Interest Bearing Reserves and Monetary Policy Implementation

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Abstract

I examine and critique the literature surrounding interest on reserves (IOR), from its theoretical backing to current implementation. I examine early theories around the conduct of IOR and its interaction with the fed funds market. I then discuss how the implementation of IOR has differed from these theories, and, through a simple model of the fed funds market, I show how IOR reshaped the market for reserves. Finally, I analyze modern challenges of IOR and monetary policy in an "abundant reserve" regime. As a whole, the IOR literature still faces many questions about how IOR influences financial markets, how many reserves are necessary, and its relevance for the macroeconomy.

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JEL Classification: E43, E52, E61, G21

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1 Introduction

Prior to 2008, the Federal Reserve mainly conducted policy by affecting the quantity of reserves in the banking system to move the fed funds rate. If they wanted to raise the interest rate, they would simply decrease the quantity of reserves through open market operations, increasing the interest rate. To lower the interest rate, they would increase the quantity of reserves. However, quantitative easing drastically increased the number of reserves in the financial system, leaving the Fed unwilling to reduce the number of reserves to conduct policy in this pre-2008 manor. Instead, the Fed now conducts policy through manipulating a new policy: interest on reserves (IOR). The idea of interest on reserves goes back to at least Lauchlin Currie's proposed 1935 banking reforms in response to the Great Depression (Phillips & Minsky, 1996). Milton Friedman (1960) even theorized that paying interest on reserves (IOR) would centralize more of the money supply at the central bank, giving it greater influence over the money supply and short term interest rates because banks demand a higher quantity of reserves.

However, it took until 2006 for Congress to authorize the Fed to ability to pay interest on reserves. The law intended to incentivize banks to hold reserves beyond what was required. The policy was originally slated to go into effect in 2011, but the Fed moved the start date up to October 2008, hoping to gain an additional policy tool and to increase bank reserve holdings in response to the financial crisis. The Bank of England started paying interest on reserves shortly thereafter in 2009, while the European Central Bank had since its inception in 1999. Shortly after the policy was implemented, the amount of reserves in the system increased significantly and has continued to stay high since (Figure 1) due to a greater incentive to hold reserves, a desire by banks to hold more reserves in response to the financial crisis, and quantitative easing.

The Fed's use of interest on reserves as standard policy worldwide is merely 15 years old, and the literature behind it is just now beginning to blossom. Further, there is still much debate on the proper way to model interest on reserves, and some ambiguity around

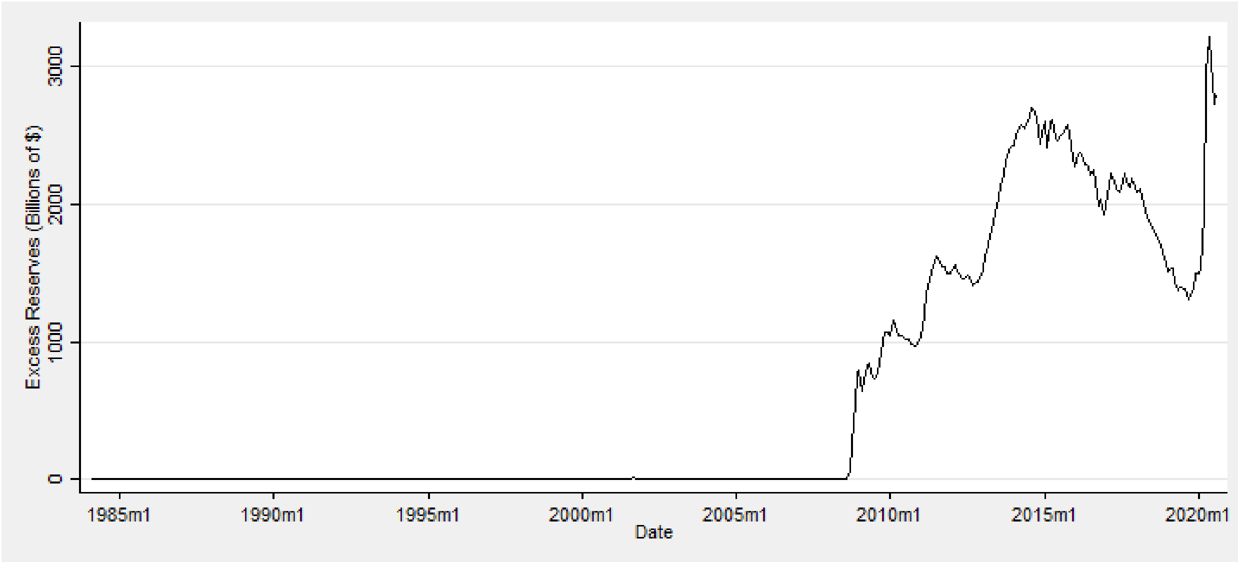

Figure 1: Quantity of excess reserves

the effects of the policy on both the fed funds market and the economy as a whole. Some of this ambiguity lies in the uncertainty around the proper model to use. The literature thus far has largely focused on the Federal Reserve but has somewhat ignored the bank side of the market and, to a certain extent, financial markets. A focus on how banks allocate assets when interest is paid on reserves can give insight into how IOR changed the Fed's instruments. The structure of this paper is as follows: section II examines the theoretical benefits of the policy, section III discusses why these theories did not hold and builds a model of the fed funds market with IOR, section IV looks at the implementation of monetary policy with IOR, and section V concludes.

2 Early Theories

Paying interest on reserves theoretically gives a central bank a greater amount of control over the economy by putting a floor on the overnight rate (Figure 2) and allowing policy-makers to better dictate inflation expectations. The primary rationale for paying interest on reserves was put forth by Goodfriend (2002). Goodfriend discusses how innovations in payment methods began to worry economists that central banks could lose some control over

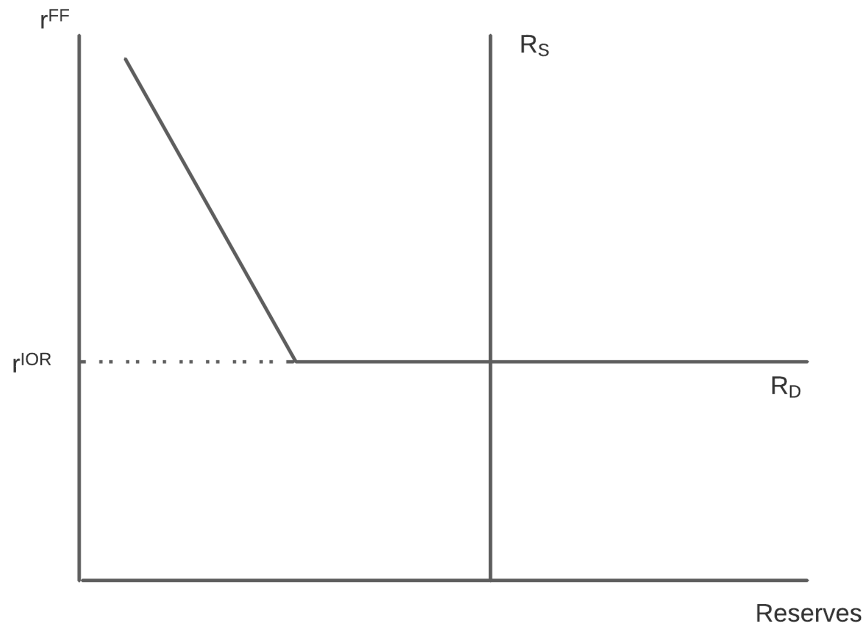

Figure 2: Market for reserves

interest rates in the future. Competition among currencies, especially with the introduction of cryptocurrency, lessens a central bank's power over the market by shrinking the relative size of their instruments. Put another way: if fewer people transact in dollars, people are less sensitive to the interest rate on dollars. Additionally, the 1990's in Japan showed that deflation could occur at the zero lower bound. Central banks needed to further consider what can or should be done in this case, and whether they have the correct tools to implement an appropriate policy.

Goodfriend lays out how a central bank can implement interest on reserves by first satiating the market for reserves. A satiated market for reserves will drive the interest rate to its lower bound because there will already exist supply to satisfy changes in demand. In tandem, the central bank can institute interest on reserves. This can act as a floor for the overnight market for reserves: banks will not lend below the IOR rate because they can simply hold their excess reserves and earn interest. As a result, a central bank would be free to use open market operations to pursue short-run financial stability, changing the quantity of reserves to ensure banks are adequately capitalized. A central bank can move the interest rate in the overnight market for reserves by simply adjusting the IOR rate, then adjusting bank reserves to smooth shocks to the financial system. The policy would also aid a bank's risk profile by allowing it to shift from other, riskier interest bearing assets to a perfectly safe interest bearing asset of reserves. This allows a central bank to limit how much of its own capital is used for investment in private credit by banks. In short, Goodfriend (2002) sees paying interest on reserves as an effective way to combat changes in the structure around monetary policy without compromising the effectiveness of policy in the short run.

Kashyap and Stein (2012) look at additional theoretical benefits of IOR. They begin with the assumption that the Fed can set IOR and the fed funds rate separately and explore how the central bank can use IOR to combat externalities created by bank debt. In their model, banks can change their maturity positions at the start of each period. As a bank sells off its shorter term assets in favor of long term assets, it depresses the price of short term assets. This tightens constraints on other institutions in the market, forcing them to change their maturity position as well to reflect the new asset values. In turn, banks create an externality by changing their maturity position. Kashyap and Stein use their model with a representative bank to explore how monetary policy can implement a sort of Pigouvian tax or cap and trade regulation to curb the effect of these externalities. These pseudo-regulatory policies can be implemented through changes in the reserve requirement and changes in the scarcity of reserves. However, for a central bank to implement this through controlling the scarcity of reserves, it cannot have an excessively large balance sheet as described by Goodfriend (2002). The introduction of interest on reserves gives a central bank an additional tool, allowing it to use the interest rate on reserves to change a bank's optimal maturity position and change the quantity of reserves to influence financial market liquidity. In this system, a central bank can control financial stability through its management of the total quantity of reserves and reserve requirements, thereby forcing the market to internalize its externality. Additionally, a central bank can control inflation through its manipulation of the interest rate on reserves.

Berentsen and Monnet (2008) explore how similar staggered funding decisions occur through a channel system in which the central banks sets upper and lower bounds for its target rate and allows the market to equilibrate in that range. They define the policy rate to be the average of the rate on reserves and the discount rate, ($r^{ff} = \frac{r^d + r^{ior}}{2}$) and assume the discount rate is always greater than or equal to the interest rate on reserves ($r^d \geq r^{ior}$). Through the Fisher equation, they find inflation increases as the policy interest rate increases. Perhaps most importantly, policy can be tightened by simply increasing the size of the spread. When the spread increases, there is less relative liquidity in the financial system, increasing interest rates across the board and decreasing consumption. As a result, Berentsen and Monnet point out that optimal policy in an interest on reserves world must focus on the interest rate corridor, that is it must specify both the upper and lower bounds of policy.

3 Realities of the Policy

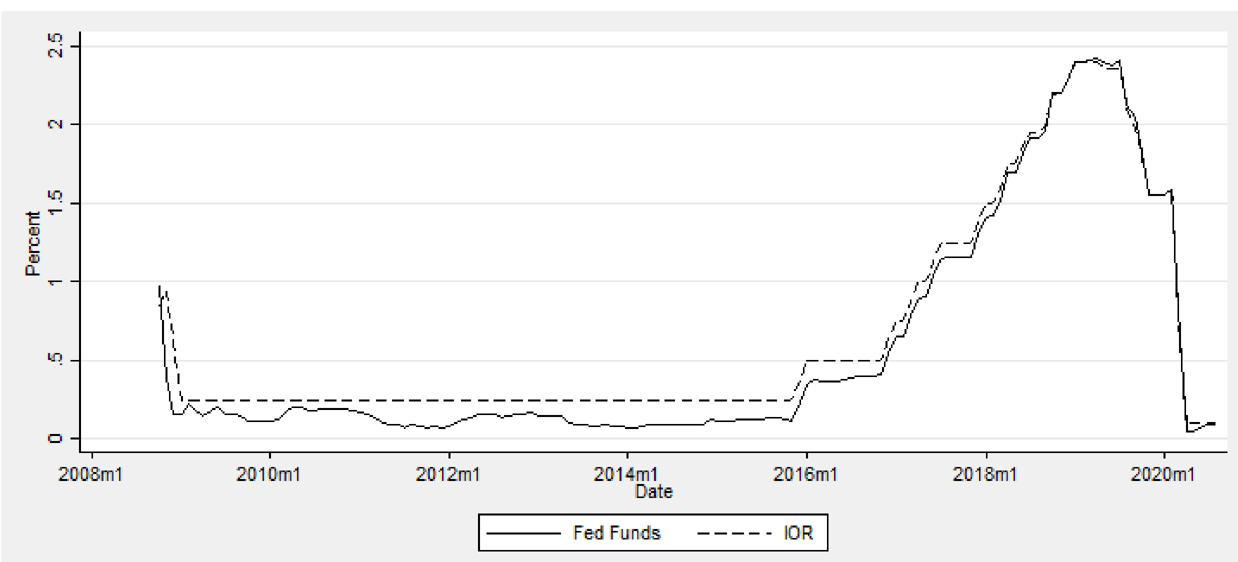

Figure 3: Fed Funds and IOR since 2008

While many of these earlier papers theorized that the Fed could set IOR and the fed funds rate independently, or that IOR would put a floor on the fed funds rate, data quickly showed neither of these predictions would hold. As Figure 3 shows, the fed funds rate has been consistently below the IOR rate. Transcripts from the Federal Reserve's October and December 2008 meetings showed many Fed officials struggling to understand this phenomenon. This confusion culminated in the December meeting with then-San Francisco Fed President Janet Yellen admitting "interest on reserves isn't working quite the way we expected," and then-Governor Elizabeth Duke noting that "this experience with interest on reserves is brand new for us, and I don't think we've had enough experience to know how it is actually going to work." Furthermore, the strong and consistent comovement between IOR and fed funds indicates that the two are not set independently, but are instead a part of the same monetary policy stance. This, in turn, left the literature with two key questions: first, why does IOR not act as a floor on fed funds, as Goodfriend (2002) had predicted? And second, given the two rates are not set independently, how can monetary policy be conducted?

Many of these papers start with a framework of a model of the interaction between the central bank and banks, similar to the one used in Armenter and Lester (2016). In the model, there are 3 primary agents: nondepository institutions without access to IOR (such as government sponsored entities like Fannie Mae and Freddie Mac), depository institutions (such as banks) with access to IOR, and the Fed. The Fed directly controls two policies: the interest rate on reserves, r^{ior} and the interest rate in a reverse repurchase facility (ON RRP), r^{rrp}, where the IOR rate is always set above the ON RRP rate ($r^{ior} >> r^{rrp}$). In turn, the fed funds rate, r^{ff}, is determined in equilibrium. A visual representation of the market can be seen in figure 4, and the timing of decisions of the market in figure 5.

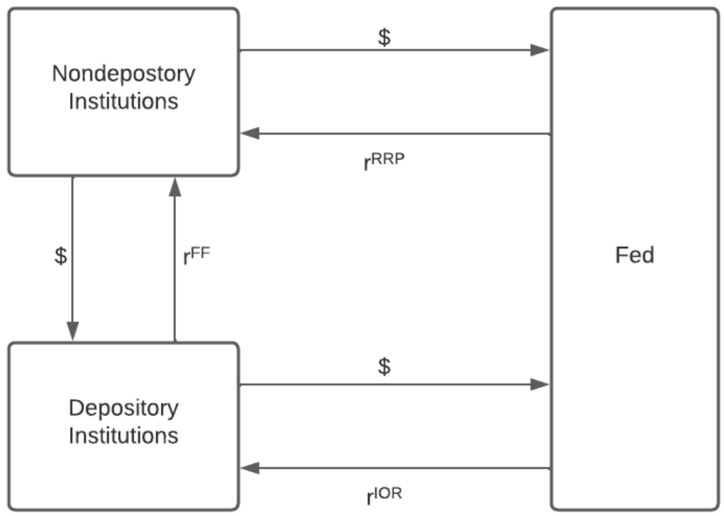

Figure 4: Visual representation of the fed funds market

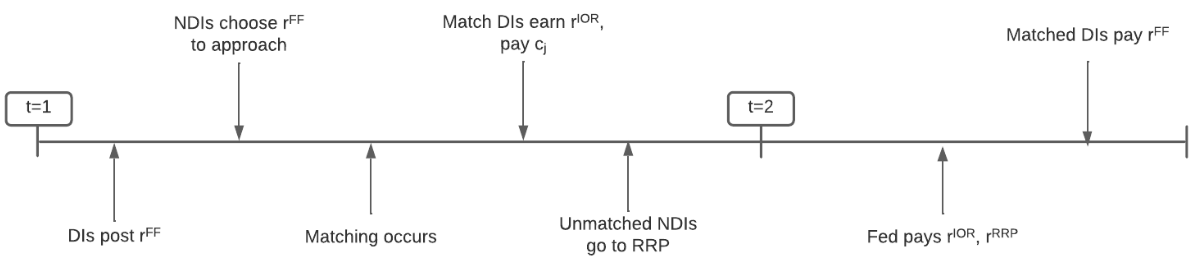

Figure 5: Timing of decisions in the fed funds market

Lenders are nondepository institutions who cannot deposit their reserves at the central bank, but they can loan through the fed funds market to a depository institution who can deposit it at the central bank and earn the interest on reserve rate, r^{ior}. Each depository institution, j, can hold these deposits at the central bank and will then keep a portion of the return as its own profit for the transaction. However, it is possible that not all lenders match with depository institutions, so lenders who do not match can enter the overnight reverse repurchase (ON RRP) facility and earn r^{rrp}. A depository institution bears a balance sheet cost, c_j, which increases if it holds reserves for lenders. Lastly, if a depository institution offers a lower interest rate in the fed funds market, they have a lower probability of matching because lenders will attempt to match with another depository institutions. However, if a depository institution offers a higher interest rate, they have a higher probability of matching, but have to pay forward more of the interest on reserves rate. As a result, lenders maximize their profit using the fed funds market rate, r^{ff}:

$$\pi(r^{ff}, q_j) = \left[\frac{1 - e^{-q_j}}{q_j}\right] r^{ff} + \left[1 - \frac{1 - e^{-q_j}}{q_j}\right] r^{rrp} \tag{1}$$

$$\pi(r^{ff}, q_j) = \Pi \tag{2}$$

$\frac{1-e^{-q_j}}{q_j}$ in equation (1) is the probability that the lender is matched with a depository institution, where q_j is the ratio of lenders to depository institutions. A depository institution's choice to enter the fed funds market depends on their balance sheet cost, c_j. A matched firm receives the fed funds rate, r^{ff}. The second term $(1 - \frac{1-e^{-q_j}}{q_j})$ is the probability the lender is not matched and enters the ON RRP facility. Equation (2) says that for a depository institution to attract lenders, their expected payoff must be equal to market profit. Solving (1) and (2) gives for the fed funds rate gives:

$$r^{ff} = r^{rrp} + \left[\frac{q_j}{1 - e^{-q_j}}\right] (\Pi - r^{rrp}) \tag{3}$$

Depository institutions with balance sheet cost c_j who choose to enter the fed funds market solve:

$$\max_{r^{ff},\, q_j} \; [1 - e^{-q_j}](r^{ior} - c_j - r^{ff}) \tag{4}$$

Subject to equation 3. Solving equation 4 gives the optimal fed funds rate and market tightness:

$$r^{ff} = r^{rrp} + \log\left(\frac{r^{ior} - c_j - r^{rrp}}{\Pi - r^{rrp}}\right)\left[\frac{(r^{ior} - c_j - r^{rrp})(\Pi - r^{rrp})}{(r^{ior} - c_j - \Pi)}\right] \tag{5}$$

$$q_j = \log\left(\frac{r^{ior} - c_j - r^{rrp}}{\Pi - r^{rrp}}\right) \tag{6}$$

Bech and Klee (2009) point to two primary factors to explain why IOR does not serve as a floor for fed funds: first, not all firms who participate in the fed funds market are eligible to receive interest on reserves. Many nondepository institutions, such as "shadow banks" and government sponsored entities, rely on the overnight market for their day-to-day funding and cannot receive interest on reserves or do not hold reserves. Next, many banks are able to borrow funds from these nondepository institutions and hold them at the Federal Reserve to collect interest on them, allowing for arbitrage in the banking market. In turn, many government sponsored entities have tightened their credit lines. Bech and Klee incorporate banks' and nonbanks' market power into a model similar to that above by weighting the probability of matching in equations (1) and (4) by the bargaining power of the firm. In essence, banks who do not need to borrow reserves to meet regulatory or withdrawal obligations have greater bargaining power in the fed funds market. These banks can instead use fed funds loans from nonbanks solely as a way to arbitrage IOR. Their model shows that there will exist a spread between the interest rate on reserves and the fed funds rate because of this discrepancy between firms in the fed funds market and those with access to interest on reserves.

The central bank can still control the fed funds rate by changing the interest on reserve rate. An increase in the interest on reserves rate does change the incentive of banks, but the different market power means that this change will likely not happen in a one for one manner. However, Bech and Klee suggest that when the spread between the interest rates becomes too large, the central bank can still control the spread by draining reserves from the system. While this will not affect the firms getting interest on reserves, it will increase the interest rate charged by firms without access to interest on reserves. This occurs by changing the relative market share of these firms in the overnight market by reintroducing many of the banks earning interest on reserves to the overnight market. In short, Bech and Klee (2009) show that interest on reserves can still have many of the benefits espoused by Goodfriend (2002), like using open market operations to influence financial stability and the reserve rate to influence the real economy, but banks' market power contributes significantly to how the spread between the IOR rate and the Fed Funds rate changes.

While the above models largely focus solely on interest on reserves, central banks can also control the ON RRP market rate. Armenter and Lester (2016) build on the above model by incorporating the concerns espoused in Bech and Klee (2009) about market power and having the central bank target the interest rate on reserves and the ON RRP rate. However, in their September 2014 press release[1], the Federal Reserve expressed interest in phasing out the ON RRP market, so Armenter and Lester use this model to explore how much control the central bank can have over the fed funds market without an ON RRP market. Without an ON RRP market, the central bank struggles to raise the overnight lending market rate by raising the interest rate on reserves. Additionally, with a cap on the volume of ON RRP market, the fed funds rate dips outside the target range only in extreme circumstances. In this scenario, depository institutions have increased power in the fed funds market: if a depositor knows the lender cannot participate in the ON RRP market, they will offer a lower fed funds rate and the lender will have greater pressure to take it. Taken as a whole, Armenter and Lester show that with interest on reserves, the central bank must utilize its control in lending markets for it to be able to influence the fed funds rate.

While the above models largely focus on the fed funds market alone, Güntner (2015) nests a fed funds market into a real business cycle model with only financial frictions to examine the market in general equilibrium. In this model, banks face liquidity risk and voluntarily enter the fed funds market. Banks hold excess reserves as a precaution against liquidity risk

[1] For more, see `https://www.federalreserve.gov/newsevents/pressreleases/monetary20140917c.htm`

and limited participation in the fed funds market, and fed funds lending emerges because of uncertainty about future deposits. While IOR and large excess reserve balances does not influence the transmission of traditional monetary policy, it does dull the transmission of quantitative easing. With the interest rate against the zero-lower bound, banks simply hold the additional reserves created by quantitative easing rather than lending. In turn, QE leads to a buildup of excess reserves and a decline in fed funds market participation.

Paying interest on reserves can also change how the economy reacts to changes in the size of the central bank's balance sheet. Williamson (2018) develops a two sector banking model similar to Armenter and Lester (2016) and others described above to examine how paying interest on reserves changes how a bank operates given balance sheet costs. These banks face capital constraints, which restricts how much they can borrow. Further, many of these banks' assets are used as collateral, so banks are further restricted when borrowing. Both the collateral and capital constraints can bind in equilibrium of Williamson's model because there is a shortage of collateral created by governments facing tighter budget constraints, limiting the quantity of bonds. Many banks are holding reserves that are on the balance sheet of other banks, which is costly. In turn, a reduction in the size of a central bank's balance sheet is welfare improving because it decreases the amount of reserves in the system, reducing this reserve-holding cost to banks and increasing the amount of collateral in the market. However, this can decrease liquidity in the financial sector, increasing risk. Further, with an introduction of an ON RRP facility into the model, a reduction in the size of the balance sheet continues to be welfare improving, but the ON RRP rate also puts a floor on the overnight funding rate. A bank with excess reserves can choose to either hold these reserves and earn interest, lend in the fed funds market, or go to the ON RRP facility. A bank will not lend in the market if it can earn a greater return in through the ON RRP, thereby putting a lower bound on the fed funds rate. Additionally, an active ON RRP market decreases the spread between the overnight funding rate and the interest rate on reserves. In Williamson's model, the interest rate on reserves is higher than the overnight funding rate, so the imposition of a floor in the ON RRP market can raise the overnight funding rate and shrink the spread with the interest rate on reserves. The introduction of the ON RRP rate as an explicit floor of the overnight rate brings this model closer to the belief set out in Armenter and Lester (2016) that the Federal Reserve can use the ON RRP facility to control the fed funds rate.

Finally, Dutkowsky and VanHoose (2020) note that, as the Fed began shrinking its balance sheet in 2017, depository institutions started to become lenders, as well as borrowers. The authors thus extend the above model to allow depository institutions to both lend and borrow in the fed funds market depending on their reserves holdings. In their model, banks choose to engage in interbank lending, as well as hold excess reserves. This, in turn, closes the spread between IOR and the fed funds rate, leaving banks indifferent between holding reserves and lending. This leads retail bank lending to be *more* sensitive to changes in IOR and fed funds, but *less* sensitive to policies such as quantitative easing. Dutkowsky and VanHoose conclude by suggesting the Fed can target the IOR-fed funds spread by manipulating the quantity of reserves in the banking system again.

4 Current Policy Implementation

Ihrig et al. (2015, 2020) lay out the Federal Reserve's perspective on policy under an interest on reserves regime. Ihrig et al. (2015) discuss that the Fed has five primary ways it can adjust interest rates. First, it can increase the interest rate on reserves. This encourages arbitrage between the fed funds rate and the reserve rate as banks attempt to borrow in the fed funds market to make a risk-free return. This puts an upward pressure on the fed funds rate as loaners can demand a higher return. While the Fed has the ability to pay interest on both required and excess reserves, interest on required reserves does not incentivize a bank to hold more reserves: they are required to hold that amount regardless of whether or not it pays interest. As such, the Fed's primary policy tool is the interest rate on excess reserves. Next, the Fed can offer reverse repurchase agreements. This can also increase the scarcity of reserves as more reserves are used in the agreements. Third, they can offer term deposits. Similar to repurchase agreements, this encourages arbitrage among banks looking for a risk free return and decreases the quantity of reserves available to be loaned in the fed funds market. Fourth and fifth, the Fed can attempt to adjust the fed funds rate the way it did before 2008: by decreasing its security holdings or increasing the reserve requirements. This increases the scarcity of reserves in the system, thereby increasing the price of reserves. Because of the large quantity of reserves now in circulation, the Fed worries that it would have to decrease the quantity of reserves too substantially to return to its pre-crisis policy. As a result, while the Fed continues to target the overnight fed funds rate, it now largely does so through both changing the quantity of reserves by adjusting its security holdings and adjusting the interest rate on reserves, somewhat similar to the system laid out in Goodfriend (2002). Changing the interest rate on reserves allows the Fed to adjust the Fed Funds rate without involvement in the market for reserves via open market operations. Given this, it is clear the interest rate on reserves is now a primary tool used by central banks to implement policy.

However, as Ihrig et al. (2020) discusses, the amount of reserves in the banking system affects the implementation of IOR. Ihrig et al. note the Fed prefers to set policy with an "ample reserves" approach where the market is satiated with reserves, similar to the proposal in Goodfriend (2002). In contrast, prior to the introduction of IOR in 2008, the Fed followed a "scarce reserves" regime which required the active management of reserves to set policy. This ample reserve regime allows the Fed to control interest rates without these daily interventions in reserves markets while still ensuring enough system-wide liquidity. However, the successful implementation of an ample reserve regime requires the Fed to carry a large balance sheet going forward, as well as remain vigilant to changes in the demand for reserves.

Dressler and Kersting (2015) take this examination a step further by incorporating a limited participation money market into a monetary DSGE model. In their model, banks can endogenously choose between holding excess reserves or lending out their reserves. Dressler and Kersting examine the implementation of IOR under these two regimes: a scarce reserve regime (where banks mostly only hold required reserves) and an ample reserve regime (where banks tend to hold many excess reserves). They find that monetary policy has a traditional effect under a scarce reserve regime. That is, a monetary contraction leads to a decline in output and inflation. However, in an ample reserve regime, a monetary contraction and increase in interest rates leads to a a small increase in output and inflation. Put simply, in an ample reserve regime, a small decline in the quantity of reserves has little effect on a bank's reserve constraint. Thus, banks choose to lend more to take advantage of higher interest rates. This leads to an unexpected result that higher interest rates lead to higher inflation through the Fisher Equation.

Using a similar model, Martin et al. (2019) argue that optimal policy in an abundant reserve regime must consider an optimal level of reserves, setting of the ON RRP rate, and setting of the IOR rate. The authors find that optimal reserve policy increases and decreases reserves to equate bank deposit rates to IOR. Further, their model shows that optimal interest rate policy equates the ON RRP rate to the IOR rate. This, in turn, equalizes nearly all short-term interest rates, allowing banks to better absorb liquidity shocks and stabilizing short-term money markets.

This method of adjusting the fed funds rate through IOR and ON RRP in an abundant reserves system seemed to have settled the question of how monetary policy should be implemented through IOR. However, in late-2019, the fed funds market and other short-term interest rates began to spike above the Fed's target, requiring daily Fed intervention. Copeland et al. (2020) found that, because of the Fed's balance sheet normalization in 2017-2019 and new banking regulations, reserves had grown more scarce and dipped below an "efficient level" of reserves for an abundant reserve regime. Indeed, Copeland et al. conclude that these instabilities would not have occurred had there been more outstanding reserves in the banking system. Further, the authors say that, for an abundant reserve regime to efficiently operate with IOR, the Fed would need to consistently hold a larger balance sheet, relax many post-crisis liquidity regulations, and expand the usage of repo facilities and the discount window.

While questions remain about the day-to-day operations of monetary policy with IOR, Hamilton (2020) argues that, in the modern abundant reserve regime, the fed funds rate is divorced from its previous role as an indicator of liquidity in the banking system. Indeed, at lower frequencies, IOR and the fed funds rate are nearly perfectly correlated.[2]. This leads Dudley (2021) to argue that a fed funds rate target is obsolete as a policy tool, and the Fed should search for an alternative indicator of monetary policy.

While most papers have focused on the theory behind interest on reserves, recent work has begun to empirically test IOR's effects. Hendrickson (2017) estimated how the introduction of IOR changed banks' demand for reserves. He finds that IOR increased the demand for reserves. Further, this greater demand for reserves likely dulled the effect of quantitative easing, similar to the finding in Güntner (2015). Using call report data, Hogan (2021) finds that bank lending is inversely related to the IOR rate, and that the introduction of IOR accounts for more than half of the decline in loans after the 2008 financial crisis.

5 Summary and Future Research Agenda

While many strides have been made in understanding interest on reserves, there is still more to learn. The papers thus far focus largely on understanding the modern structure of the fed funds market and how policy can be conducted with abundant reserves. However, the literature has yet to fully tackle at what level reserves become "abundant," or whether there is a point at which there are too many reserves. Finding a consensus in how an abundant reserve regime should be conducted is among the first steps to a greater understanding of interest on reserves. Moreover, the fed funds market and excess reserves have similar maturities,

[2]Specifically, they have a .99 correlation coefficient at a monthly frequency

but there is little examination into how this influences the term structure of interest rates throughout the economy. An examination into the response of financial markets and the yield curve will give a clearer picture of the ramifications of this new policy.

Taken together, future research should be three pronged. First, it should examine to a greater extent the asset allocation decisions banks make with interest on reserves. Banks will naturally allocate assets differently when reserves change from a non-interest bearing asset to an interest bearing asset or from scarce to abundant, and these decisions can affect how policy trickles down into the real economy. Second, the literature must find a greater understanding about how many reserves are necessary, as well as studying whether there can exist "too many" reserves for this regime to be effective. Finally, the future research should consider in greater detail the concerns of Hamilton (2020) and Dudley (2021) that the fed funds rate is no longer a sufficient indicator for monetary policy.

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