Reserve Balances, the Federal Funds Market and Arbitrage in the New Regulatory Framework *

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Abstract

We study demand for reserves and trading dynamics in the federal funds market in the context of two banking regulatory changes: the widening of the FDIC assessment base and the introduction of the Basel III regulatory ratios. Using a novel panel of FDIC fee rates, we show that the new assessment base changed the relative funding costs and incentives for banks to hold reserves. We find that foreign banks, not subject to the FDIC fee, experienced positive and improving conditions for arbitraging between borrowing funds in the federal funds market and holding those funds in their reserves accounts to earn interest on excess reserves. As a result, foreign banks increased their reserve holdings and federal funds borrowing relative to domestic banks, contributing to a change in the distribution of reserves in the banking system and in the composition of banks’ balance sheets. Furthermore, we find that since the implementation of the Basel III leverage ratio, foreign banks have engaged in window dressing, with reserves and federal funds borrowing temporarily declining on reporting days. We introduce a model that incorporates the new regulatory framework and derive testable hypotheses to support our findings. Results suggest that: 1) following the implementation of the new FDIC rule, the share of reserves over assets held by domestic banks was 4.5 percentage points lower than the share held by foreign banks. 2) after the public disclosure of the Basel III leverage ratio, foreign banks’ reserves on reporting dates relative to the period average dropped by 18.3 percentage points compared to domestic banks.

Keywords: IOER arbitrage, reserve balances, federal funds market, FDIC fee, Basel III ratios

JEL Classification: E49, E52, G28

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1 Introduction

Financial institutions keep reserve balances at Federal Reserve Banks (FRBs) to meet their reserve requirements and to clear financial transactions. Institutions with reserve balances in excess of reserve requirements can lend these excess reserves to depository institutions (DIs) with reserve deficiencies. These transactions occur in the market for federal funds, which is an interbank over-the-counter market for unsecured, mostly overnight loans of dollar reserves held at FRBs. This market is at the core of monetary policy implementation, as the Federal Open Market Committee (FOMC) sets the target for the federal funds rate. Historically, through its influence on financial conditions, the federal funds rate has been a key policy instrument for the FOMC in its quest for maximum employment and price stability. In the current context of monetary policy normalization, and given the unprecedented large level of reserves in the banking system, understanding dynamics in the federal funds market and reserves is of key relevance both from a monetary policy and financial stability perspective.

Before the financial crisis, the federal funds market was an interbank market in which the largest players on both the demand and supply sides were domestic commercial banks. During the 2007-2008 financial crisis, there were two developments in the Federal Reserve's monetary policy framework and implementation that affected the size of and return on reserves, which triggered new trading dynamics in the federal funds market. First, on October 6, 2008, the Federal Reserve Board announced that it would begin to pay interest on required and excess reserves (IOER) held by depository institutions. Second, with short-term interest rates at nearly zero, between late 2008 and October 2014, the Federal Reserve made a series of large-scale asset purchases (LSAPs). While IOER was effective at influencing the federal funds effective rate, it did not serve as a hard minimum rate at which all institutions were willing to lend in the federal funds market. This environment created incentives for banks to engage in IOER arbitrage: borrow funds in wholesale funding markets at below IOER and hold those funds in their reserve accounts earning IOER.
In this paper we study how these trading dynamics and incentives for IOER arbitrage were altered by two banking regulatory changes: the widening of the Federal Deposit Insurance Corporation (FDIC) assessment base (April 2011) and the introduction of the Basel III leverage ratio (reported to the supervisors since January 1, 2013, and publicly disclosed since January 1, 2015).

Using a novel panel of FDIC fee rates and federal funds transaction data, we document that the new FDIC assessment base changed the relative funding costs and incentives for depository institutions to hold reserves. As a result, while domestic depository institutions (DDIs) held the large majority of reserve balances in the system before the crisis, foreign bank organizations (FBOs) not subject to the FDIC fee absorbed increasing amounts of liquidity over recent years.\footnote{FBOs are U.S. branches and agencies of foreign banks. Branches established after December 1991 are not subject to the FDIC assets maintenance requirement. For details see https://www.fdic.gov/regulations/laws/rules/2000-6900.html. Of the 243 foreign banks filing the FFIEC 002 form, 11 were subject to the FDIC fee. Of those, only 1 bank was an active participant in the federal funds market. FDIC fee data at the bank level is confidential. Throughout the paper, we show aggregated FDIC fee series.}

The increase in balance sheet costs related to the widening of the FDIC assessment base significantly reduced the profits of domestic banks from IOER arbitrage trades. Conversely, FBOs experienced positive and improving conditions for IOER arbitrage, contributing to an increase in reserve balances and federal funds borrowing by foreign banks relative to domestic banks.

Furthermore, we find that since the implementation of the Basel III leverage ratio, foreign banks have consistently engaged in window dressing, with reserves and federal funds borrowing temporarily declining on reporting dates. For instance, from January 2013 to December 2015, a period when the leverage ratio was reported to supervisors, federal funds borrowing by FBOs fluctuated at around 40 percent lower at quarter-end compared to the daily average amount for the corresponding period. In line with this decline, quarterly balance sheet data for European banks show that during the same period, the average share of federal funds in total liabilities also dropped from 2 percent to 0.7 percent.\footnote{Borrowing by foreign banks is concentrated in only a few banks that are persistent participants in the market, with European banks having the largest share.}

Building on these findings, we introduce a model of bank’s profit maximization that incorporates
these regulatory changes. More specifically, the model yields testable hypotheses on the effect of the new FDIC assessment base and Basel III regulatory ratios on IOER arbitrage dynamics, including the effects on demand for reserve balances and overnight funding markets. We test the model using a difference-in-difference identification strategy and banks’ balance sheet data. We find empirical evidence that the increase in balance sheet costs due to the new FDIC policy negatively affected demand for reserve balances by domestic institutions. In particular, following the implementation of the new FDIC rule, the share of reserves over total assets held by domestic banks was 4.5 percentage points lower than the share held by foreign banks. Also, results indicate that following the public disclosure of the Basel III leverage ratio, foreign banks’ reserve holdings on reporting dates relative to the period average dropped by 18.3 percentage points compared to domestic banks.

Our paper is at the intersection of several literatures that study the effects of post-crisis regulation and unconventional monetary policy on financial markets and institutions. More specifically, the paper contributes to the emerging literature on Basel III regulatory ratios. On the theoretical side, (Bech & Keister, 2013) introduce term funding and a liquidity coverage ratio (LCR) requirement to a model of monetary policy implementation and show that when banks face the possibility of an LCR shortfall, it becomes more challenging for them to control the overnight interest rate, and the short end of the yield curve becomes steeper. On the empirical side, the closest study related to our paper is by (Bonner & Eijffinger, 2012). They use the liquidity rule introduced by De Nederlandsche Bank in 2003 as a proxy for the LCR, in combination with interbank data for the Dutch banks. They find that banks that are just above or below their short-term liquidity requirement pay and charge a higher interest rate for unsecured interbank loans and decrease their lending volume during a crisis.

Our analysis also brings new evidence to the study of deposit insurance. Although a large literature has focused on this topic, the work on the post-crisis widening of the FDIC assessment
base is still limited. Related to our study, (Kreicher, McCauley, & McGuire, 2013) argue that the widening of the FDIC base can be viewed as a corrective tax on domestic banks’ wholesale liabilities that changed their funding models. Consistent with our findings, they show that the new FDIC base fee had a negative effect on DDIs’ demand for reserve holdings during LSAP2. More recent work by (Allen, Davidson, Hein, & Whitledge, 2017) focuses on the economic effects of the FDIC base change on community versus non-community U.S. banks. Making assumptions on FDIC fee rates, they provide estimates for the gains and losses experienced by these two groups of banks following the change in regulation. They find that the dollar amount of the FDIC fee paid by community banks declined following the base change while that of non-community banks increased temporarily.

Our work also contributes to the broader literature on federal funds market. (Hamilton, 1996), (Ashcraft & Duffie, 2007), (Afonso & Lagos, 2015b), and (Afonso & Lagos, 2015a) focus on the federal funds market as a market for reserves. (Afonso, Kovner, & Schoar, 2011) and (Ashcraft, McAndrews, & Skeie, 2011) look at the federal funds market during the 2007-2008 financial crisis and examine the importance of liquidity hoarding and counterparty risk during this period. (Bech & Klee, 2011) show that, following the financial crisis and the unprecedented increase in reserve balances in the system, the federal funds market, as a market for reallocating reserves among banks, almost disappeared. (Kim, Martin, & Nosal, 2017) find that even at a sufficiently low supply of reserves, costs associated with banking regulation might hinder the federal funds market from returning to its pre-crisis function.

This paper is organized as follows. The next section provides background information on the pre- and post-crisis monetary policy framework and the associated trading dynamics in the federal funds market. Section 3 presents the new FDIC policy and Basel III regulatory ratios. Section 4

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3See (Calomiris & Jaremski, 2016) for a detailed historical reviewed on bank liability insurance as well as for a complete literature review. Also, recent work by (Demirg-Kunt, Kane, & Laeven, 2015) provides a comprehensive database on deposit insurance schemes for a universe of 189 countries.
documents recent developments in reserve balances and federal funds in light of these regulatory changes. Section 5 introduces a model of bank’s profit maximization that incorporates this new regulatory framework, and section 6 presents the empirical implications of the model. Section 7 concludes.

2 Monetary Policy Framework and incentives for IOER arbitrage

Before the financial crisis, under the traditional framework of monetary policy implementation, the trading desk at the Federal Reserve Bank of New York (FRBNY) would adjust the level of reserve balances in the banking system, as instructed by the FOMC, to create conditions that would encourage federal funds to trade at the target rate. At that time, DIs would keep their reserve balances at a minimum, as those balances did not earn interest.

During the financial crisis, two developments in the Federal Reserve’s monetary policy framework and implementation affected the size of and return on reserve balances. First, on October 6, 2008, the Federal Reserve Board announced that it would begin to pay interest on required and excess reserves held by DIs. Intuitively, interest on excess reserves (IOER) is expected to influence market rates by discouraging DIs from lending federal funds at rates below the IOER rate. Second, with short-term interest rates at nearly zero, between late 2008 and October 2014, the Federal Reserve made a series of large-scale asset purchases (LSAPs).

In conducting LSAPs, the Fed purchased longer-term securities issued by the U.S. government and longer-term securities issued or guaranteed by government-sponsored agencies, putting downward pressure on yields of a wide range of longer-term securities, supporting mortgage markets, and promoting a stronger economic recovery. LSAPs significantly expanded and changed the com-

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4 For the federal funds role in policy transmission under the traditional framework see Bernanke & Blinder [1992]. For a detailed explanation on monetary policy framework see Ihrig, Meade, & Weinbach [2015].
5 https://www.federalreserve.gov/monetarypolicy/20081006a.htm
6 https://www.federalreserve.gov/newsevents/press/monetary/20081125b.htm (Agency debt and Agency MBS purchases), http://www.federalreserve.gov/newsevents/press/monetary/20090318a.htm (Treasury purchases).
7 For more details on LSAPs and their effect see D’Amico, English, Lopez-Salido, & Nelson [2012], Gagnon.
position of the Federal Reserve’s balance sheet. Before the crisis, the size of the balance sheet was about $870 billion, and expansion was driven mainly by currency growth. At the end of the second quarter of 2014, the balance sheet had reached $4.37 trillion, and the increase was largely due to securities purchases. As the asset side of the balance sheet increased dramatically through the asset purchase programs, the Federal Reserve’s liabilities expanded an equal amount. As shown in figure 1, this increase in liabilities was primarily due to a surge in excess reserves. As a result of the first LSAP program (LSAP1), the Federal Reserve created $397 billion in reserve balances. Starting in November 2010, assets purchased as part of the second LSAP program (LSAP2) introduced an additional $615 billion in reserve balances into the banking system, leaving the Federal Reserve’s liabilities at a record level of $2.8 trillion by the end of June 2011. Subsequent flow-based purchases since September 2013 continued to inject liquidity into the banking system, with new reserve balances increasing $1.2 trillion since the beginning of the program. Overall, since the outbreak of the financial crisis in the second half of 2008, reserve balances have risen dramatically from $10.3 billion to approximately $2.7 trillion.

Before the crisis, required reserves accounted for the large majority of reserve balances in the system, with the levels of required and excess reserves close to $6.5 billion and $1.5 billion, respectively. Furthermore, the share of excess reserves over total reserve balances was consistently around 20 percent. Beginning with the introduction of various liquidity facilities, asset purchase programs, and the payment of interest on required and excess reserves, the share of excess reserves rose dramatically, reaching 98 percent by the end of 2008. As shown in figure 1, although the level of both required and excess balances has continued to increase significantly since then, the ratio of

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8 Required reserves are calculated as a share of a bank’s transaction deposits less vault cash. This share can vary between 0 and 10 percent depending on the level of net transaction accounts.

9 The Federal Reserve began paying interest on required and excess reserves in October 2008. While rates paid on required balances were initially considerably higher than those paid on excess balances, both rates have been set at the same level since the end of 2008.
excess to total reserve balances has remained steady.\textsuperscript{10}

This exceptionally high level of reserve balances in the banking system along with the introduction of interest on reserves created new trading dynamics in the federal funds market. While IOER was effective at influencing the federal funds effective rate, it did not serve as a hard minimum rate at which all institutions were willing to lend funds. Some institutions, such as government-sponsored enterprises (GSEs), are eligible to lend funds in the federal funds market but are not eligible to earn IOER. In this case of market segmentation, (Bech & Klee, 2011) show that if GSEs command low interest rates and their share is sufficiently large, then the effective federal funds rate would be below the IOER rate. Under these conditions, DIs have the incentive to engage in IOER arbitrage: in this setting, fed funds market participants who are not eligible to earn IOER on their balances at the FRBs (such as the GSEs) appear to have become the primary sellers of federal funds. These institutions sell federal funds to DIs who have an incentive to borrow funds at below the IOER rate and hold the funds in their reserve account to earn the IOER rate. The widening of the FDIC assessment base negatively affected potential profits from this trading strategy for domestic banks and the resulting allocation of reserves between domestic and foreign banks.

3 The new regulatory framework

Reserve holdings and trading dynamics in the federal funds market were affected by two banking regulatory changes: the widening of the FDIC assessment base and the Basel III regulatory ratios. This section describes this new regulatory framework and the expected effects of demand for reserve balances and federal funds borrowing on the these regulatory ratios.

\textsuperscript{10}By the end of the second quarter of 2014, required and excess reserve balances reached $81 billion and $2.6 trillion, respectively.
3.1 The new FDIC policy

Effective April 1, 2011, the FDIC redefined the deposit insurance assessment base as required by the Dodd-Frank Wall Street Reform and Consumer Protection Act by widening of the FDIC assessment base. Before the change in regulation, U.S. chartered banks paid FDIC fees based on their level of domestic deposits; after the widening, the assessment base was expanded to include domestic institutions total assets less tangible equity. The rationale behind the new base was to redistribute the FDIC assessments from small to large banks in a way that better reflects market shares in the banking industry. This regulatory change created asymmetries between domestic and foreign institutions in the funding costs of reserves, making reserve balances funded in short-term wholesale funding markets relatively more expensive for domestic institutions than for FBOs not subject to the FDIC fee.

In this context, using a confidential panel from the FDIC, we first attempt to characterize the assessment fees paid by domestic institutions. Our sample comprises the universe of domestic institutions (3,008 entities) with over $1 million in balances due from the Federal Reserve and covers the period of January 2011 through October 2013. The FDIC assessment rate is based on a bank’s supervisory ratings and a set of financial measures. More specifically, for most institutions with $10 billion or more in assets, the initial FDIC assessment rate is calculated based on a bank’s CAMELS rating and its ability to withstand asset- and funding-related stress. These factors account for 30 percent, 50 percent, and 20 percent, respectively, of a bank’s performance score. To produce a total score, the performance score is then combined with a measure of the potential losses to the FDIC in the event of a bank’s failure. The total score is then nonlinearly translated into an initial assessment

\[ \text{Initial Assessment Rate} = \text{Performance Score} \times \text{Potential Losses} \]

\[ \text{Potential Losses} = \frac{\text{Total Assets} - \text{Tangible Equity}}{\text{Total Assets}} \]

\[ \text{Performance Score} = 0.3 \times \text{Capital Adequacy} + 0.5 \times \text{Asset Quality} + 0.2 \times \text{Management Capability} \]

For details see https://www.fdic.gov/news/news/financial/2011/fil11008.html.

The sample period of the analysis that involves FDIC fee data is dictated by our access to these confidential data sets. The sample includes commercial banks and savings and loans institutions, covering around 93 percent of total assets and almost the entire share of reserve balances held by insured depository institutions. The sample does not include credit unions, which are not insured by the FDIC.

The CAMELS rating is a score used by U.S. regulators to evaluate the soundness of banks based on capital adequacy, asset quality, management capability, earnings quality, liquidity adequacy, and sensitivity to market risk.
rate, which can range between 5 and 35 basis points. This initial rate is adjusted downward for a bank’s unsecured debt and upward for debt own and brokered deposits. For institutions with less than $10 billion in assets, a simpler scorecard method is used that combines a bank’s CAMELS rating and a risk-rating score.\(^{14}\)

As depicted in figure 2, domestic banks were able to consistently reduce the rate of their FDIC assessment fee since the new assessment base was implemented. This trend largely reflects improvements in financial performance, condition measures, and supervisory evaluations used by the FDIC in the calculation of the assessment fee rates. Reportedly, the downward trend might also reflect, in part, the greater ability of larger institutions to manage the composition of their balance sheet in response to regulatory changes. For instance, the reduction in their FDIC fees could also be related, partially, to management of their liquidity coverage ratio, which also positively affects these banks’ asset quality and liquidity positions.

[INSERT FIGURE 2 HERE]

### 3.2 Basel III

Basel III introduced both capital and liquidity ratios. In this section, we will focus on the leverage ratio (LR), the liquidity coverage ratio (LCR), and their implications for banks borrowing in the federal funds market.\(^{15}\) As most of the borrowing in the federal funds market is by foreign banks, we will discuss reporting requirement for this group of banks.\(^{16}\)

**Leverage ratio**\(^{17}\)

\(^{14}\)A detailed explanation of FDIC assessment rates can be found on the FDIC website. See Federal Deposit Insurance Corporation (2013), “FDIC Assessment Rates, www.fdic.gov/deposit/insurance/assessments/proposed.html (last updated April 22, 2013).

\(^{15}\)For details on the implementation schedule and definition of ratios see http://www.bis.org/bcbs/basel3/basel3_phase_in_arrangements.pdf.

\(^{16}\)See http://libertystreeteconomics.newyorkfed.org/2013/12/whos-borrowing-in-the-fed-funds-market.html

\(^{17}\)The definition of the leverage ratio is based on [BIS 2014] and [BIS 2013b].
The Basel III leverage ratio is a non-risk based leverage ratio intended to act as a credible supplementary measure to the risk-based capital requirements. Implementation of the leverage ratio requirements began with the bank-level reporting to national supervisors of the leverage ratio and its components from January 1, 2013, and proceeded with public disclosure starting January 2015.

The Leverage Ratio is expressed as the capital measure divided by the exposure measure, with this ratio expressed as a percentage as in (1):

\[
\text{Leverage ratio} = \frac{\text{Capital measure}}{\text{Exposure measure}} \tag{1}
\]

The capital measure for the leverage ratio is the Tier 1 capital of the risk-based capital framework as defined in the Basel III framework. A bank’s total exposure measure is the sum of the following exposures: (a) on-balance sheet exposures; (b) derivative exposures; (c) securities financing transaction exposures; and (d) off-balance sheet items.

Borrowing in the federal funds market causes reserve balances to increase boosting on-balance-sheet exposure and leading to a reduction in the leverage ratio. Furthermore, as the exposure measure is not risk weighted, banks might chose to shift their asset allocation from holding excess reserves to holding other assets that provide a higher return. However, this shift from reserves to other assets is not likely to occur if current market conditions persist. (McCauley & McGuire 2014) show that about half of the claims created by the Federal Reserve to pay for its LSAPs are taken by foreign banks (mostly the branches unaffected by the new FDIC assessment base), which financed these reserves by recalling advances from their affiliates abroad. They also show that since the financial crisis, foreign banks’ consolidated claims on U.S. non-banks private sector have declined, and their exposure to the U.S. official sector has increased, with most of the increase reflected in reserves rather than holdings of Treasury securities. These changes in foreign banks’ balance sheets reveal that, given market conditions at that time, their preference was to hold reserves rather than other
Liquidity Coverage Ratio

The objective of the liquidity coverage ratio is to promote short term resilience of a bank’s liquidity risk profile. This standard aims to ensure that a bank has an adequate stock of unencumbered high quality liquid assets (HQLA) that consists of cash or assets that can be converted into cash at little or no loss of value in private markets to meet its liquidity needs for a 30 calendar day liquidity stress scenario. The LCR was introduced on January 1, 2015, but the minimum requirement was set at 60 percent and set to rise in equal annual steps to reach 100 percent on January 1, 2019.

The liquidity coverage ratio has two components: 1) the value of the stock of HQLA; and 2) total net cash outflows and it is expressed as in (2):

\[
\text{Liquidity Coverage Ratio} = \frac{\text{Stock of HQLA}}{\text{Total net cash outflows over the next 30 calendar days}} \geq 100\% \tag{2}
\]

HQLA are comprised of Level 1 and Level 2 assets. Level 1 assets generally include cash, central bank reserves, and certain marketable securities backed by sovereigns and central banks, among others. These assets are typically of the highest quality and the most liquid, and there is no limit on the extent to which a bank can hold these assets to meet the LCR. Level 2 assets may not in aggregate account for more than 40 percent of a bank’s stock of HQLA.

Total net cash outflows are defined in (3):

\[
\text{Total net cash outflows over the next 30 calendar days} = \text{Total expected cash outflows} - \min \left\{ \text{Total expected cash inflows; 75 percent of total expected cash outflows} \right\} \tag{3}
\]

Different types of outflows are weighted by their run-off factors. Borrowing from banks falls into

\[^{18}\text{The definition of the Liquidity Coverage Ratio is based on } \text{BIS} \ 2013a.\]
“Unsecured wholesale funding provided by other legal entity customers”, and it has a run-off factor of 100 percent. Borrowing from non-banks falls into “Unsecured wholesale funding provided non-financial corporates”, and it has a run-off factor of 40 percent. For the purposes of the LCR, “unsecured wholesale funding” is defined as those liabilities and general obligations that are raised from non-natural persons, and are not collateralized by legal rights to specifically designated assets owned by the borrowing institution in the case of bankruptcy, insolvency, liquidation or resolution.

The wholesale funding included in the LCR is defined as all funding that is callable within the LCRs horizon of 30 days or that has its earliest possible contractual maturity date situated within this horizon (such as maturing term deposits and unsecured debt securities) as well as funding with an undetermined maturity.

The effect of borrowing in the federal funds market would depend on the maturity of the borrowing and the current value of the liquidity coverage ratio. We will assume that borrowing in the federal funds market is used to finance reserves. Regardless of the maturity, borrowing would increase reserves and, hence, increase the stock of HQLA (the numerator) by the same amount.

In the case of overnight borrowing, which accounts for the majority of trading in the interbank market, the borrowing would be paid within 30 days and would increase the denominator by the amount of the overnight borrowing adjusted by a corresponding runoff factor that depends on the counterparty type. When the counterparty is a bank, the runoff factor is 100 percent, and the denominator and the numerator of the LCR increase by the same amount. Depending on the bank’s current LCR value, we have the following scenarios: If LCR < 100 percent, then overnight borrowing in the federal funds market would provide limited help for the LCR to reach 100 percent. If LCR > 100 percent, then LCR considerations would not affect the bank’s behavior regarding

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19 This category consists of all deposits and other funding from other institutions (including banks, securities firms, insurance companies, etc.), fiduciaries, beneficiaries, conduits and special purpose vehicles, affiliated entities of the bank and other entities that are not specifically held for operational purposes and not included in the following categories: 1) operational deposits generated by clearing, custody or cash management activities (25 percent), 2) deposits in institutional networks or cooperative banks (25 percent or 100 percent) and 3) unsecured wholesale funding provided by non-financial corporates and sovereigns, central banks, multilateral development banks, and PSEs (20 percent or 40 percent).
overnight borrowing in the federal funds market. However, borrowing for a term longer than 30 days would only increase the HQLA and not the denominator, as the cash outflow to repay the loan is beyond the 30-day period. Longer-term borrowing could be used by banks to meet their LCR requirement. As the longer maturities might become more attractive, the introduction of the LCR might affect the term premium at the very short end of the yield curve.

Table 1 summarizes likely changes in banks’ borrowing in the federal funds market to meet the leverage ratio and LCR requirements. The leverage ratio and LCR point to different effects for borrowing for longer maturities. In this paper, we focus on the overnight market.

[INSERT TABLE 1 HERE]

4 Arbitrage payoffs, demand for reserves and federal funds borrowing

In this section, we examine the economic incentives of depository institutions to engage in IOER arbitrage and quantify the effects of the FDIC assessment base change on arbitrage payoffs. We also document recent developments in reserves and federal funds market and relate them to the new FDIC policy and Basel III reporting dates.

4.1 IOER arbitrage and the new FDIC policy

To understand the economic incentives of depository institutions to engage in IOER arbitrage and how the FDIC base change affected arbitrage payoffs, we explore the gains associated with IOER arbitrage trades funded by borrowing in the federal funds market. Given the different regulatory requirements, costs, and funding structures of banks, we again group the sample into DDIs and FBOs. Also, since funding rates tend to vary with asset size, we evaluate the cases of large, medium,

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20 If LCR > 100 percent by a small margin, the bank might prefer to decrease borrowing in the federal funds market. While if the bank has satisfied the LCR requirement, it might prefer to take a conservative position to allow for forecast error which could potentially jeopardize this position.
and small depository institutions. Using federal funds transaction data aggregated by bank and day, we create volume-weighted average federal funds rates for large, medium, and small banks. We then use these series together with confidential FDIC fee bank level data to calculate a time series of returns from IOER arbitrage.

Overall, we find that the widening of the FDIC assessment base significantly reduced the profits of domestic banks from IOER arbitrage trades funded through wholesale funding markets. In the two years before the FDIC assessment base change, small, medium, and large domestic banks on average earned 5 basis points, 9 basis points, and 7 basis points, respectively, on their IOER arbitrage trades; following the FDIC policy change in 2011, their profits dropped significantly. As shown in figure 3, small domestic banks experienced negative returns, at an average of negative 3 basis points, throughout almost the entire period. Similarly, the higher balance sheet costs faced by medium DDIs significantly reduced the net return earned on their excess reserve balances. Only large banks were able to consistently produce positive profits from IOER arbitrage, although at a lower level (around 3 basis points). In part, these positive returns are explained by the ability of domestic banks to consistently reduce their FDIC assessment fees, as well as the lower and decreasing borrowing rates they obtained in the federal funds market.

Economic incentives for IOER arbitrage appear to be substantially stronger for the universe of FBOs. As depicted in figure 4, FBOs, which are not subject to the FDIC fee, were able to consistently produce positive average returns from IOER arbitrage trades. From the inception of the

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21 Federal funds transaction data are from Fedwire-identified federal funds using a (Furfine, 1999) type algorithm. The algorithm uses daily federal funds rates that FRBNY collects from federal funds brokered trades, which, until March 1, 2016, were used in calculating the effective federal funds rate. Those rates were used to match incoming and outgoing payments in Fedwire that correspond to federal funds trades. By construction, rates in Fedwire-identified federal fund trades represent federal funds rates, which is the focus of analysis in this section. Volumes, however, are consistently higher than the federal funds volume from other sources, such as brokered trades (which is aggregate data) or FR2420 (a transaction-based report that collects daily liability data on federal funds and other money market data), which the Federal Reserve began collecting in April 2014. One likely reason could be that the Fedwire-identified trades might include other overnight borrowing. However, reporting days dynamics are similar across data sets.

22 In a hypothetical environment free of FDIC fees, and given the rates these entities obtained in the fed funds market, domestic banks would have earned positive returns on their IOER arbitrage trades, on average.
new FDIC assessment base through the end of 2013, large and medium FBOs generated an average of 14 basis points and 13 basis points, respectively, while small FBOs were able to produce an average of 6 basis points. Furthermore, as shown in figure 4, returns from IOER arbitrage for large and medium FBOs trended upward during the period. These positive and improving conditions for IOER arbitrage experienced by FBOs could have largely motivated their desire to absorb large volumes of the newly created reserve balances.

4.2 Distribution of reserves

Returns from IOER arbitrage likely affected the distribution of reserve holdings among domestic and foreign institutions. At the beginning of 2007, DDIs held roughly 90 percent, or $7.1 billion, of the reserve balances in the system. Most of this amount was accounted for by required reserves. As depicted in figure 5, the share of reserves held by FBOs rose notably during LSAP1. Before the first LSAP program began, FBOs held around 13 percent of total reserve balances; by the end of the program, their share had increased to 33 percent. During the second LSAP program, which began in late 2010, this trend continued: FBOs’ share of total reserve balances jumped to 51 percent. Afterward, the constantly increasing stock of reserve balances was split equally between foreign and domestic institutions. The widening of the FDIC assessment base implemented in April 2011 appears to be an important factor affecting this pattern in the distribution of new reserves. Before this change in regulation, U.S. chartered banks paid FDIC fees based on their level of domestic deposits, whereas afterward the assessment base was expanded to include a domestic institution’s total assets less tangible equity. While FBO gains from IOER remained unaffected by the new

\[\text{Note that the pace at which DDIs and FBOs absorbed the newly created balances differed across LSAP programs. Whereas DDIs took up roughly $275 billion, or 69 percent, of the new reserve balances during the first LSAP program, FBOs led during LSAP2 with $521 billion, or 85 percent, of new reserves.}\]
regulation, the funding cost of reserve balances faced by domestic institutions increased by the amount of the FDIC fee.\textsuperscript{24}

[INSERT FIGURE 5 HERE]

Among domestic institutions, larger banks have been the main driver of demand for reserves.\textsuperscript{25} Figure 6 depicts their dramatic buildup in reserves since the last quarter of 2008 as well as the increasing concentration of reserve holdings in the large domestic institutions. While large domestic institutions held, on average, around $4.5 billion, or 39 percent, of domestic reserves before the crisis, their balances reached $731.3 billion, or 60 percent, of domestic reserves by the end of the second quarter of 2014.\textsuperscript{26} Conversely, small and medium banks, although they substantially increased their reserve balance holdings, decreased their average share of total reserves from around 36 percent and 25 percent, respectively, to 19 percent and 22 percent. This pattern in the distribution of reserves among domestic institutions is likely related to the better ability of large banks to manage the size and composition of their balance sheets in response to the large amounts of liquidity injected by the Federal Reserve and the new regulatory framework. As shown in figure 6, the announcement of Basel III's new regulations on liquidity in early 2013 and the proposed U.S. rulemaking in October 2013 coincided with this surge in the share of reserve balances held by large domestic banks.

Reportedly, larger institutions began to manage their balance sheet holdings to comply with the LCR ahead of the implementation date scheduled for January 2015.\textsuperscript{27} Under this new liquidity framework, excess reserve balances are classified as level 1 HQLA and have become an increasingly attractive asset for depository institutions that are trying to restructure their balance sheet to

\textsuperscript{24}Reportedly, FBOs may have also, in part, increased their reserve balance holdings in response to European guidance following EU bank stress testing in 2010.

\textsuperscript{25}Large domestic banks are defined as entities holding at least $250 billion in total assets. Medium banks hold between $50 and $250 billion in assets, and small banks hold up to $50 billion.

\textsuperscript{26}Note that pre-crisis averages are calculated using weekly data from 07-02-2008 to 09-17-2008.

\textsuperscript{27}In general, the LCR will not apply to domestic depository institutions with less than $50 billion in assets. The proposed U.S. rule is stricter than the Basel III framework and the implementation schedule is more accelerated. U.S. banks are required to use the peak net cumulative outflow over a 30-day stress period rather than the cumulative net outflow on the thirtieth day. Also, the U.S. transition timelines are shorter: the U.S. LCR has been at 80 percent since 2015 and will be at 100 percent by 2017, whereas Basel III requires a 60 percent LCR since 2015 and a 100 percent LCR by 2019.

17
improve the quality of their liquid assets. As shown in figure 7, large and medium FBOs built up approximately equal volumes of reserve balances from the peak of the financial crisis through the end of 2011. However, as with domestic banks, large FBOs have absorbed greater volumes of reserve balances since 2013 than smaller institutions.

Furthermore, the LSAPs together with the new regulatory policies appeared to have affected not only the level and distribution of reserve balances of depositary institutions, but also the composition of banks’ balance sheets. For instance, as shown in figure 8, FBOs’ share of reserve holdings to total assets rose from an average 9 percent during the period spanning from 2009 to 2010, to about 20 percent during 2011 and 2012. This jump in the share of reserves coincides with the improving conditions for IOER arbitrage faced by foreign institutions. Meanwhile, although at a lower level, DDIs’ share of reserves to assets show a similar trend during the pre-FDIC assessment change period. However, as DDIs begun positioning for the implementation of the new FDIC base, the patterns of reserves of DDIs and FBOs diverge significantly.

4.3 Reserves and federal funds dynamics on Basel III reporting days

In this section we document balance sheet adjustments - reserve balances and federal funds borrowed - on reporting days. Basel reporting requirements vary by jurisdiction: for U.S. banks the Basel III leverage ratio is calculated based on averages of daily values, while for European banks it is based on quarter-end values.28

We measure the reporting day effect using the ratio of reserve balances on reporting dates to

28 Until October 2014, the basis for the calculation of the leverage ratio for European banks was the average of the three month-ends over a quarter ([BIS 2013b], paragraph 6). On October 10, 2014, the European Commission amended the regulation with regard to the leverage ratio: The leverage ratio for the reporting period would be the ratio at quarter-end, instead of a three-month average. For a reference about rules by country see [BIS 2016].
the average for the corresponding reporting period. A ratio less than 1 represents a decrease in reserve balances on reporting days compared to the period average. Figure 9 plots the average reporting day effect for domestic and foreign banks. The time axis corresponds to quarter-end dates. As depicted by this figure, there is a notable decrease in reserve balances held by foreign banks on reporting days during preparation for and implementation of the Basel III Leverage ratio, suggesting that FBOs engage in window dressing to meet the new regulatory requirements.

Similarly, we next examine the pattern of federal funds borrowing on reporting days. Figure 10 plots total borrowing by foreign banks in the federal funds market at quarter-end compared with the average for the period. From 2013 to 2015 when the ratio was publicly disclosed, borrowing was consistently lower at quarter-end, dropping on average to 40 percent of the period average. Furthermore, results point to a decline in federal funds borrowing at quarter-ends even before Basel III. This adjustment is similar to window dressing behavior by FBOs in the US tri-party repo market even before Basel III as documented by (Munyan, 2015). However, window dressing in the federal funds market has been more persistent and pronounced since Basel III.

In addition, during this period, the decline in borrowing at month-end was reflected in a lower share of the federal funds borrowed in total liabilities, as shown in Table 2. Especially for European banks, the average share of federal funds in liabilities dropped from 2 percent to 0.7 percent. The lack of a trend in the quarter-end dynamic before the public disclosure of the leverage ratio on January 1, 2015 suggests that banks had already adjusted their quarter-end behavior to address the

\[ \text{INSERT FIGURE 9 HERE} \]

\[ \text{INSERT FIGURE 10 HERE} \]

\[ 29 \text{Balance sheet data are from the form "Report of assets and liabilities of U.S. branches and agencies of foreign banks (FFIEC 0002), which banks file quarterly. Foreign banks do not report capital, and assets are equal to liabilities.} \]
regulatory requirements. Indeed, month-end dynamics in federal funds borrowing and the share of federal funds borrowed in total liabilities remained largely unchanged following public disclosure of the leverage ratio. This is in line with implications from McCauley & McGuire (2014) who show that in the low-interest-rate environment, foreign banks revealed a preference for reserve balances over other assets. Under this environment, there would be temporary balance sheet adjustments on reporting dates rather than a permanent decrease in federal funds borrowed by foreign banks.

[INSERT TABLE 2 HERE]

5 Model

In this section, we introduce a model of bank’s profit maximization that explores the effect of the new FDCI assessment fee, Basel III Liquidity Coverage Ratio, and Leverage Ratio on reserve balances and overnight funding markets.\(^{30}\)

The bank receives deposits and wholesale funding, such as borrowing in the federal funds market. The bank uses these funds to provide loans, invest in market securities or hold as reserve balances at the Federal Reserve. For simplicity, we assume that reserves are the only source of HQLA and that equity is fixed.

The bank’s balance sheet is then:

\[
L_t + S_t + V_t = D_t + B_t + \bar{E}_t
\]

(4)

where \(L\) is loans, \(S\) is market securities, \(V\) is reserves, \(D\) is deposits, \(B\) is wholesale funding, \(\bar{E}\) is capital.

The bank maximizes its profits subject to the balance sheet constraint and regulatory requirements. The FDIC fee is incorporated in the model by increasing the cost of funding.

\(^{30}\)We thank our discussant Christina Wang for suggesting this approach.
\[
\max \sum_{t=0}^{\infty} E_0 \left\{ \rho_t \left[ r_t^L L_t + r_t^S S_t + r_t^V V_t - (r_t^D + \theta)D_t - (r_t^B + \theta')B_t \right] \right\}
\] (5)

s.t

Balance sheet: \( L_t + S_t + V_t = D_t + B_t + \bar{E}_t \)

Liquidity requirement (liquidity coverage ratio): \( V_t \geq \phi D_t + B_t \)  (6)

Capital requirement (leverage ratio): \( \bar{E}_t \geq \kappa (L_t + \mu V_t) \)

where, \( \rho \) is the discount factor, \( \theta \) and \( \theta' \) capture the FDIC fee, \( \phi \) is the run-off rate of \( D_t \) relative to \( B_t \), \( \kappa \) is the leverage ratio, \( \mu \) is the capital requirement on reserves. Under Basel III, the leverage ratio is not risk weighted, and we capture this by increasing \( \mu \) to 1. If the bank is subject to the FDIC fee, then until April 2011, \( \theta > 0 \) and \( \theta' = 0 \), as the FDIC fee was assessed only on the level of deposits. With the widening of the FDIC assessment base, \( \theta = \theta' > 0 \). If a bank is not subject to the FDIC fee then, \( \theta = \theta' = 0 \).

We can set the maximization problem as follows.

\[
L_t = \left[ r_t^L L_t + r_t^S (D_t + B_t + \bar{E}_t - L_t - V_t) + r_t^V V_t - (r_t^D + \theta)D_t - (r_t^B + \theta')B_t \right] + \lambda_t^V (V_t - \phi D_t - B_t) + \lambda_t^E \left[ \bar{E}_t - \kappa (D_t + B_t - (1 - \mu) V_t) / (1 - \kappa) \right]
\] (7)

FOCs:

\[
\frac{\partial L_t}{\partial V_t} : (r_t^V - r_t^S) + \lambda_t^V + \frac{\kappa (1 - \mu) \lambda_t^E}{1 - \kappa} = 0
\]

\[
\frac{\partial L_t}{\partial D_t} : r_t^S - (r_t^D + \theta) - \phi \lambda_t^V - \frac{\kappa \lambda_t^E}{1 - \kappa} = 0
\]

\[
\frac{\partial L_t}{\partial B_t} : r_t^S - (r_t^B + \theta') - \lambda_t^V - \frac{\kappa \lambda_t^E}{1 - \kappa} = 0
\]

\[
\lambda_t^V (V_t - \phi D_t - B_t) = 0
\]

\[
\lambda_t^E \left[ \bar{E}_t - \frac{\kappa (D_t + B_t - (1 - \mu) V_t)}{1 - \kappa} \right] = 0
\]

where \( \lambda_t^V \) is the shadow value of HQLA: \( \lambda_t^V > 0 \) if the LCR constraint is binding and 0 otherwise.

Similarly, \( \lambda_t^E \), the shadow cost of capital is > 0 if the leverage ratio constraint is binding and 0 otherwise.
otherwise. Domestic banks report their regulatory ratios daily. As such, we will consider the liquidity coverage ratio and the leverage ratio constraints to be always binding. FBOs are subject to these constraints only on reporting days (month-ends, quarter-ends).

Next we look at the effect of regulation on IOER arbitrage, allocation of asset between loans and reserve balances and the term structure of liabilities.

**IOER arbitrage**

In IOER arbitrage, the bank borrows in the wholesale funding market, \( B_t \), at rate \( r_t^B \) and holds these funds as reserve balances, \( V_t \), at rate \( r_t^V \). The rate of return from this trade is then, \( (r_t^V - r_t^B) \). We can then analyze the effect of the FDIC fee, liquidity coverage ratio, and leverage ratio on this spread. Basel reporting requirements vary by jurisdiction: for U.S. banks the Basel III leverage ratio is calculated based on averages of daily values, while for European banks it is based on quarter-end values. Given these reporting rules, for the case of FBOs, we distinguish between reporting and non-reporting days.

Using the FOCs for \( V_t \) and \( B_t \) we can express the spread from IOER arbitrage as in (9).

\[
\text{DDIs : } r_t^V - r_t^B = \theta' + \frac{\kappa \lambda E_t \mu}{1 - \kappa} \\
\text{FBOs, on reporting dates : } r_t^V - r_t^B = \frac{\kappa \lambda E_t \mu}{1 - \kappa} \\
\text{FBOs, on non-reporting dates : } r_t^V - r_t^B = 0
\]

For DDIs to engage in IOER arbitrage, the spread \( (r_t^V - r_t^B) \) has to be large enough to justify: 1) the new FDIC fee assessed on wholesale borrowing, \( \theta' \), and 2) Basel III leverage ratio which is not risk-weighted and captured by \( \mu \) increasing to 1. As a result, both the new FDIC assessment base and leverage ratio would lead to a permanent decrease in the DDIs’ demand for wholesale funding for IOER arbitrage purposes. As FBOs are not subject to the FDIC fee and are subject to the leverage ratio constraint only on reporting dates, we would observe a decrease in demand for
wholesale funding and reserve balances only on these dates.

**Term structure of liabilities: Long versus short-term borrowing**

In our model, deposits and wholesale borrowing represent long and short-term borrowing, respectively. Using the FOCs for \( D_t \) and \( B_t \), we can express the spread between these two sources of funding as in (10)

\[
\text{DDIs : } r_t^D - r_t^B = \theta' - \theta + (1 - \phi)\lambda_t^V
\]

\[
\text{FBOs : } r_t^D - r_t^B = (1 - \phi)\lambda_t^V
\]

For DDIs, the introduction of the new FDIC assessment base increases the relative cost of wholesale funding, triggering a decline on returns from IOER arbitrage trades, and a lower demand for this source of funding. In addition, as deposits have a lower run-off coefficient than wholesale funding, i.e. \( \phi < 1 \), there would be an increase in demand for deposits versus wholesale funding. However, we should note that this would apply to wholesale funding with a maturity of 30 days or longer. In the case of federal funds, which are mostly of overnight maturity, the corresponding net cash outflows would be zero and LCR considerations would not be applicable. The net effect would be a decrease in short-term borrowing versus long-term borrowing for DDIs.

**Asset allocation: High risk versus low risk**

We look at the effect of regulation on the spread between the interest on loans and interest on reserves, \( (r_t^L - r_t^V) \) and the bank’s decision to allocate its assets between loans and reserve balances. It is reasonable to assume that, given the nature of the loans, FBOs would not be able to adjust their portfolio around reporting dates and that they face the same constraints both on reporting and non-reporting dates.

Using the FOCs for \( L_t \) and \( V_t \), we can express this spread as in (11).
The decision to allocate assets between lending or holding reserve balances does not change the size of the balance sheet and, as expected, is not affected by the FDIC fee. Both DDIs and FBOs face the same constraints. With the capital requirement on reserves, captured by \( \mu = 1 \) under the non-risk weighted Basel III leverage ratio, the spread \( (r_t^L - r_t^V) = \lambda_t^V \) is smaller than under a risk-weighted leverage ratio. As a result, holding reserves balances, a low-risk asset, is more costly both for DDIs and FBOs.

To summarize, our model suggest that: 1) the new FDIC assessment base makes IOER arbitrage and short-term borrowing less profitable for DDIs than for FBOs; 2) leverage ratio constraints make IOER arbitrage less profitable for FBOs on reporting days; 3) the effects of the leverage ratio and liquidity coverage ratio constraints on asset allocation and term structure of liabilities do not differ for DDIs and FBOs. In the next section we empirically test the following hypotheses:

**Hypothesis 1**: The widening of the FDIC assessment base leads to a permanent decrease in demand for reserve balances by DDIs.

**Hypothesis 2**: The leverage ratio constraint decreases demand for reserve balances by FBOs on reporting dates.

### 6 Empirical testing

#### 6.1 FDIC assessment base change and domestic banks’ demand for reserve balances

To formally assess the effect of the widening of the FDIC base on demand for reserve balances, we next perform a difference-in-difference regression analysis. We define DDIs, which comprise the universe of domestic banks affected by the FDIC policy change, as the treatment group, and FBOs as the control group. The demand for reserve balances can be modeled as:

**Equation (11)**

\[
\begin{align*}
\text{DDIs: } r_t^L - r_t^V &= \lambda_t^V + \frac{\kappa \lambda_t^E (1 - \mu)}{1 - \kappa} \\
\text{FBOs: } r_t^L - r_t^V &= \lambda_t^V + \frac{\kappa \lambda_t^E (1 - \mu)}{1 - \kappa}
\end{align*}
\]
FBOs as the control group. Dating regulatory changes can be challenging since new rules generally involve many stages, such as a proposal, commenting, adoption, and an implementation period. For instance, by the time the new FDIC base was implemented, the affected banks may had already adapted their funding models as a response to the new regulatory framework. To acknowledge this possibility, we consider both a "preparation" and an "implementation" period. We then estimate the following regressions:

\[
\text{Res/Asset}_{i,t} = \beta_0 + \gamma_1 (\text{Domestic}_i \times \text{Preparation}_t) + \gamma_2 (\text{Domestic}_i \times \text{FDIC}_t) \\
+ \beta_1 \text{Domestic}_i + \beta_2 \text{Large}_{i,t} + \beta_3 \text{Medium}_{i,t} + c_i + \lambda_t + \epsilon_{i,t}
\]  

(12)

\[
\text{Res/Asset}_{i,t} = \beta_0 + \gamma_1 (\text{Domestic}_i \times \text{Preparation}_t) + \gamma_2 (\text{Domestic}_i \times \text{FDIC}_t) \\
+ \alpha_i + \lambda_t + \epsilon_{i,t}
\]  

(13)

where \(\text{Res/Asset}_{i,t}\) is the share of reserve balances to total assets, \(\text{Domestic}\) is a dummy that equals 1 for the universe of domestic banks affected by the policy change, and \(\text{Preparation}\) is set to 1 for the 2010Q3–2011Q1 period, covering the adoption of the Dodd-Frank Wall Street Reform and Consumer Protection Act in July 2010 through the period prior to the implementation of the new FDIC assessment base.\(^{31}\) \(\text{FDIC}\) is a time indicator that captures the post-treatment period spanning from the second quarter of 2011 through the third quarter of 2012. The difference-in-difference estimators, \(\gamma_1\) and \(\gamma_2\), show the average change in reserve balances for domestic banks during the preparation period and after the widening of the FDIC base relative to the share of reserves of foreign banks. As we documented earlier, the ability of banks to absorb reserves varied with the size of their balance sheet, so we also define \(\text{Large}_{i,t}\) and \(\text{Medium}_{i,t}\) as indicator variables to identify large, medium, and small institutions. In addition, \(\lambda_t\) controls for time fixed effects that could have affected reserve holdings by foreign and domestic banks, while \(\alpha_i\) and \(c_i\) are dummies that control for bank-specific characteristics and country-specific idiosyncratic factors, respectively. Our sample

\(^{31}\)The Dodd-Frank Act, signed on July 21, 2010, required the FDIC to amend its definition of a bank’s assessment base as its average consolidated total assets minus its average tangible equity.
comprises bank-level balance sheet data from the Call Report for a total of 1,948 banks.\footnote{Specifically, the sample includes institutions that fill out the FFIEC 031, FFIEC 041, FFIEC 002, and FR 2886b report forms.}

Consistent with our model, and as shown in Table 3, results suggest that the widening of the FDIC base had an economically and statistically significant negative effect on demand for reserve balances, and that the effect is robust across alternative specifications. More specifically, the negative sign of the estimated coefficient for \((\text{Domestic} \times \text{FDIC})\) indicates that, all else equal, following the implementation of the new FDIC assessment base, the share of reserves over total assets held by domestic banks was, on average, 4.5 percentage points lower than the share held by FBOs. Also, size appears to be a factor in explaining demand for reserve balances, with large and medium institutions holding larger volumes and shares of reserves than small banks.

### 6.2 Basel III Leverage ratio and foreign banks behavior on reporting days

In this section, we test the hypothesis that the Basel III leverage ratio incentivizes FBOs to decrease their holdings of reserve balances on reporting days. We measure the reporting day effect by the ratio of reserve balances on reporting dates to the average for the corresponding reporting period. A ratio less than 1 represents a decrease in reserve balances on reporting days compared to the period average.

We perform a difference-in-difference regression analysis. We define DDIs as the control group and the FBOs as the treatment group. While both DDIs and FBOs are subject to the leverage ratio, DDIs report their Leverage ratio based on daily averages.

We estimate the following difference-in-difference regressions at the bank level:
QuarterEndEffect_{i,t} = \beta_0 + \alpha_i + \delta \text{Basel}_t + \gamma (\text{Foreign}_i \times \text{Basel}_t) + \epsilon_{i,t} \quad (14)

QuarterEndEffect_{i,t} = \beta_0 + \alpha_i + \lambda_t + \gamma (\text{Foreign}_i \times \text{Basel}_t) + \epsilon_{i,t} \quad (15)

QuarterEndEffect_{i,t} is the ratio of reserve balance holdings at quarter-end divided by the average reserve balances for the last 10 preceding days. Foreign_i equals 1 for foreign banks. Basel_i is equal to 1 for the period following reporting of the the Leverage ratio to supervisors, and Foreign \times Basel equals 1 for foreign banks in the Basel implementation period. The difference-in-difference coefficient, \gamma, shows the quarter-end decrease in reserve balances for foreign banks compared to domestic banks. In 14, we include bank fixed effects, \alpha_i, to control for potential bias that might result from time-invariant bank characteristics. Additionally, in 15 we include quarter fixed effects, \lambda_t, to account for any changes that might have occurred around the same time as the implementation of Basel III and which could have affected the reserve holdings at quarter end.\footnote{We do not include the indicator variables Foreign_i and Basel_t separately as they are a linear combination of bank fixed effects and time fixed effects.}

The data is from FR 2900 for the period December 2010 to June 2017.\footnote{See https://www.federalreserve.gov/apps/reportforms/default.aspx for details.}

Our model suggests that foreign banks should adjust their balance sheets on reporting days, that is \gamma should be negative and significant. Since U.S. banks would not have such incentive, \delta should be zero.

Table 4 shows the regression results for 14 and 15. We find a significant quarter-end effect on reserves holdings by foreign banks and no quarter-end effect for domestic banks following reporting of Basel III leverage ratio to the supervisors. This result is robust to including time fixed effects which account for other concurrent factors that could have influenced quarter-end adjustments in reserve holdings. As shown by the coefficient on (Baseline \times Foreign), following Basel III, reserves holding at quarter-end relative to the period average decreased by 14.3 percentage points for foreign
banks compared to domestic banks. The coefficient on Basel is insignificant, implying that there was no quarter-end effect in reserve holdings by domestic banks following Basel III, leaving their reserve holdings at quarter-end largely unchanged following Basel III.

We also distinguish between the period when the leverage ratio was reported to the supervisors and when it was disclosed to the public. We estimate the following empirical specifications.

\[
QuarterEndEffect_{i,t} = \beta_0 + \alpha_i + \delta_1 \text{Reported}_i + \delta_2 \text{Disclosed}_i + \gamma_1 (\text{Foreign}_i \times \text{Reported}_i) + \gamma_2 (\text{Foreign}_i \times \text{Disclosed}_i) + \epsilon_{i,t}
\]  

\[
QuarterEndEffect_{i,t} = \beta_0 + \alpha_i + \lambda_t + \delta_2 \text{Disclosed}_i + \gamma_1 (\text{Foreign}_i \times \text{Reported}_i) + \gamma_2 (\text{Foreign}_i \times \text{Disclosed}_i) + \epsilon_{i,t}
\]

\text{Reported} equals 1 for the period when the ratio was reported to supervisors (January 2013 to December 2014) and \text{Disclosed} is equal to 1 for the period starting from January 1, 2015. The difference-in-difference coefficients are then \gamma_1 and \gamma_2. Our model suggests that \gamma_1 and \gamma_2 should be negative and significant, \delta_1 and \delta_2 should be zero.

The regression results for 16 and 17 are shown in Table 5. We find a significant quarter-end effect on reserves holdings by foreign banks following Basel III implementation of the leverage ratio, both for the earlier period (January 2013 to December 2014) when the ratio was reported only to the supervisors as well as for the later period (from January 2015) when the ratio was disclosed to the public. As expected, the quarter-end effect in the later period is larger and more representative of the final effect, as we can think of the earlier period as more of an adjustment period in preparing for meeting Basel III requirements. During the period the leverage ratio was reported to supervisors, foreign banks’ reserve holdings at quarter-end relative to the period average dropped
by 9.2 percentage point on average compared to domestic banks. Following public disclosure of the leverage ratio, this relative drop in reserves holdings is 18.3 percentage points.

7 Conclusion

In response to the 2007-08 financial crisis, the Federal Reserve started paying interest on reserve balances held by depository institutions, kept the federal funds rate near zero from December 2008 to December 2015, and also engaged in large-scale asset purchases, which created a tremendous amount of reserves in the banking system. We argue that this unconventional monetary policy, along with changes in banking regulations, changed the incentives for financial institutions to participate in the federal funds market as well as their incentives to hold reserves. In particular, using bank-level data on FDIC fees and federal funds transactions, we find that the new assessment base created asymmetries between domestic and foreign institutions in the funding costs of reserves, making reserves funded in short-term wholesale funding markets relatively more expensive for domestic banks than for foreign banks not subject to the FDIC fee. This new environment contributed to an increase in foreign banks’ reserve holdings and federal fund borrowing relative to domestic institutions, shifting the distribution of reserves in the banking system from domestic to foreign banks. Our analysis also shows that, since the implementation of the Basel III leverage ratio, foreign banks have engaged in window dressing on reporting days to comply with the new regulatory requirements.

Taken together, this paper brings unique evidence to the study of the effects of post-crisis banking regulation on trading dynamics in the federal funds market and demand for reserves. Future research could explore the financial stability implications associated with the substantial increased participation of foreign banks in the distribution of reserves in the banking system.
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Figure 1: Evolution of Federal Reserve’s Liabilities

Note: This figure plots the evolution of the Federal Reserve’s liabilities over the period spanning June 2008 to July 2014. Data series are from the H.4.1 FRB Statistical Release. As shown in this figure, the increase in liabilities was primarily due to a surge in excess reserves following the outburst of the financial crisis and the subsequent implementation of a series of large-scale asset purchase programs.
Figure 2: Effective FDIC Rates (Basis Points)

Note: This figure plots the volume-weighted effective FDIC fee rate paid by domestic institutions over the period covering 2Q2011, when the new assessment base was implemented, to 1Q2014. The sample includes commercial banks and savings and loans institutions, covering around 93 percent of total assets and almost the entire share of reserve balances held by insured depository institutions. The sample does not include credit unions, which are not insured by the FDIC. Bank-level fee rates are from the FDIC.
Figure 3: IOER Net Returns for Federal Funds Borrowing by DDIs (by Institution Size, Net of FDIC fees)

Note: This figure depicts domestic depository institutions’ net gains from IOER arbitrage trades funded by borrowing in the fed funds market. Net returns from IOER arbitrage trades are defined as the gains from interest on excess reserves (IOER), less the rate paid in the fed funds market and the FDIC fee rate. We create weekly volume-weighted net return series for large, medium, and small domestic banks, from January 2011 through October 2013.
Figure 4: IOER Net Returns for Federal Funds Borrowing by FBOs (by Institution Size)

Note: This figure presents FBOs’ net gains from IOER arbitrage trades funded by borrowing in the fed funds market. Net returns from IOER arbitrage trades are defined as the gains from interest on excess reserves (IOER) less the rate paid in the fed funds market. We create weekly volume-weighted net return series for large, medium, and small foreign banks, from December 2008 through April 2014.
Figure 5: Foreign versus Domestic Reserve Holdings

Note: This figure shows the distribution of reserve balances between domestic and foreign-related institutions over the period covering the Federal Reserves large-scale asset purchase programs. Weekly reserve balance data are from the FR 2900 report and span from July 2008 to July 2014.
Figure 6: Reserve Balances by Institution Size - DDIs

Note: This figure depicts the evolution of domestic depository institutions’ reserve balances by institution size. Large banks are defined as entities holding at least $250 billion in total assets. Medium banks hold between $50 and $250 billion in assets, and small banks hold up to $50 billion. Data are from the FR 2900 report and span from July 2008 to July 2014.
Figure 7: Reserve Balances by Institution Size - FBOs

Note: This figure shows the evolution of FBOs holdings of reserve balances by institution size. Large banks are defined as entities holding at least $50 billion in total assets. Medium banks hold between $1 and $50 billion in assets, and small banks hold under $1 billion. Data are from the FR 2900 report and span from July 2008 to July 2014.
Figure 8: Share of Reserve Balances to Total Assets over Time

Note: This figure shows the evolution of the share of reserve balances to total assets of domestic and foreign banks. Time series are calculated as cross-sectional weighted averages using bank level data from the Call reports over the period spanning from 2009Q1 to 2013Q3. The first vertical line marks the beginning of the “preparation period”, defined as the date that the Dodd-Frank Wall Street Reform and Consumer Protection Act was signed into law (July 2010), and the second vertical line points to the implementation date of the new FDCI assessment base (April 2011).
Figure 9: Quarter-end effect: Reserve balances

Note: This figure plots the average quarter-end effect for reserve balances for domestic and foreign banks. The time axis corresponds to quarter-end dates. We define the quarter-end effect as the ratio of reserve balances at quarter-end divided by the average reserve balances for the last 10 preceding days. A ratio of less than 1 represents a decrease in the reserve balances at quarter-end. This variable is calculated using the FR 2900 data for the period December 2010 to June 2017. The first vertical line corresponds to January 1, 2013 when the leverage ratio was reported to the supervisors. The second vertical line corresponds to January 1, 2015 when the leverage ratio was reported to the public.
Figure 10: Quarter-end effect: Federal funds borrowing

Note: This figure plots the average quarter-end effect for federal funds for domestic and foreign banks. The time axis corresponds to quarter-end dates. We define the quarter-end effect as the ratio of federal funds borrowed at quarter-end divided by the average for the last month in that quarter. A ratio of less than 1 represents a decrease in federal funds borrowed at quarter-end. Federal funds transaction data are from Fedwire-identified federal funds using a Furfine (1999) type algorithm. The first vertical line corresponds to January 1, 2013 when the leverage ratio was reported to the supervisors. The second vertical line corresponds to January 1, 2015 when the leverage ratio was reported to the public.
Table 1: Basel III Ratios and Their Impact on Banks Borrowing in Federal Funds Market

|                         | Banks borrowing in the federal funds market | 30-day maturity | >30-day maturity |
|-------------------------|---------------------------------------------|-----------------|------------------|
| Leverage Ratio          | decrease                                    | decrease        |                  |
| Liquidity Coverage Ratio| likely no change                            | increase        |                  |

Note: This table summarizes the expected effect of the Basel III leverage ratio and liquidity coverage ratio on banks’ borrowing in the federal funds market.

Table 2: Share of Fed Funds Borrowing in Liabilities

|                              | European Banks          | Non-European Banks |                      |
|------------------------------|-------------------------|---------------------|----------------------|
|                              | Average | Stdev | Min | Max | Average | Stdev | Min | Max |
| Before (2009:Q1-2012:Q4)     | 2.00%   | 5.90% | 0.00% | 70.10% | 3.00%   | 10.80% | 0.00% | 98.70% |
| Reported to supervisors (2013:Q1 - 2014:Q4) | 0.70%   | 2.80% | 0.00% | 28.20% | 2.20%   | 8.30% | 0.00% | 95.80% |
| Disclosed to the public (2015:Q1 - 2015:Q4) | 0.90%   | 3.00% | 0.00% | 31.10% | 1.90%   | 7.70% | 0.00% | 92.00% |
| Reported to supervisors/Before | 0.4     | 0.5   | 0.4  |      | 0.74    | 0.76   | 0.97 |      |
| Disclosed to the public/Reported to supervisors | 1.2     | 1.1   | 1.1  |      | 0.84    | 0.94   | 0.96 |      |

Note: This table shows the ratio of federal funds borrowing to total liabilities for foreign banks for different periods: 1) before Basel III implementation, 2) when the leverage ratio was reported only to supervisors, and 3) when the leverage ratio was disclosed to the public. The data is from FFIEC 002 for the period from 2009Q1 to 2015Q4.
### Table 3: Reserve balances and the New FDIC Assessment Base

|                           | Reserves/Assets (1) | Reserves/Assets (2) |
|---------------------------|---------------------|---------------------|
| Preparation period x Domestic | -0.008 (-0.90)     | -0.009 (-0.93)     |
| FDIC x Domestic           | -0.045*** (-3.88)  | -0.047*** (-3.85)  |
| Domestic                  | -0.073 (-1.03)     |                     |
| Large                     | 0.119*** (3.74)    |                     |
| Medium                    | 0.099*** (5.45)    |                     |
| Constant                  | 0.093 (1.31)       | 0.098*** (10.05)   |

Number of obs. 29186 29186  
Number of entities 1948 1948  
Adjusted $R^2$ 0.25 0.74  
Country FE Yes No  
Time FE Yes Yes  
Bank FE No Yes  

Notes: This table shows estimated coefficients and t-statistics (in parenthesis) for difference-in-difference regressions where the dependent variable is the share of banks’ reserve balances to total assets. **Domestic** equals 1 for the institutions affected by the FDIC policy change; **Preparation period** equals 1 for the period from 2010Q3 to 2011Q1, the period covering the adoption of the Dodd-Frank Wall Street Reform and Consumer Protection Act through the period prior to the implementation of the new FDIC assessment base; **FDIC** equals 1 from 2011Q2, when the new FDIC assessment base was implemented, through 2012Q3. The difference-in-difference coefficients are **Domestic x Preparation period** which equals 1 for domestic banks during the preparation period, and **Domestic x FDIC** which equals 1 for domestic banks in the post-implementation period. **Large** and **Medium** are indicator variables for large and medium banks. The regression in Column (1) includes country fixed-effects while that of column (2) is based on bank fixed-effects. Standard errors are clustered by entity. Bank data is from Call Reports and run from 2009Q1 to 2012Q3.
Table 4: Reserve Balances and Basel III Leverage Ratio.

|                               | (1)             | (2)             |
|-------------------------------|-----------------|-----------------|
|                               | Quarter-End/Average | Quarter-End/Average |
| Basel x Foreign               | -0.143***       | -0.143***       |
|                               | (-4.67)         | (-4.63)         |
| Basel                         | -0.002          |                 |
|                               | (-0.48)         |                 |
| Constant                      | 1.097***        | 1.009***        |
|                               | (279.44)        | (80.21)         |

Number of obs. 49543 49543
Number of banks 1855 1855
Adjusted $R^2$ 0.156 0.165
Bank FE yes yes
Time FE no yes

Notes: This table shows estimated coefficients and t-statistics for difference-in-difference regressions for the quarter-end effect of Basel III leverage ratio on reserve balances. For any given bank, the quarter-end effect is given by the ratio of reserve balances at quarter-end divided by the average reserve balances for the last 10 preceding days. Foreign equals 1 for foreign banks. Basel is equal to 1 for the period following reporting of the Leverage ratio to supervisors. $(\text{Basel} \times \text{Foreign})$ is difference-in-difference coefficient which refers to foreign banks in the post treatment period. We also include bank fixed effects to control for potential bias that might result from time-invariant bank characteristics, and quarter fixed effects to account for any changes that might have occurred around the same time as the implementation of Basel III and which could have affected the reserve holdings at quarter end. We do not include the indicator variables Foreign and Basel separately, as they are a linear combination of bank fixed effects and time fixed effects. The data is from FR 2900 for the period December 2010 to June 2017, https://www.federalreserve.gov/apps/reportforms/default.aspx.
|                                | (1)                      | (2)                      |
|--------------------------------|--------------------------|--------------------------|
|                                | Quarter-End/Average      | Quarter-End/Average      |
| Reported                       | -0.019***                | -0.092***                |
|                                | (-3.37)                  | (-2.72)                  |
| Disclosed                      | 0.011**                  | -0.183***                |
|                                | (2.00)                   | (-5.49)                  |
| Reported x Foreign             | -0.093***                | -0.092***                |
|                                | (-2.73)                  | (-2.72)                  |
| Disclosed x Foreign            | -0.183***                | -0.183***                |
|                                | (-5.53)                  | (-5.49)                  |
| Constant                       | 1.097                    | 1.009***                 |
|                                | (279.44)                 | (80.21)                  |
| Number of obs.                 | 49543                    | 49543                    |
| Number of banks                | 1855                     | 1855                     |
| Adj. $R^2$                     | 0.156                    | 0.165                    |
| Bank FE                        | yes                      | yes                      |
| Time FE                        | no                       | yes                      |

Notes: This table shows estimated coefficients and t-statistics for difference-in-difference regressions for the quarter-end effect of Basel III leverage ratio on reserve balances. For any given bank, the quarter-end effect is given by the ratio of reserve balances on quarter-end divided by the average reserve balances for the last 10 preceding days. Foreign equals 1 for foreign banks. We distinguish between when the leverage ratio was reported to the supervisors and when it was disclosed to the public. Reported equals 1 for the period when the ratio was reported to supervisors (January 1, 2013 to January 1, 2015). Disclosed is equal to 1 for the period starting from January 1, 2015. The difference-in-difference coefficient are then (Reported x Foreign) and (Disclosed x Foreign). We also include bank fixed effects to control for potential bias that might result from time-invariant bank characteristics, and quarter fixed effects to account for any changes that might have occurred around the same time as the implementation of Basel III and which could have affected the reserve holdings at quarter end. We do not include the indicator variables Foreign and Basel, separately, as they are a linear combination of bank fixed effects and time fixed effects. The data is from FR 2900 for the period December 2010 to June 2017. https://www.federalreserve.gov/apps/reportforms/default.aspx.