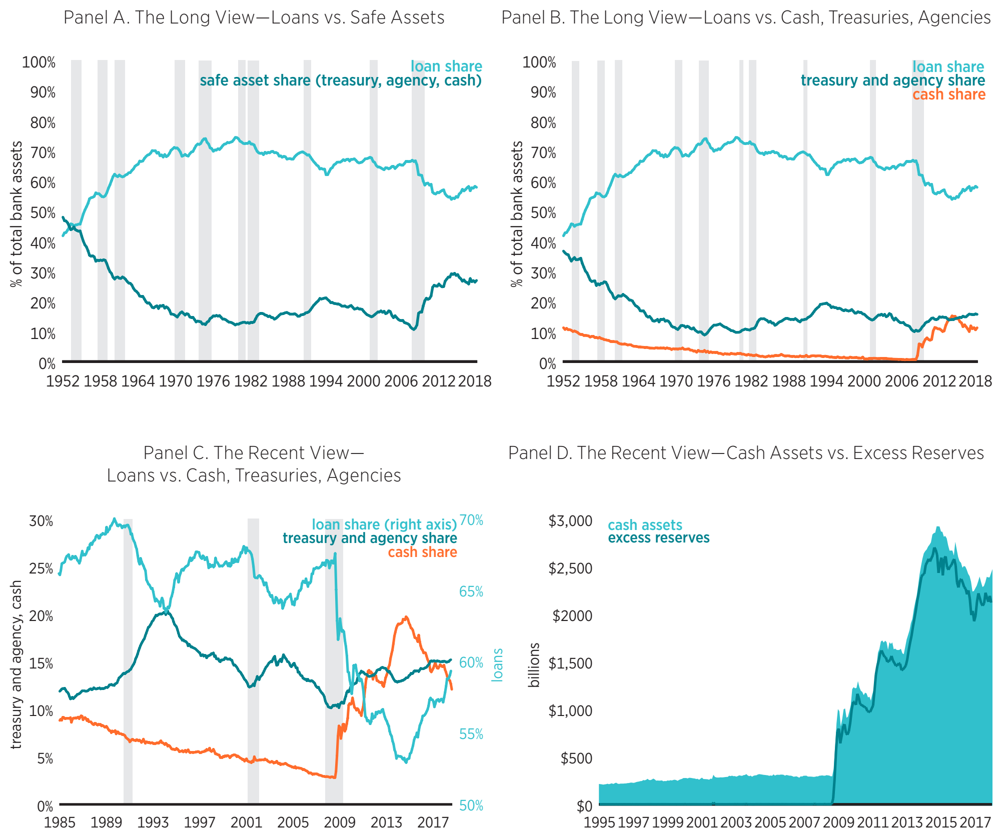
$$\frac{L}{A} = f\left(\overbrace{IOER - i_{ST}}^{-}, \overbrace{L^D}^{+}\right). \tag{2}$$

Here R/A are bank reserves over total bank assets, L/A are loans over total bank assets, and L^D is loan demand. These equations will be used in the next section to motivate some of the the empirical analysis.

THE FED'S FLOOR SYSTEM AND BANK PORTFOLIOS: EMPIRICAL TRENDS AND EVIDENCE

As noted above, the Fed's floor system has potentially big implications for the structure of bank portfolios. This possibility is empirically examined in this section, in three steps. First, the section looks at the composition of commercial bank portfolios before and after the introduction of the Fed's floor system. If the portfolio rebalancing concern discussed earlier has merit, then one would expect to see significant structural changes in bank asset allocation between reserves and loans. Second, the section examines whether any of the observed changes in

FIGURE 7. PORTFOLIO SHARES OF US COMMERCIAL BANK ASSETS



Note: The safe asset category is defined as treasuries, agencies, and cash held by the bank. Data reflect all commercial banks. Shaded time periods represent recessions.

Sources: Board of Governors of the Federal Reserve System, "Financial Accounts of the United States - Z.1: Release Dates," September 20, 2018, https://www.federalreserve.gov/releases/z1/; Board of Governors of the Federal Reserve System, "Assets and Liabilities of Commercial Banks in the United States - H.8," October 19, 2018, https://www.federalreserve.gov/releases/h8/current/default.htm; Federal Reserve Bank of St. Louis, Federal Reserve Economic Data (database), accessed October 25, 2018, https://fred.stlouisfed.org.

bank asset allocations can be tied to exogenous changes in the spread between the IOER rate and the overnight interest rate. Third, the section shows what the estimated changes in bank portfolios due to the IOER spread imply for counterfactual cash asset and loan asset shares.

Bank Portfolio Trends: Aggregates

Figure 7 provides evidence about the composition and relationships of loans and safe assets on all commercial bank balance sheets since the 1950s. Panel A shows the relationship between loan and safe asset shares in bank portfolios for the period from quarter 1, 1952, through quarter 1, 2018. This long view of these two asset classes reveals them to be almost mirror images of each other. This relationship is unsurprising from a business cycle perspective—banks become more risk averse during downturns, and less risk averse during upturns—but it also holds up over the long run. Coming out of World War II, banks began to invest more in loans and less in safe assets, until the loan share of total bank assets reached a high of about 70 percent and the safe asset share hit a low of about 12 percent. This portfolio mix of bank assets prevailed, with some variation, until the Great Recession in 2008. Since then, the loan share has fallen precipitously while the safe asset share has sharply risen.

Panel B shows the same relationship but with the safe asset category decomposed into two subcategories: a treasury and agency share and a cash share. The cash category since the Fed began using the floor system has consisted mostly of excess reserves, as shown in panel D.[32] Panel B reveals that the composition of bank portfolios underwent a big change with the adoption of the floor system in late 2008. Specifically, the strong negative relationship between loans and safe assets was actually based on a strong underlying relationship between loans and treasury and agencies *before* the adoption of the floor system and a strong underlying relationship between loans and cash *after* the adoption of the floor system.

Panel C zooms in on this relationship at the monthly frequency for the period from January 1985 to July 2018. This panel also puts the loan share on a different scale to help illuminate the relationships. It shows that the loan share reached its peak in September 2008 at 68 percent before falling to a low of 53 percent in late 2014. During the same period, the cash share rose from 3 to 20 percent, and its rise mirrors the loan share decline. Some of this shift, ostensibly, was due to the Great Recession early on, as banks raised their precautionary holdings of reserves and the demand for loans collapsed during the crisis. This tight fit, however, continues throughout the entire post-2008 period. More recently, loan shares have started rising while cash shares have started declining. Consequently, something more than the crisis is driving this new relationship between loans and banks' cash holdings.

32. The H.8 database defines this category as "vault cash, cash items in process of collection, balances due from depository institutions, and balances due from Federal Reserve Banks." Board of Governors of the Federal Reserve System, "Assets and Liabilities of Commercial Banks in the United States - H.8," October 19, 2018, https://www.federalreserve.gov/releases/h8/current/default.htm. Before the floor system period, excess reserves were a small part of this category, but they now make up most of it.

TABLE 1. DEPENDENT VARIABLE: LOAN SHARE

Variables	Full period 1952:Q1–2018:Q2	Pre-floor period 1952:Q1–2008:Q3		Floor period 2008:Q4–2018:Q1	
	(1)	(2)	(3)	(4)	(5)
Safe Assets (All)	−0.803 (−41.77)***	−0.770 (−45.51)***	–	−0.517 (−12.68)***	–
Cash Share	–	–	0.066 (−0.93)	–	−0.699 (−12.86)***
Treasury/Agency Share	–	–	−1.08 (−36.75)***	–	−0.04 (−0.38)
Intercept	0.808 (189.12)***	0.807 (220.41)***	0.829 (241.61)***	0.699 (67.89)***	0.652 (46.40)***
R^2	0.88	0.90	0.94	0.82	0.88
Partial R^2: Cash Share	–	–	0.00	–	0.83
N	265	227	227	38	38

* = significant at the 10% level, ** = significant at the 5% level, *** = significant at the 1% level.

Figure 7, in short, reveals a dramatic and persistent shift from loans to cash in bank portfolios, a shift that occurred at the same time as the Fed's adoption of a floor system. The rise in the share of cash holdings is not surprising, because the Fed's floor system intentionally eliminated the opportunity cost of holding bank reserves. What might be more surprising to some observers is the persistent decline in the loan share that roughly matches the rise in the cash share.

To more carefully analyze the relationships in figure 7, a series of regressions were run on the data and are reported in table 1. The regressions were run for the entire period, the pre-floor-system period (i.e., the corridor-system period), and the floor-system period, with the loan share as the dependent variable. These regressions do not identify causality, but they clarify the strength and direction of the relationships seen in figure 7.

The first regression, in column (1), runs the total safe asset category on the loan share over the entire sample, from quarter 1, 1952, to quarter 1, 2018. This first regression shows that the relationship has an R^2 of 88 percent over this period, and that a 1-percentage-point increase in the safe asset share is associated with a 0.80 percent decline in the loan share. This tight negative relationship corresponds to the relationship seen in panel A of figure 7.

The second set of regressions, in columns (2) and (3), regress the safe asset share, the treasury and agency share, and the cash share on the loan share for the pre-floor period of quarter 1, 1952, to quarter 3, 2008. The safe asset share regression results in column (2) are similar to those in column (1), but now its subcategories in column (3) confirm the visual impressions from panel B of figure 7. Specifically, the treasury and agency share is significant in this pre-floor period, whereas the cash share is insignificant. Moreover, the overall regression R^2 for column (3) is 94 percent, whereas the partial R^2 for the cash share, which shows the marginal strength of its relationship to the loan share, is 0 percent. These results indicate that there was no relationship between the cash and loan shares before the advent of the floor system. Accordingly, the strong relationship between safe assets and loan share from quarter 1, 1952, to quarter 3, 2008, was entirely the result of the link between the treasury and agency share and the loan share.

The third set of regressions, in columns (4) and (5), shows an almost complete reversal of the pre-floor relationship. While safe assets continue to be negatively and strongly related to the loan share, it is the cash share that is now significant, whereas the treasury and agency share is insignificant. Now the R^2 for column (5) is 88 percent, whereas the partial R^2 for the cash share is 83 percent. During the floor period, then, the cash share is driving the relationship between safe assets and loan share.

So, while the safe asset share remains significant and tied to the loan share over both periods, the reason for this relationship changes with the advent of the Fed's floor system. To be clear, these regressions only show relationships and do not indicate causality. The causality issue is addressed later in this paper. For now, the takeaway is that the change in the Fed's operating system from a corridor system to a floor system coincided with a dramatic change in the underlying relationship between loans and safe assets.

Bank Portfolio Trends: Subcategories

Further insight into this large shift within bank portfolios can be found by looking at the subcategories of banks provided in the Federal Reserve's monthly H.8 dataset.[33] These groupings are as follows: *large domestic banks*, defined as the top 25 domestically chartered commercial banks, ranked by domestic assets; *small domestic banks*, defined as all domestically chartered banks not included in the top 25; and *foreign-related institutions*, which are branches of foreign banks located in the United States. Figure 8 plots the time series for these series in a

33. Board of Governors of the Federal Reserve System, "Assets and Liabilities of Commercial Banks in the United States - H.8," October 19, 2018, https://www.federalreserve.gov/releases/h8/current/default.htm.

similar manner to what was done in figure 7. These charts, however, only go back to 1985 because of data limitations in the H.8 dataset. For the sake of brevity, these subcategories are referred to as *large banks*, *small banks*, and *foreign banks* in the figures and tables that follow.

Figure 8's panels A and B show the aggregated bank portfolio for foreign-related institutions. Panel A suggests that there was some relationship between the safe asset share and the loan share before the advent of the floor system. After 2008, however, there is a stronger relationship; they become almost mirror images of each other. Panel B indicates that this stronger relationship was driven by a tightening of the link between the cash share and the loan share after 2008. In other words, the US branches of foreign banks appear to be affected by the Fed's move to a floor system.

Panels C and D show the aggregated bank portfolio for large domestic banks. Panel C suggests that there was a downward-drifting relationship between the safe asset share and the loan share before 2008. During the floor period, the relationship again appears stronger. Panel D indicates that the relationship before 2008 was driven by the link of the treasury and agency share with the loan share. After 2008, the relationship appears to be the result of the cash share. Like the foreign-related banks, then, the large domestic banks seem to be affected by the Fed's move to a floor system.

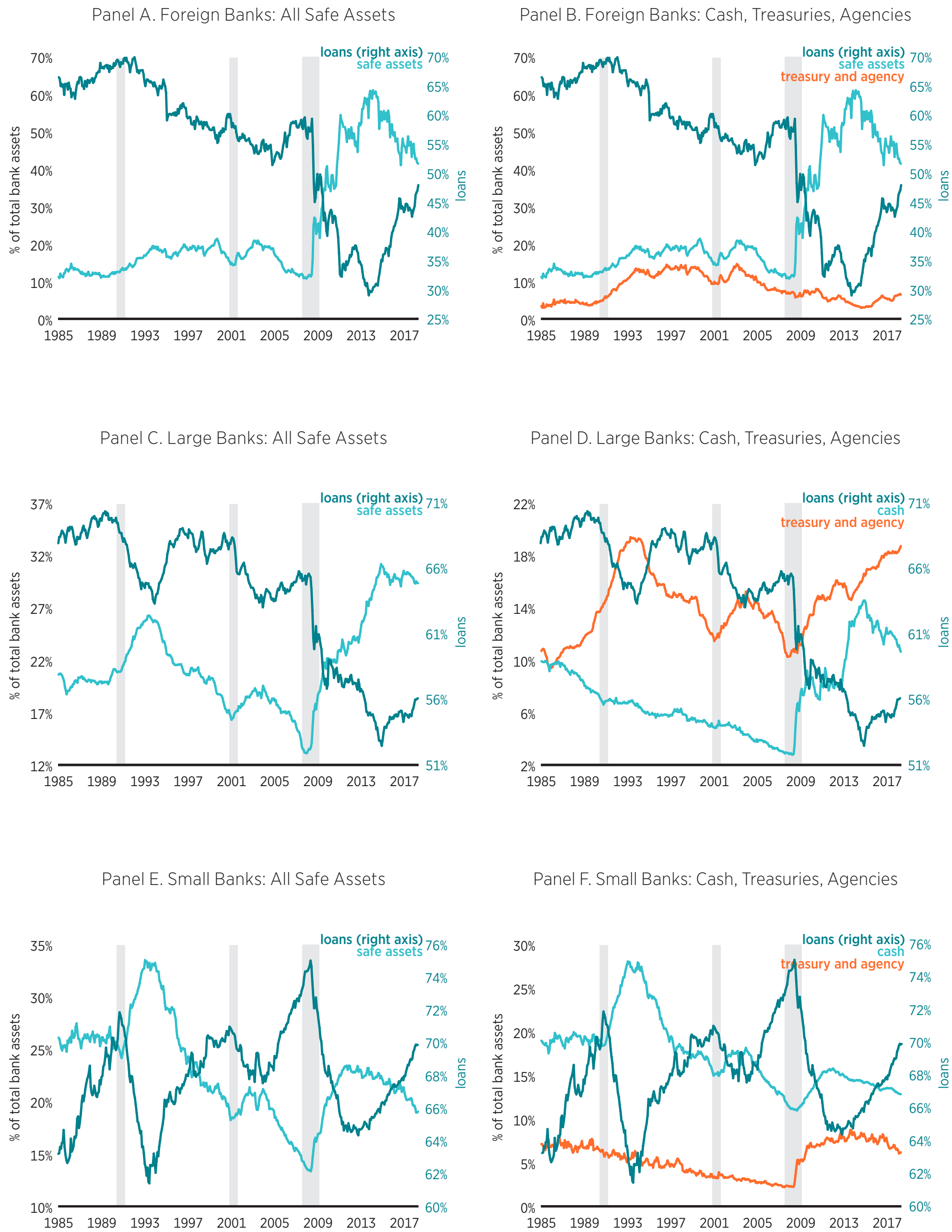
Panel E shows the aggregated bank portfolio for small domestic banks. It reveals that, unlike the foreign-related institutions and large domestic banks, the small banks show a strong relationship between the safe asset share and the loan share both before and after 2008. However, panel F shows that there is a rise in the cash share after 2008 similar to what was found for the other bank subcategories. The treasury shares, though, appear to maintain a relationship with the loan share, too.

To allow better analysis of these bank subcategory relationships, table 2 replicates the regressions run in table 1 for both the pre-floor and floor periods. The results generally confirm the visual impressions from figure 8.

For the foreign banks, there is a modest relationship between the safe asset share and the loan share before late 2008, with an R^2 of 25 percent that jumps to 73 percent during the floor period. Most of this change comes from the cash share: its partial R^2 goes from 2 percent before late 2008 to 53 percent afterward.

The regression for large domestic banks shows a modest relationship between the cash share and the loan share before the floor period, but the sign is the wrong direction—it is positive—and reflects the downward trend in both series. After 2008, the cash share gets the expected sign—negative—and its

FIGURE 8. PORTFOLIO SHARES OF US COMMERCIAL BANK ASSETS—SUBCATEGORIES



Note: Shaded time periods represent recessions.

Sources: Board of Governors of the Federal Reserve System, "Financial Accounts of the United States - Z.1: Release Dates," September 20, 2018, https://www.federalreserve.gov/releases/z1/; Board of Governors of the Federal Reserve System, "Assets and Liabilities of Commercial Banks in the United States - H.8," October 19, 2018, https://www.federalreserve.gov/releases/h8/current/default.htm.

TABLE 2. DEPENDENT VARIABLE: LOAN SHARE

Variables	Foreign banks				Large domestic banks				Small domestic banks			
	Pre-floor period 4/1985–9/2008		Floor period 10/2008–7/2018		Pre-floor period 4/1985–9/2008		Floor period 10/2008–7/2018		Pre-floor period 4/1985–9/2008		Floor period 10/2008–7/2018	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Safe Assets (All)	−0.827 (−9.54)***	–	−0.497 (−17.53)***	–	0.052 (1.25)	–	−0.493 (−34.56)***	–	−0.601 (−30.94)***	–	0.835 (−19.66)***	–
Cash Share	–	0.487 (2.11)**	–	−0.498 (−11.48)***	–	0.627 (14.39)***	–	−0.639 (−22.91)***	–	−0.827 (−12.93)***	–	−0.282 (−2.34)**
Treasury/ Agency Share	–	−0.725 (−8.71)***	–	−0.505 (−1.40)	–	−0.238 (−7.19)***	–	−0.309 (−9.06)***	–	−0.516 (−17.46)***	–	−1.224 (−13.74)***
Intercept	0.739 (53.53)***	0.645 (31.99)***	0.618 (46.01)***	0.619 (17.53)***	0.657 (78.62)***	0.662 (114.50)***	0.690 (184.43)***	0.676 (167.25)***	0.786 (170.69)***	0.781 (167.70)***	0.834 (91.58)***	0.848 (96.63)***
R^2	0.25	0.33	0.73	0.73	0.06	0.53	0.91	0.93	0.77	0.78	0.78	0.82
Partial R^2: Cash Share	–	0.02	–	0.53	–	0.43	–	0.83	–	0.11	–	0.56
N	282	282	118	118	282	282	118	118	282	282	118	118

* = significant at the 10% level, ** = significant at the 5% level, *** = significant at the 1% level.

partial R^2 goes to 83 percent. The partial R^2 is large relative to the overall partial R^2 of 93 percent.[34]

For the small domestic banks, the safe asset share is an important explanatory variable across both periods, with an R^2 of 77 percent before 2008 and an R^2 of 82 percent afterward. The underlying treasury, agency, and cash assets are significant across both periods, but the cash share's explanatory power grows during the floor period. Its partial R^2 goes from 11 percent to 56 percent. The small banks are unique, then, in that all the safe asset subcategories maintain significant relationships across both periods.

To summarize, across the entire US banking system there has been a consistently negative relationship between the safe asset share and the loan share both before and after 2008. These two series move in opposite directions, both cyclically and structurally. While this overall relationship has proven to be robust, the underlying assets driving this relationship have changed in a dramatic fashion since the floor system was adopted. Whereas treasury and agency securities drove the relationship before 2008, it has been almost entirely driven by the cash share since that time. Expressed differently, since the advent of the floor system there has been a huge shift within bank portfolios toward cash and away from loans.

Explaining the Change in Bank Asset Allocation

The previous section reported a dramatic and persistent shift in bank portfolios for the asset classes of loans, cash, and government securities, starting in 2008. This timing points to the Fed's floor system and, in particular, the setting of IOER rates above comparable short-term market interest rates as the key culprit behind the change. This section of the paper empirically tests this understanding using this IOER spread in a series of two-stage least square (2SLS) regressions to predict changes in the cash and loan shares held by banks.

This focus on bank asset shares rather than asset levels is important, since banks collectively determine the asset composition of their portfolios, not the absolute size. That is, banks in the aggregate only have complete control over the asset shares on their balance sheets. They do not have such control over the aggregate dollar level of reserves and loans. The level of reserves, in particular, is

34. For the large domestic banks, the safe asset share was positive and had a small R^2 of 5.60 percent before the floor period. This seems to contradict the visual impressions of panel C in figure 8 and all the other regressions. Further regressions analysis using a time trend or first-differenced data creates the expected negative sign and a larger R^2. The apparent reason for this is the downward trend in both series.

determined by the Fed, while the level of loans is jointly determined by monetary policy, regulations, the state of the economy, and banks' investment decisions. Consequently, it is important to treat bank asset ratios as the choice variables in the regression analysis.

In addition, the simple theoretical model outlined in the "Stylized History" section provided the following predictions for the cash and loan asset shares:

$$\frac{R}{A} = f\left(\overbrace{IOER - i_{ST}}^{+}, \overbrace{L^D}^{-}\right) \tag{1}$$

$$\frac{L}{A} = f\left(\overbrace{IOER - i_{ST}}^{-}, \overbrace{L^D}^{+}\right), \tag{2}$$

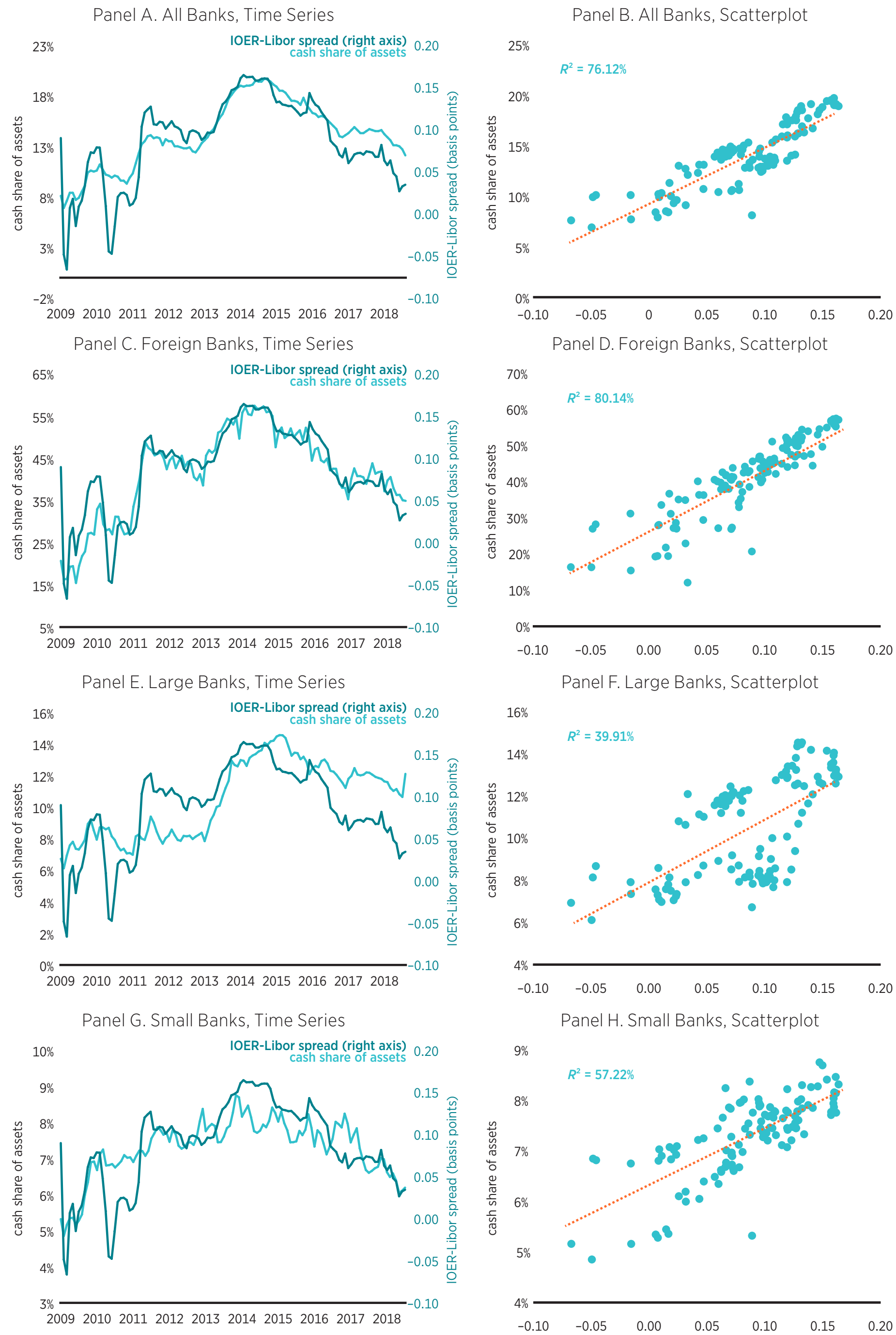
where R/A are bank reserves (i.e., cash) over total bank assets, L/A are loans over total bank assets, and L^D is loan demand. These equations will be used to motivate the 2SLS regressions that follow. The spread used in these regressions is the IOER rate minus the overnight dollar Libor rate and can be seen in figure 1. The latter is an overnight dollar interbank interest rate and is therefore a relevant interest rate for banks in evaluating the relative return to reserves.

Figures 9 and 10 begin the analysis by first plotting the time series of the cash share and loan share categories against the IOER-Libor spread for each grouping of banks. These figures provide a first look at the data and relationships before the 2SLS regressions. Panels A, C, E, and G in both figures show the times series of the variables, while panels B, D, F, and H show their scatterplots. The analysis starts in January 2009 to avoid the noise from the Fed's experimentation with the IOER rate in late 2008.[35] The sample, therefore, runs from January 2009 to July 2018.

Panels A and B of figure 9 show that for all commercial banks, the link between the IOER-Libor spread and the cash asset share is strong and positive, with an R^2 of 76 percent. The subsequent panels show the relationships for the various bank subcategories. The strongest relationship is found for the foreign banks in the United States (foreign-related institutions), with an R^2 of 80 percent.[36] The weakest relationship is found for the large domestic banks, with a

35. The IOER rate was first introduced at 0.75 percent, which was below the effective federal funds rate, making the operating system more like a corridor system. Then, during the rest of the 2008, the Fed raised the IOER rate to 1.15 percent, then lowered it to 0.65 percent, and raised it back to 1.00 percent. During this last period, the IOER rate was as much as 90 basis points higher than the federal funds rate. Not until January 2009 do we see the floor system settling down into its current form.
36. The relationship for the US branches of foreign banks may be stronger because such banks are better able to profit from the IOER-Libor spread, since they do not have to pay Federal Deposit Insurance Corporation insurance premiums for noninsured US deposits.

FIGURE 9. CASH SHARE AND THE IOER-LIBOR SPREAD



Sources: Board of Governors of the Federal Reserve System, "Financial Accounts of the United States - Z.1: Release Dates," September 20, 2018, https://www.federalreserve.gov/releases/z1/; Board of Governors of the Federal Reserve System, "Assets and Liabilities of Commercial Banks in the United States - H.8," October 19, 2018, https://www.federalreserve.gov/releases/h8/current/default.htm; Federal Reserve Bank of St. Louis, Federal Reserve Economic Data (database), accessed October 25, 2018, https://fred.stlouisfed.org.

still-nontrivial R^2 of 40 percent. The small domestic banks show a link with an R^2 of 57 percent. In all cases, however, there is a positive systematic relationship between the IOER-Libor spread and the cash asset share held by banks.

Figure 10 shows a similar but negative relationship between the IOER-Libor spread and the loan asset share. For all commercial banks the link is strong, with an R^2 of 82 percent. Once again, the strongest relationship is found with the foreign banks in the United States (foreign-related institutions), with an R^2 of 66 percent. One difference, though, is that now the large domestic banks and small domestic banks have relationships that are similar in strength. The large banks' relationship has an R^2 of 47 percent while the small banks' relationship has an R^2 of 46 percent. In short, across all banks there is a negative systematic relationship between the IOER-Libor spread and the loan asset share held by banks.

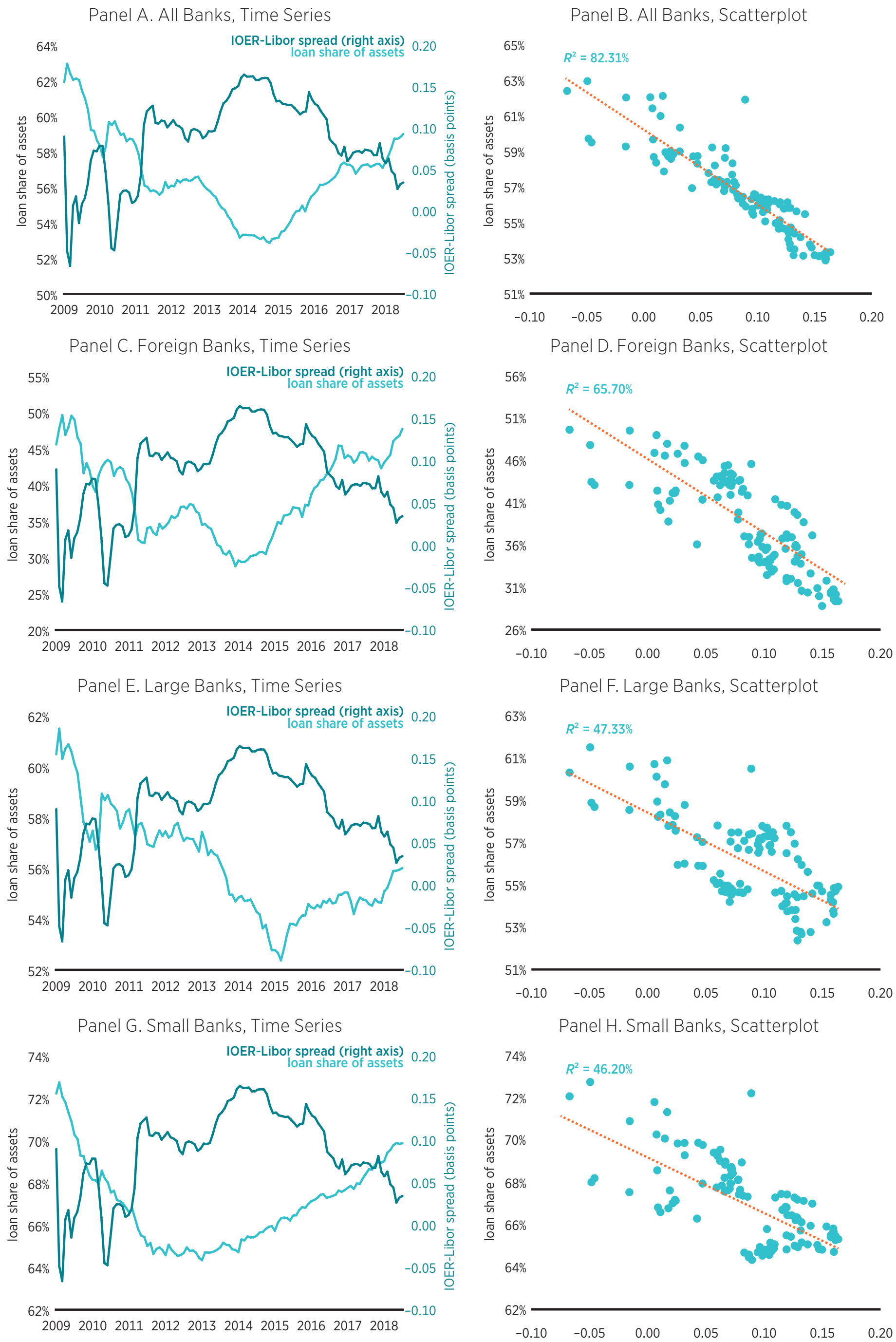
Although these initial results support the argument that the Fed's floor system is behind the structural change in bank portfolios, they suffer from simultaneity bias. An increase in the IOER-Libor spread may raise the relative return and therefore the demand for reserves, but it is also possible that a large injection of reserves via the Fed's LSAPs could create a liquidity effect that lowers short-term interest rates and thereby causes the IOER spread to rise.

To deal with this endogeneity issue, this paper reestimates these relationships using a series of 2SLS regressions using two instrumental variables (IVs). The first IV is the IOER rate minus the repo yield spread seen in figure 1. The repo rate is calculated by the Depository Trust & Clearing Corporation and is based on repos that use treasury bills as collateral. The idea behind this instrument is that banks take prices as given in the overnight repo market and, in turn, have little influence on repo yields. This understanding finds support in the Fed's H.8 database measure "Fed Funds and Reverse Repos with Non-banks" for all commercial banks. It provides a gauge of bank activity in the overnight market and, when divided by the measure of the repo market put forward by Adam Copeland and his coauthors,[37] it reveals that banks accounted for, on average, about 12 percent of the overnight repo market activity from 2008 to 2017. Banks, in other words, were price takers rather than price makers in the overnight repo market. The IOER-repo spread, consequently, should be exogenous to any liquidity effects the LSAPs may have created for the IOER-Libor spread.[38]

37. Copeland et al., "Mapping and Sizing the U.S. Repo Market."

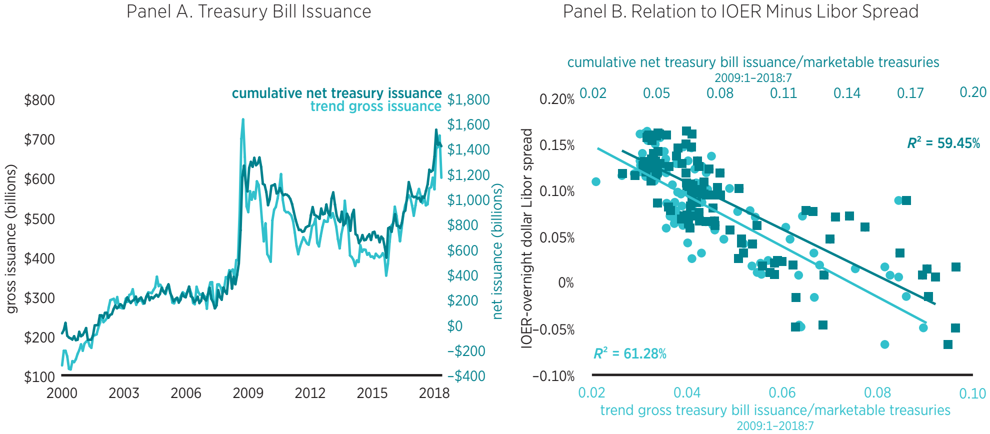
38. It is also worth noting that the Fed's LSAPs were done for longer-term treasury securities, not treasury bills. In fact, the Fed has no treasury bills on its balance sheet. Its LSAPs, then, should not have affected the IOER spread either.

FIGURE 10. LOAN SHARE AND THE IOER-LIBOR SPREAD



Sources: Board of Governors of the Federal Reserve System, "Financial Accounts of the United States - Z.1: Release Dates," September 20, 2018, https://www.federalreserve.gov/releases/z1/; Board of Governors of the Federal Reserve System, "Assets and Liabilities of Commercial Banks in the United States - H.8," October 19, 2018, https://www.federalreserve.gov/releases/h8/current/default.htm; Federal Reserve Bank of St. Louis, Federal Reserve Economic Data (database), accessed October 25, 2018, https://fred.stlouisfed.org.

FIGURE 11. TREASURY BILL ISSUANCE AND THE IOER-LIBOR SPREAD



Note: Panel B shows data for the period from January 2009 to July 2018.

Sources: SIFMA Statistics; Federal Reserve Bank of St. Louis, Federal Reserve Economic Data (database), accessed October 25, 2018, https://fred.stlouisfed.org.

This insight echoes a point from earlier in this paper: because only banks have access to the IOER rate, and given that banks face increasing costs as they seek to expand their balance sheets, they are not able to arbitrage away any IOER spread over the overnight repo interest rate. The overnight market, on the other hand, is large enough that it can arbitrage away the IOER spread if there is some development that causes repo yields to rise. The Federal Open Market Committee contends that President Trump's budget deficits *are* such a development since they are being funded mostly by the sharp increase in the issuance of treasury bills, as seen in panel A of figure 11.[39] This panel shows two measures of treasury bill issuance: the trend of the gross issuance and the cumulative net issuance. Both have risen sharply since 2017.

This sudden increase in treasury bill supply since 2017 has coincided with a rise in overnight repo yields and appears to be driving up, via arbitrage, other short-term interest rates, such as the overnight dollar Libor rate.[40] This is a pattern that has been in place since 2008, depending on how many new treasury bills were issued. Panel B of figure 11 shows that the two treasury bill issuance measures, normalized by the outstanding marketable treasury debt, are closely

39. Minutes of the Federal Open Market Committee, June 2018. See also Beckworth, "Donald Trump's Real Influence on Fed Policy."
40. This increased issuance, if continued, could lead to the end of the Fed's floor system if it causes overnight rates to rise above the IOER rate on a sustained basis. Beckworth, "Donald Trump's Real Influence on Fed Policy."

TABLE 3. ALL BANKS REGRESSIONS

Variables	Dependent Variable: Cash Asset Share			Dependent Variable: Loan Asset Share		
	(1)	(2)	(3)	(4)	(5)	(6)
IOER-Libor Spread	0.672 (12.72)***	0.657 (10.22)***	0.602 (8.33)***	−0.498 (−8.78)***	−0.467 (−9.59)***	−0.473 (−10.55)***
ΔConsumer Sentiment	–	−0.015 (−0.66)	−0.005 (−0.25)	–	0.008 (0.39)	0.009 (0.35)
ΔBusiness Sentiment	–	−0.750 (−0.45)	−0.882 (−0.55)	–	1.598 (1.83)*	1.554 (2.03)**
Δln(Real Stock Prices)	–	−0.046 (−1.05)	−0.026 (−0.60)	–	0.009 (0.26)	0.010 (0.27)
ΔUncertainty	–	0.001 (−0.68)	0.002 (0.92)	–	−0.001 (−0.37)	−0.001 (−0.32)
Liquidity Coverage Ratio	–	–	1.620 (3.41)***	–	–	0.029 (0.14)
Intercept	8.386 (15.82)***	8.600 (12.69)***	8.440 (11.86)***	60.893 (98.03)***	60.543 (113.10)***	60.581 (110.23)***
IV regression	yes	yes	yes	yes	yes	yes
R^2	0.73	0.74	0.82	0.79	0.83	0.83
IV exogeneity test (*p*-value)	0.14	0.15	0.97	0.30	0.54	0.34
N	115	115	115	115	115	115

* = significant at the 10% level, ** = significant at the 5% level, *** = significant at the 1% level.

Note: The instrumental variable exogeneity test is the Hansen J overidentification chi-square test. Standard errors are robust to heteroskedasticity and autocorrelation. The sample period is January 2009 to July 2018.

tied to the IOER-Libor spread. Since the causality goes from treasury bill issuance to the IOER-Libor spread, this provides another IV for the the 2SLS regressions. Specifically, this paper uses the trend of the gross issuance of treasury bills normalized by the outstanding marketable treasury securities as the second IV. As reported in the regression tables, the Hansen J overidentifying restriction test indicates that this intuition is correct and that instruments are indeed exogenous and valid.[41]

Table 3 provides the 2SLS regression results for all commercial banks for the period from January 2009 through July 2018. The former three regressions use the cash share of bank assets as the dependent variable while the latter three use the loan share. Columns (1) and (4) regress the respective shares on the

41. For the large domestic bank regressions and for the second foreign bank regression, a lag of the treasury bill issuance IV was used in addition to the other two IVs. This was done since Hansen J overidentification tests indicated it was necessary in these cases to get a *p*-value greater than 5 percent. The first-stage regression results are available upon request.

IOER-Libor spread alone, while the other columns attempt to control for factors that affect loan demand, L_D, to fully reflect equations (1) and (2) described above. Four variables are used to capture loan demand at the monthly frequency: the change in consumer sentiment, the change in business sentiment, the change in the log of real stock prices, and the change in uncertainty. The better the economic outlook and wealth prospects of households and businesses, the greater should be the demand for loans. Conversely, the greater the economic uncertainty, the lower should be the demand for loans.

The change in consumer sentiment is the first difference in the University of Michigan's consumer sentiment index, and the change in business sentiment is the first difference in the Organisation for Economic Co-operation and Development's business confidence index. Real stock prices are constructed by dividing the Wilshire 5000 index by the core Personal Consumption Expenditure deflator. The uncertainty measure is the average of the economic policy uncertainty index and the equity market-related economic uncertainty index provided by Scott Baker, Nicholas Bloom, and Steven Davis.[42]

Column (1) reveals that a 1-basis-point increase in the IOER-Libor spread leads to a statistically significant 0.67 percent increase in the cash asset share. Moreover, the R^2 for this relationship comes in at a strong 73 percent. This initial regression indicates that for this period there is a robust exogenous link between the IOER spread and the share of reserves held on bank balance sheets.

Column (2) extends the analysis to include the four loan demand proxy variables. None of them are significant, but they all have the correct sign, per equation (1). The R^2 in this regression barely changes, indicating that the IOER spread is driving most of the change in the cash share asset. Column (3) now includes a dummy variable for the January 2015 to December 2017 period. This dummy variable is attempting to capture the implementation of the liquidity coverage ratio (LCR) that was phased in over these years. The LCR requires banks to hold a certain amount of high-quality liquid assets in order to cover a potential bank run. Bank reserves are one of these high-quality liquid assets. Column (3) shows the LCR dummy to be significant and to have raised the average cash share ratio by 1.62 percent.[43]

Still, the IOER-Libor spread coefficient remains significant and large in this regression. Over this period, then, the IOER-Libor spread is one of the most

42. Scott Baker, Nicholas Bloom, and Steven Davis, "Measuring Economic Policy Uncertainty," *Quarterly Journal of Economics* 131, no. 4 (2016).
43. Mark House, Tim Sablik, and John R. Walter, "Understanding the New Liquidity Coverage Ratio Requirements" (Economic Brief 16-01, Federal Reserve Bank of Richmond, January 2016).

important causal determinants of the reserve holdings by banks. It alone explains about 73 percent of the variation in the cash share of bank portfolios.

Column (4) looks at the loan share. It finds that a 1-basis-point rise in the IOER-Libor spread leads to 0.50 percent decline in the loan share. Moreover, the R^2 comes in at 79 percent, indicating another robust causal link emanating from the IOER spread. Column (5) adds the loan demand control variables and, again, they have the correct signs per equation (2), but are insignificant. The R^2 does not change much, again, pointing to the IOER spread as an important determinant of the loan share. Finally, column (6) adds the LCR dummy variable and it is found to be insignificant, an unsurprising result given that this regulatory requirement should only affect the cash holdings.

Table 4 repeats these 2SLS regressions for each of the subcategories of banks over the same period. Here the LCR is only run in the cash share regressions, given the previous results for the aggregate bank regressions. The IOER spread again has the right sign in both the cash share and loan share cases. The univariate regressions create R^2s that are very similar to the regular regression R^2s seen in figures 9 and 10. Specifically, foreign banks in the United States have the strongest cash share and loan share relationships, with R^2s of 76 and 66 percent, respectively. Small domestic banks and large domestic banks have lower R^2s, but they are still fairly strong and always significant. Adding the loan demand variables does not meaningfully change these measures of fit, except for the large domestic banks in their cash share regressions. The LCR is significant only for them and appears to be the reason for the change in R^2. The LCR, then, appears to be a binding constraint only on the large domestic banks.

In short, the IOER-Libor spread is found to be an important causal determinant of the cash share and loan share held by commercial banks in the United States at the aggregate and subcategory levels. These results explain the structural changes seen in bank portfolios, as displayed in figures 7 and 8 and in tables 1 and 2. Specifically, they strongly suggest that it was the Fed's move to its floor system that radically changed the portfolios of banks, starting in early 2009.

Counterfactual Analysis

To shed further light on the role the Fed's floor system has played in changing the structure of bank portfolios, figure 12 creates counterfactual cash and loan shares at the aggregate level for commercial banks in the United States. This involves taking the estimated multivariate regression models and plugging in the actual data for all variables, with one modification: the IOER rate is set to

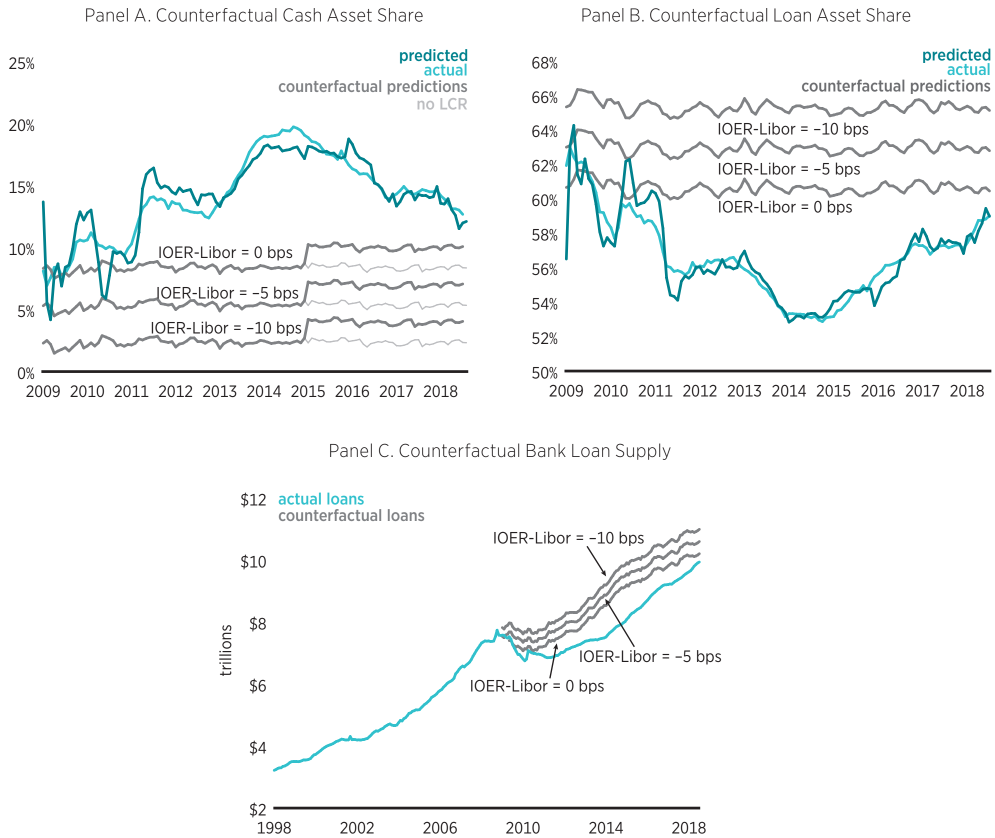
TABLE 4. SUBCATEGORY BANKS REGRESSIONS

	Dependent Variable: Cash Asset Share									Dependent Variable: Loan Asset Share					
Variables	Small banks	Small banks	Small banks	Large banks	Large banks	Large banks	Foreign banks	Foreign banks	Foreign banks	Small banks	Small banks	Large banks	Large banks	Foreign banks	Foreign banks
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
IOER-Libor Spread	0.151 (4.48)***	0.136 (4.68)***	0.141 (5.16)***	0.391 (6.64)***	0.405 (6.24)***	0.304 (4.50)***	2.215 (10.76)***	2.081 (9.76)***	2.050 (10.90)***	−0.3150 (−3.53)***	−0.269 (−3.84)***	−0.384 (−5.46)***	−0.377 (−5.01)***	−0.904 (−6.70)***	−0.796 (−4.38)***
ΔConsumer Sentiment	–	−0.003 (−0.32)	−0.003 (−0.38)	–	−0.028 (−0.94)	−0.010 (−0.39)	–	−0.107 (−1.64)	−0.101 (−1.55)	–	0.007 (0.39)	–	0.021 (0.96)	–	−0.025 (−0.61)
ΔBusiness Sentiment	–	−0.821 (−1.69)*	−0.789 (−1.59)	–	0.662 (0.38)	0.379 (0.30)	–	−6.963 (−1.57)	−7.015 (−1.50)	–	2.450 (2.81)***	–	0.389 (0.26)	–	5.326 (1.87)*
Δln(Real Stock Prices)	–	0.020 (1.58)	0.018 (1.45)	–	−0.046 (−1.69)*	−0.012 (−0.38)	–	−0.128 (−0.94)	−0.117 (−0.88)	–	−0.048 (−2.03)**	–	0.024 (0.79)	–	−0.023 (−0.32)
ΔUncertainty	–	0.001 (2.12)**	0.001 (2.03)**	–	0.002 (0.78)	0.002 (1.29)	–	−0.005 (−0.71)	−0.005 (−0.70)	–	−0.001 (−0.50)	–	−0.001 (−0.70)	–	−0.001 (−0.24)
Liquidity Coverage Ratio	–	–	−0.068 (−0.43)	–	–	2.863 (6.14)***	–	–	1.017 (0.82)	–	–	–	–	–	–
Intercept	5.997 (16.72)***	6.143 (20.39)***	6.125 (19.92)**	7.116 (16.30)***	7.035 (10.35)***	6.795 (11.16)***	22.600 (9.79)***	24.230 (11.21)***	24.096 (10.58)***	69.651 (70.39)***	69.198 (83.04)***	59.428 (104.44)***	59.321 (93.49)***	46.281 (33.70)***	45.154 (28.73)***
IV regression	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
R^2	0.53	0.60	0.59	0.36	0.35	0.73	0.76	0.81	0.82	0.44	0.52	0.39	0.40	0.66	0.69
IV exogeneity test (*p*-value)	0.33	0.52	0.36	0.09	0.09	0.60	0.39	0.65	0.89	0.979	0.6	0.087	0.12	0.12	0.16
N	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115

* = significant at the 10% level, ** = significant at the 5% level, *** = significant at the 1% level.

Note: The instrumental variable exogeneity test is the Hansen J overidentification chi-square test. Standard errors are robust to heteroskedasticity and autocorrelation. The sample period is January 2009 to July 2018.

FIGURE 12. COUNTERFACTUAL ASSET SHARES AND LOAN SUPPLY



Sources: Federal Reserve Bank of St. Louis, Federal Reserve Economic Data (database), accessed October 25, 2018, https://fred.stlouisfed.org; author's calculations.

counterfactual values that are equal to or less than the overnight Libor rate. Specifically, the IOER-Libor spread is set as equal to 0, −5, and −10 basis points (bps). The negative values are used because, as mentioned earlier, the IOER rate would fall below the other overnight rates in a corridor system.

This counterfactual experiment, in other words, asks what would have happened to the cash share and the loan share if the IOER rate had not been set above overnight interest rates. What would have happened if the Fed had stuck with the corridor system instead of going to the floor system?

Panel A of figure 12 reports the results for the counterfactual cash asset shares. At its peak in 2014, the cash share reached about 20 percent. The counterfactual levels would have ranged from 3 percent to 9 percent. Cash reserves, in other words, were over twice as high as they would have been in a corridor system, according to a conservative estimate. As of mid-2018, the actual cash share had fallen to roughly 13 percent. This narrowing, though, is largely the result of President Trump's budget deficits, which pushed up short-term interest rates, rather than of anything the Fed has done.[44]

Panel B shows a similar pattern for the actual and counterfactual loan shares. The actual loan share had fallen to about 53 percent in 2014, while the counterfactual loan shares ranged from 60 percent to 65 percent. Loan shares, however, have recently risen and now make up approximately 59 percent of bank assets.

Panel C takes the counterfactual analysis one step further by plotting the implied dollar level of loans, given the counterfactual loan share ratios and the actual level of bank assets since early 2009. The biggest gap among the counterfactual and actual loan levels emerges in 2014, when actual bank loans amounted to $7.89 trillion, compared to a counterfactual range of $9.10 trillion to $9.81 trillion. As of July 2018, the actual loan supply is $9.93 trillion, compared to a range of $10.20 trillion to $10.98 trillion. At the high end, then, the loan supply is still short by up to a trillion dollars.

While these counterfactuals are speculative, they suggest that the Fed's floor system may have come at a steep cost in terms of forgone loan supply. Thomas Hogan arrives at a similar conclusion, though he takes a different approach. Unlike the aggregate H.8 data used in this study, Hogan uses Federal Deposit Insurance Corporation Call Report data for the period from quarter 1, 2000, to quarter 3, 2017, at the bank holding company level. These data provide him with just over 7,000 firm observations each quarter. He finds that the "Fed's IOER policy . . . accounts for approximately 72% of the decline in banks' post-crisis loan allocations."[45] Hogan's results are consistent with the findings presented in this paper. Both point to the introduction of the Fed's floor system as not just a divorce from money, but a Great Divorce—one that has dramatically affected bank portfolios and, as a result, the loan supply and ostensibly broad money growth as well.

POLICY IMPLICATIONS

This paper has shown that, since 2008, there has been a significant reallocation within US bank portfolios away from loans and toward reserves. The paper has also shown that a majority of this change appears to be explained by the spread between the IOER rate and other comparable short-term interest rates. On the

44. Beckworth, "Donald Trump's Real Influence on Fed Policy."
45. Hogan, "Bank Lending and Interest on Excess Reserves," 32.

one hand, this is an unsurprising result: the Fed's floor system intentionally aims to eliminate the opportunity cost of holding bank reserves so that the Fed can independently use its balance sheet as tool. This is supposed to a feature, not a bug, of a floor system.

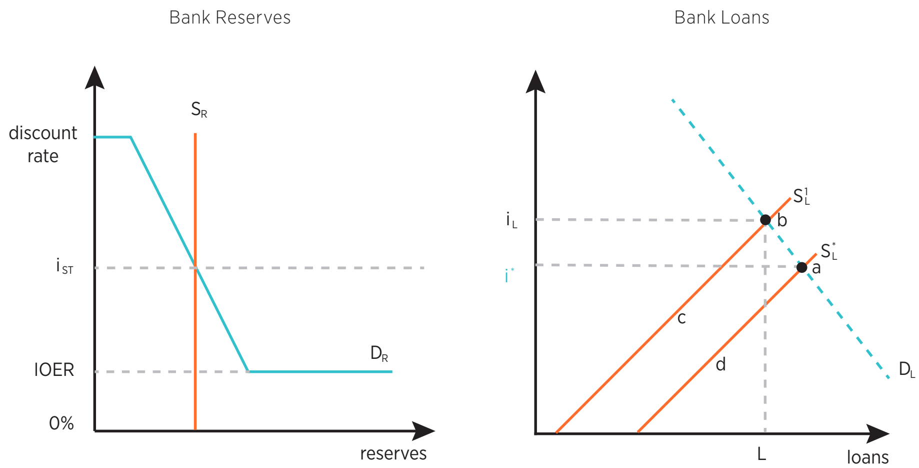
What may be surprising, on the other hand, is the persistent decline in the portion of bank portfolios allocated to bank loans. Not only has this decline in the loan share mirrored the rise in the cash share, but the level of loans remains below the precrisis trend and below the counterfactual values estimated above. This record is consistent with broad measures of the money supply, which have also been growing on a trend path that is lower than their pre-2008 trajectory.[46] Since loan creation drives the broader money supply, the Fed's floor system may be having broader ripple effects on economic growth. This is the Great Divorce.

The added monetary policy flexibility created by the Fed's floor system, consequently, may be coming at a steep price. In addition, a floor system generally leads to a larger central bank balance sheet, which creates a new set of problems. For the Fed, these include greater interest rate risk, the crowding out of the private financial system, the bad optics of larger IOER payments to banks, and the potential distortion of the Treasury Department's cash- and debt-management plans.[47] For all these reasons, then, the Fed should consider a move back to a corridor system, as has been suggested by George Selgin and John Taylor.[48]

One concern about returning to a corridor system is that the Fed would lose the extra interest rate control it has gained with IOER. IOER, however, can coexist with a corridor system. In fact, as Selgin has shown, the introduction of IOER was originally intended by Congress to support the Fed's pre-2008 corridor system.[49] Congress never intended IOER to become the main instrument of

46. David Beckworth and Josh Hendrickson, "Money Still Matters" (working paper, 2018).
47. For more on these concerns see David Beckworth, "The Political Economy of Shrinking the Fed's Balance Sheet," *Macro Musings Blog*, September 21, 2017; David Beckworth, "The Other Side of the Fed's Balance Sheet," *Macro Musings Blog*, October 20, 2017; Peter Ireland, "Fed Should Stop Paying Interest on Reserves," e21 (Manhattan Institute for Policy Research), February 22, 2018.
48. Selgin, *Floored!*; John B. Taylor, "Alternatives for Reserve Balances and the Fed's Balance Sheet in the Future" (Economics Working Paper 18103, Hoover Institution, Stanford, CA, January 2018).
49. George Selgin, "A Further Examination of Federal Reserve Reform Proposals" (Testimony before the House Subcommittee on Monetary Policy and Trade, January 10, 2018). IOER were introduced as part of the Financial Services Regulatory Relief Act of 2006. This act also allowed the Fed to pay interest on required reserves (IORR). The idea was to eliminate the implicit tax on reserves and remove the incentive for banks to engage in reserve-avoidance measures. IOER would support the corridor system by providing better interest rate control by creating a lower bond on short-term interbank interest rates. Along these lines, Congress stipulated that IOER were to paid "at rate or rates not to exceed the general level of short-term interest rates."

FIGURE 13. A CORRIDOR SYSTEM WITH IOER



monetary policy, as it has under the floor system. Instead, IOER were created to improve interest rate control in the existing pre-2008 corridor system.

Figure 13 shows how IOER were originally intended to work, and how they could do so again. In this system, IOER sets the floor to an interest-rate corridor at a value greater than zero but below the short-term interest rate, i_{ST}, while the Fed's discount or prime rate sets the ceiling. This corridor will shift on the basis of the state of the economy and, consequently, so will the IOER rate. For example, during a deep recession, the corridor could fall below 0 percent. The key is that the IOER rate and discount rates would form a constant buffer around an ever-changing short-term interest rate target. A move to this system would preserve the added flexibility provided by IOER while avoiding the problems of the floor system.[50]

The transition to a corridor system is straightforward. First, keep the IOER rate fixed and allow comparable short-term interest rates to rise above it as the Fed shrinks its balance sheet. Since the contraction of the Fed's balance sheet is conditional upon a continued recovery, short-term interest rates should naturally rise during this process. When this happens, the market for bank reserves

50. This corridor system would also be consistent with implementing a negative interest rate policy, as envisioned in Ruchir Agarwal and Miles Kimball, "Breaking through the Zero Lower Bound" (IMF Working Paper 15/224, International Monetary Fund, October 2015); and in Miles Kimball, "Negative Interest Rate Policy as Conventional Monetary Policy," *National Institute Economic Review* 234, no. 1 (2015).

will be back on the downward-sloping portion of the reserve demand curve. Money will again matter for monetary policy, and presumably there will be more robust loan and credit growth. In general, the efficacy of monetary policy should improve under a corridor system and end the Great Divorce that has been plaguing Fed policy since 2008.

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