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Theoretical Explorations by the Money Markets Group of Long-run Framework

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Overview

This memo summarizes a project aimed at identifying the key determinants of interest rates, trading volume, and participants in the federal funds (FF) market. We introduce a simple model that captures the key features of the FF market both before and after the 2008-09 financial crisis, and can serve as a laboratory to evaluate and explore proposals regarding the long-run framework.

There are two key developments in the FF market since 2009:

1. *Abundant reserves*: Before the crisis, excess reserves were scarce—less than $2 billion in excess of total reserve requirements—obliging banks to actively manage their balances in the FF market. Some banks needed to borrow funds to meet reserve requirements, typically from banks with excess balances looking to obtain some return overnight. After the extraordinary measures taken during and following the crisis, banks find themselves with far more balances than they need to satisfy reserve requirements—by a factor of more than 20. Bank-to-bank lending has essentially disappeared and what remains is mainly lending to banks by non-banks, such as government-sponsored enterprises (GSEs) in the FF market and money market mutual funds (MMFs) in the Eurodollar market.

2. *New policy instruments*: In this new environment of abundant reserves, the traditional means of policy implementation—small adjustments to the supply of reserves via open market operations—would fail to move FF rates. Instead, the Federal Reserve

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relies mainly on two new tools for interest-rate control, namely interest on excess reserves (IOER) and the interest rate offered by the overnight reverse repurchase (ON RRP) facility.[2]

Our model captures the salient features of the FF market with either scarce reserves as observed before 2008 or abundant reserves as is currently the case, and also incorporates the new policy tools that were introduced during and after the recent financial crisis. We ascribe a central role to how a bank's level of excess reserves determines whether it uses the FF market to borrow or lend funds. This decision interacts with both the size and distribution of reserves balances across banks and GSEs, as well as with the policy instruments that have been introduced since 2008. The model also incorporates a flexible specification for the banks' cost of holding reserves.

The long tradition of research on the FF market and monetary policy implementation starts with Poole (1968) and treats the FF market as a centralized, competitive market operating with scarce reserves. Recent contributions are Furfine (1999) and Whitesell (2006), inter alia. Since Ashcraft and Duffie (2007), models have tried to capture the over-the-counter nature of the FF market. Most existing work focuses on regimes with scarce reserves due to its historical prevalence (e.g., Ennis and Weinberg (2013), Berentsen and Monnet (2008) and Afonso and Lagos (2015), inter alia). The current regime of abundant reserves, and its implications for the FF rate, are studied in Bech and Klee (2011) and Armenter and Lester (2015), as well as in Williamson (2015). The model presented here treats the FF market as an over-the-counter market and is the first to capture both the scarce- and abundant-reserves regimes in a single specification.

1. The composition of the federal funds market

In response to the Great Recession, the Federal Reserve resorted to a number of unconventional policies that drastically changed the landscape of the FF market. Prior to

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[2] "Policy Normalization Principles and Plans," press release, September 17, 2014.

2008, depository institutions actively relied on the FF market, borrowing to satisfy their reserve requirements and payments needs or lending to avoid holding unremunerated excess reserves. Trading volume in the FF market was robust, averaging more than $250 billion per day, and the majority of trades occurred between banks.[3] In this environment, the Desk would implement the desired target for the effective federal funds rate (EFFR) by adjusting the supply of reserves via open market operations.

Since 2008, the credit and liquidity facilities and the subsequent large-scale asset purchase programs have left most depository institutions awash with excess reserves. As a result, trading activity between banks has become rare, and volume in the FF market has fallen to $60-$70 billion per day. With few trades occurring between banks, activity in the FF market and the Eurodollar market is now dominated by GSEs and MMFs, respectively, seeking some yield on their overnight balances. The EFFR is kept in its target range by setting the IOER rate and the rate of return at the ON RRP facility, which is available to an expanded set of counterparties, including GSEs and some MMFs.

The way depository institutions value their reserve holdings has also changed with the introduction of new regulations. For example, since banks rely on reserve holdings as high-quality liquid assets to satisfy liquidity coverage ratios, they may be more reluctant to lend these balances. Similarly, FDIC insurance fees and concerns about leverage appear to have reduced the banks' appetite to borrow reserves.

2. A model of the federal funds market[4]

We have developed a simple model that is capable of reproducing the main features of the FF market in regimes with either scarce or abundant reserves, as observed before and after 2008, respectively. The model can be used to evaluate how the FF

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[3] Market size is estimated by aggregating FF activity from quarterly regulatory filings. For details, see the blog posts published in the Liberty Street Economics by Afonso, Entz, and LeSueur in December 2013.
[4] Based on "A Model of the Federal Funds Market: Yesterday, Today, and Tomorrow" by Gara Afonso, Roc Armenter and Benjamin Lester.

market might evolve in response to changes in the supply of reserves, policy rates, and regulatory requirements.

Reflecting the over-the-counter nature of the FF market, the model assumes that banks seeking to borrow funds meet at random with a GSE or a bank seeking to lend funds. With some probability, determined by the ratio of borrowers to lenders, any given participant may fail to find a counterparty to trade with. Participants that meet then negotiate the terms—rate and volume—of the federal funds transaction.

To understand how rates and trading patterns are determined in the model, it is useful first to describe the terms of trade between two banks and between a bank and a GSE. Consider first two banks negotiating a funds trade. The bank seeking to lend balances will share some of the gains from trade by charging a rate above the IOER—the bank's return for its balances if the negotiation fails. The fewer the balances the borrowing bank has, the larger the gains of trade and the higher the negotiated rate.[5]

Consider now a bank that, seeking to borrow funds, meets a GSE. The latter seeks to lend its balances, knowing that if it fails to agree to a trade then it can resort to the ON RRP facility and earn the offered rate. The borrowing bank will enjoy a higher return for the funds, namely the IOER. Not surprisingly, the negotiated rate will be somewhere between these two rates, splitting the arbitrage profits between the borrowing bank and the GSE, net of any balance sheet costs associated with borrowing funds.

We ascribe a central role to each bank's decisions to approach the FF market as a lender or a borrower. In a regime with scarce reserves, banks with large balances look to lend funds, confident that they will obtain a sizeable margin over the IOER from banks eager to borrow funds due to a shortfall in their reserve holdings.[6] As a result, there is robust volume in the FF market driven by bank-to-bank trades, the average fed funds rate

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[5] Our model has a very flexible specification for the gains of trade, which allows us to capture a host of considerations in banks' cost of holding reserves, including the impact of regulation.

[6] In our model, each bank's decision to borrow or lend depends on its level of excess reserves, among other factors. For ease of exposition, we present our discussion as depending on the level of reserves since we take each bank's reserve requirement as given.

exceeds the IOER rate, and the EFFR is sensitive to small adjustments to the aggregate supply of reserves.

In contrast, when reserves are abundant, few (if any) banks find it profitable to lend, as the gains of trade with other banks are small, shrinking the margin the lending bank would earn above the IOER. Instead, banks prefer to borrow funds from a GSE and earn some of the spread between the IOER and ON RRP rates. Indeed, if reserves are abundant enough, no bank seeks to lend funds as the profits from arbitraging the spread between the IOER and ON RRP rates swamp the gains from trade between any two banks. Thus there is negligible or no trade between banks, FF trading volume is almost reduced to the funds provided by GSEs, and the EFFR typically trades below the IOER. A similar situation appears to currently characterize the Eurodollar market, with the supply of funds reduced to those of money market funds, and Eurodollar rates averaging below the IOER.

Naturally, each bank's decision to borrow or lend FF depends on its level of reserves; along with the supply of liquidity from GSEs and the spread between the IOER and the ON RRP rate, which determines the potential profits for banks from participating in the FF market. Moreover, because of the over-the-counter nature of the FF market, a bank's decision to borrow or lend also depends on the distribution of reserves across other banks seeking to lend or borrow. Banks' decisions, in turn, determine the market composition as well as rates and trading volume. This reinforcing mechanism enables the model to reproduce the varying landscape of the FF market as a function of the aggregate supply of reserves, IOER and ON RRP rates, and other factors including new regulations that influence the banks' cost of holding reserve balances.

3. Results

Formally, we show that no bank chooses to lend when the supply of reserves is sufficiently high; in this case, all FF trades are between a GSE and a bank. As the supply of reserves declines, bank-to-bank trading resumes as there are banks willing to pay a

high enough rate to borrow, which in turn induces a positive fraction of banks to lend out balances. If the supply of reserves falls even more, trading activity in the FF market is predominantly between banks and the EFFR eventually rises above the IOER rate.

For ease of exposition, we distinguish between three regimes as a function of the aggregate level of reserves:

- *Abundant:* Reserves are "abundant" when there is no bank-to-bank trading as banks are only interested in borrowing from the GSEs. In this regime the EFFR is typically below the IOER.
- *Scarce:* Reserves are "scarce" when the EFFR is above the IOER. In this regime bank-to-bank trades typically dominate the FF market.
- *Semi-scarce:* Finally, there is an intermediate regime of "semi-scarce" reserves, or "semi-abundant," where some banks trade with other banks, but the EFFR stays below the IOER.

The model's regimes map into the historical evidence and the commonplace usage of the nomenclature of "scarce" and "abundant" reserves in a straightforward way. The scarce-reserves regime corresponds to the period prior to the financial crisis, with both the IOER and the ON RRP rate set to zero (as neither policy instrument existed yet). The current experience corresponds to the regime of abundant reserves.

Turning to some selected comparative statics, we show how the thresholds separating these model regimes depend on policy rates, the amount of liquidity in the hands of GSEs, and the costs associated with holding reserves. The three figures illustrating these exercises are provided in the appendix.

Figure 1 illustrates the effect of increasing the ON RRP rate, holding IOER fixed at one percent. As the spread between these rates shrinks, the margin the banks earn from borrowing funds from a GSE decreases: accessing the ON RRP facility is an outside option for the GSEs, so a higher rate at the ON RRP allows the GSEs to negotiate a better rate for their balances. As a result, for any given level of reserve holdings, banks become more willing to lend to other banks. As more trades occur between banks—at rates above

the IOER—the EFFR rises, eventually above the IOER, which is reflected in a widening of the region in which reserves are scarce.

Figure 2 has a similar interpretation. As GSE balances increase, banks have more incentive to borrow from GSEs, as the potential profits from arbitrage rise with GSE balances. As a result, banks are less willing to lend to other banks, which is reflected in the widening of the region in which reserves are abundant. In other words, all else equal, an increase in the supply of liquidity coming from GSEs implies that the aggregate supply of reserves would have to be even lower to induce banks to resume lending.

Finally, figure 3 illustrates the effect of increasing the costs that banks incur when they hold too few reserves; this increase could arise, for instance, from an increase in the discount window primary rate or in overdraft fees. As these costs rise, banks with low reserve balances become more desperate to borrow and are willing to pay higher rates. The promise of higher interbank rates induces banks with high reserve balances to lend, which is reflected in the expansion of the semi-scarce and scarce regions. This suggests that policies that raise the costs of falling short of reserve requirements ease the conditions necessary for bank-to-bank lending to resume and for the EFFR to rise above the IOER rate.

In sum, the model replicates the key features of the FF market both before and after the 2008/9 financial crisis, and can be used to evaluate different proposals regarding the long-run framework, as well as to explore the impact of other factors.

4. Other considerations

There are several important considerations for monetary policy implementation that are not part of our model. We briefly discuss some of the existing and ongoing work regarding the transmission of policy rates to broad money markets via the ON RRP facility; alternative frameworks that engineer reserve scarcity; and the reluctance of some depository institutions to participate in the federal funds market.

As discussed earlier, the ON RRP facility is a tool aimed at providing a floor for FF rates. However, the ON RRP facility is accessible to an extended set of counterparties that include some MMFs, which are major lenders in the Eurodollar and tri-party repo markets. The larger availability of the ON RRP facility may help the transmission of rates to money markets more broadly, though not without raising concerns. Frost et al. (2015) describes the ON RRP facility and some of its potential negative implications for financial stability, as well as some proposals to mitigate the latter. Ongoing work by Borghan Narajabad and Ian Kotliar, "ON RRP and stability of tri-party repo market," formally models the effects of the ON RRP facility in the tri-party repo market.

There are also alternative frameworks based on Voluntary Reserve Targets (VRT) that could engineer reserve scarcity for any level of aggregate reserves, as outlined in ongoing work by Garth Baughman and Francesca Carapella. Previous work on VRTs is limited: Clews (2005) and the Bank of England Red Book (2015) describe the VRT framework implemented by the Bank of England between 2006 and 2009. Whitesell (2006b) also discusses VRTs within a model of centralized trading for the federal funds.

Finally, our model does not capture the lack of participation in the FF market by some banks. Armenter and Lester (2015) posit that banks have heterogeneous balance sheet costs associated with borrowing funds, perhaps due to regulatory and risk considerations. Those banks with high enough balance sheet costs are unable to attract any lender and effectively forgo participation in the market, creating downward pressure on FF rates.

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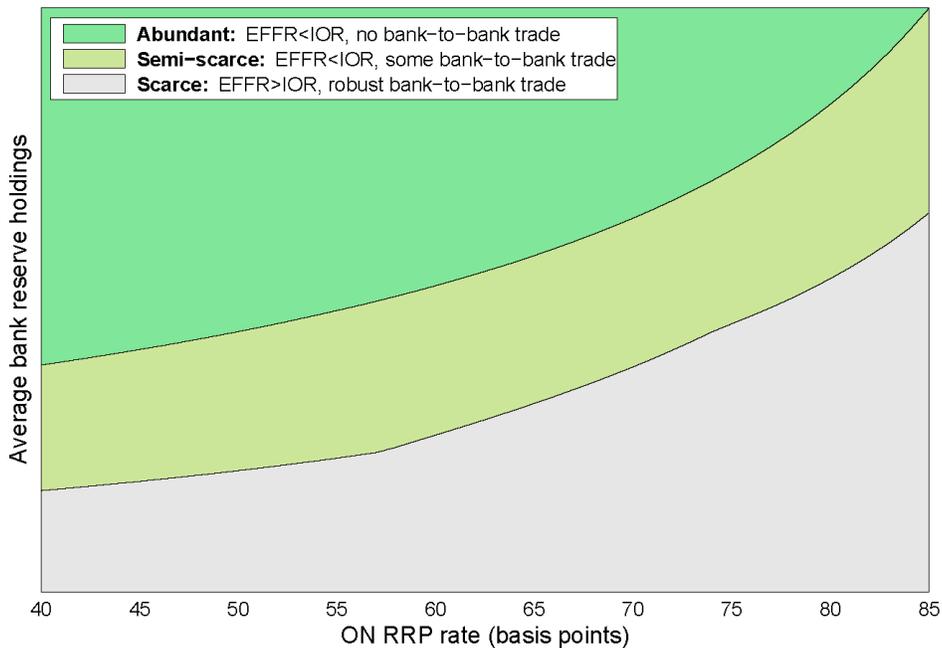
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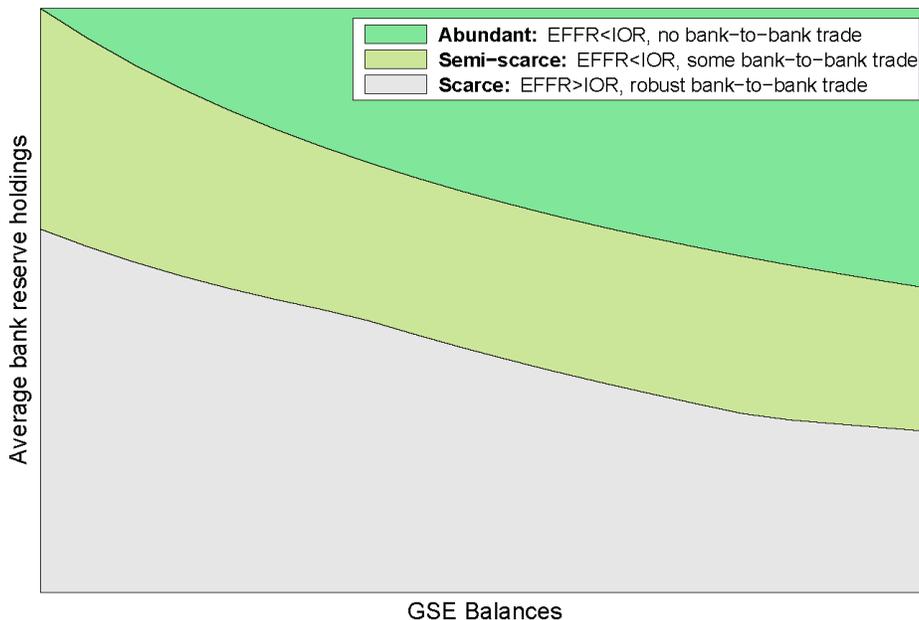

Figure 1: Effect of varying ON RRP rates
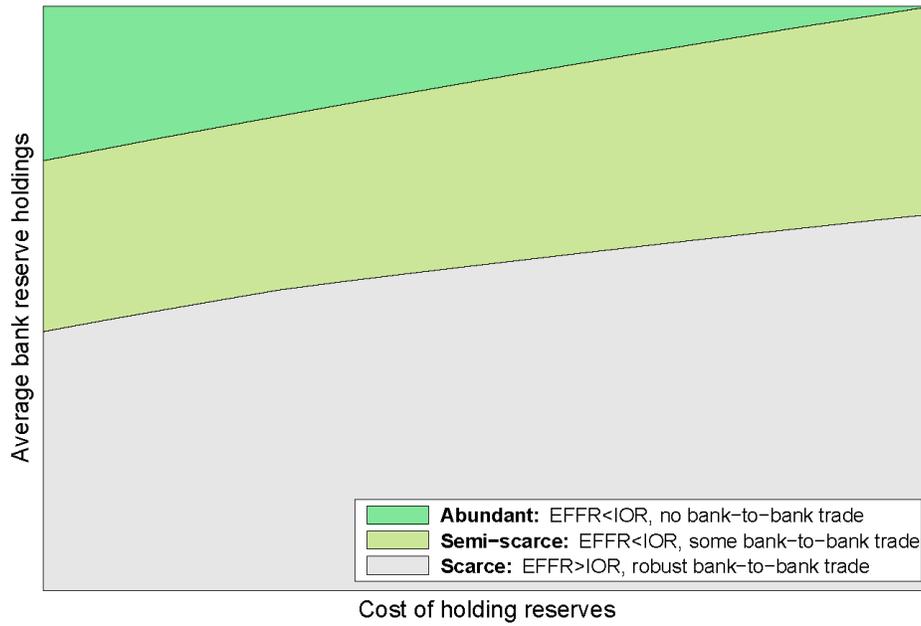

Figure 2: Effect of varying GSE balances

Figure 3: Effect of varying the cost of holding reserves