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

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Abstract

We study developments in reserve balances and the federal funds market in the context of two banking regulatory changes: the widening of the Federal Deposit Insurance Corporation (FDIC) assessment base and the introduction of the Basel III regulatory ratios. First, using a novel dataset, we document that as most foreign banks were not subject to the FDIC fee, they absorbed increasing amounts of reserve balances. Furthermore, foreign banks experienced positive and improving conditions for arbitraging between borrowing reserve balances in the federal funds market and earning interest on excess reserves by holding those reserves at the Federal Reserve Banks, contributing to an increase in federal funds borrowing by foreign banks relative to domestic banks. However, the implementation of the Basel III leverage ratio was associated with temporary declines in foreign banks’ reserve balances and federal funds borrowing on reporting dates. Second, we present a model that incorporates the new regulatory framework and derive testable hypotheses in line with the documented facts. Third, we test the model using difference-in-difference estimation and bank-level data. We find that: 1) following the implementation of the new FDIC rule, the share of reserves over total assets held by domestic banks was 4.3 percentage points lower than the share held by foreign banks; 2) following the public disclosure of the Basel III leverage ratio, foreign banks’ reserve balances on reporting dates relative to the period average dropped by 18.3 percentage points compared to domestic banks.

Keywords: Reserve balances, IOER arbitrage, federal funds market, FDIC fees, Basel III

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. The federal funds market is at the core of monetary policy implementation, as the Federal Open Market Committee (FOMC) sets the target for the federal funds rate. 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. 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 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). We document that the new FDIC assessment base fee changed the relative funding costs and incentives for depository institutions to hold reserve balances. 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. 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.

The implementation of the Basel III regulatory ratios also induced changes in FBOs' reserve holdings and federal funds borrowing on reporting dates. For example, 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.

Building on these results, we present a model of bank's profit maximization that incorporates these regulatory changes. The model yields testable hypotheses on the effect of the new FDIC assessment base and Basel III regulatory ratios. We test the model using difference-in-difference regression models and bank-level 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 4.3 percentage points lower than the share held by foreign banks. Following the public disclosure of the Basel III leverage ratio, the foreign banks' reserve balances decreased further.

1 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.

2 FDIC fee data at the bank level is confidential. Throughout the paper, we show aggregated FDIC fee series.

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.
reserve holdings on reporting dates relative to the period average dropped by 18.3 percentage points compared to domestic banks.

Our paper contributes to the new literature on Basel III regulation. 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 the banks face the possibility of an LCR shortfall, it becomes more challenging for a bank to control the overnight interest rate, and the short end of the yield curve becomes steeper. On the empirical side, the closest work 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 work also contributes to the broader literature on federal funds market. (Hamilton, 1996) (Ashcraft & Duffie, 2007) (Afonso & Lagos, 2015b) (Afonso & Lagos, 2015a) focus on the federal funds market as a market for reserves. (Afonso, Kovner, & Schoar, 2011) (Ashcraft, McAndrews, & Skeie, 2011) look at the federal funds during the 2007-2008 financial crisis and they examine the importance of liquidity hoarding and counterparty risk during the financial crisis. Following the financial crisis and the unprecedented increase in reserves, the federal funds market as a market for reallocating reserves among banks almost disappeared as shown in (Bech & Klee, 2011). (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 gives some background information. Section 3 presents the new FDIC policy and Basel III regulatory ratios. Section 4 documents developments in reserve balances and federal funds in light of these regulatory changes. Section presents a model of bank’s profit maximization that incorporates this new regulatory framework, and empirical testing
of the model follows in Section 6. Section 7 concludes.

2 Background information

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.\footnote{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).} 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.\footnote{https://www.federalreserve.gov/monetarypolicy/20081006a.htm} 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).\footnote{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).}

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.\footnote{For more details on LSAPs and their effect see See (D’Amico, English, Lopez-Salido, & Nelson 2012), (Gagnon, Raskin, Remache, & Sack 2011) (Krishnamurthy & Vissing-Jorgensen 2011).} LSAPs significantly expanded and changed the composition 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 excess to total reserve balances has remained steady.

This exceptionally high level of reserve balances in the banking system along with the introduc-
tion 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.

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. 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.\(^\text{10}\) 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 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.

As depicted in figure, 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

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11 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.

12 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.

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.

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.\(^{14}\) As most of the borrowing in the federal funds market is by foreign banks, we will discuss reporting requirement for foreign banks.

**Leverage ratio\(^ {15}\)**

The Basel III leverage ratio is a non-risk based leverage ratio 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):

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

\(^{14}\)For details on the implementation schedule and definition of ratios see http://www.bis.org/bcbs/basel3/basel3_phase_in_arrangements.pdf.\(^{15}\)The definition of the leverage ratio is based on BIS (2014) and BIS (2013b).
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 were taken by foreign banks (mostly the branches unaffected by the new FDIC 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 assets.

**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)

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16The definition of the Liquidity Coverage Ratio is based on (BIS 2013a).
total net cash outflows and is expressed as in (2):

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

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):

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

Different types of outflows are weighted by their run-off factors. Borrowing from banks falls into “Unsecured wholesale funding provided by other legal entity customers”, and it has a run-off factor of 100 percent.\(^{17}\) 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

\(^{17}\) 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).
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 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.

If LCR > 100 percent by a small margin, the bank might prefer to decrease borrowing in the federal funds market. While 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.
4 Developments in reserve balances and federal funds market

In this section, we explore the economic incentives of depository institutions to engage in IOER arbitrage and examine how the FDIC base change affected arbitrage payoffs. We then document developments in reserves balances and federal funds market related to the new FDIC policy and Basel III reporting dates.

4.1 IOER arbitrage and the new FDIC policy

To understand the economic incentives for 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, 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.\(^{19}\) We then use these series together with FDIC fee 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

\(^{19}\)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 would 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.
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).\(^{20}\) 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.\(^{21}\)\(^{22}\)

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 fees, were able to produce positive average returns from IOER arbitrage trades. From the inception of the 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.

\[\text{INSERT FIGURE 3 HERE}\]

\[\text{INSERT FIGURE 4 HERE}\]

\(^{20}\)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.

\(^{21}\)Note that these estimates do not take into account other balance sheet costs involved in financing reserve balances.

\(^{22}\)Using Rate Watch data, we find that arbitrage trades funded by deposits outperform trades funded through the federal funds market, on average. These results are associated with the decreasing and low rates paid by domestic banks on their deposit liabilities during our sample period.
4.2 Evolution 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 regulation, the funding cost of reserve balances faced by domestic institutions increased by the amount of the FDIC fee.

Among domestic institutions, larger banks have been the main driver of demand for reserves. 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, whereas 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.

Reportedly, FBOs may have also increased their reserve balance holdings in response to European guidance following EU bank stress testing in 2010.

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.
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\textsuperscript{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 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 improve the quality of their liquid assets. As shown in figure\textsuperscript{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 the domestic banks, large institutions have absorbed greater volumes of reserve balances since 2013.

\[\text{[INSERT FIGURE 6 HERE]}\]

\[\text{[INSERT FIGURE 7 HERE]}\]

\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.
4.3 Reserve balances 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.\footnote{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 (\citeo{BIS2013b}, paragraph 6). On October 10, 2014, the European Commission amended the regulation with regard to the leverage ratio: The leverage ratio would be reported at the end of the quarterly reporting period, instead of a three-month average. For a reference about rules by country see \citeo{BIS2016}.}

We measure the reporting day effect using 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. Figure 8 plots the average reporting day effect for domestic and foreign banks. The time axis corresponds to quarter-end dates. 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.

[INSERT FIGURE 8 HERE]

Similarly, we compare the borrowing activity at the end of the quarter with the daily average for the last month in the corresponding quarter. Figure 9 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. We also see some drop 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 \citeo{Munyan2015}. 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 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 that environment, there would be temporary balance sheet adjustments on reporting dates rather than a permanent decrease in federal funds borrowed by foreign banks.

5 Model

In this section, we present a model 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.

The bank receives deposits and wholesales 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.

---

29 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.

30 We thank our discussant Christina Wang for suggesting this approach.
The bank’s balance sheet is then:

\[ L_t + S_t + V_t = D_t + B_t + \bar{E}_t \tag{4} \]

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.

\[
\max_{L_t, S_t, V_t} \sum_{t=0}^{\infty} E_0 \left\{ \rho_t \left[ r^L_t L_t + r^S_t S_t + r^V_t V_t - (r^D_t + \theta)D_t - (r^B_t + \theta')B_t \right] \right\} \tag{5}
\]

s.t

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

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

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

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.

\[
\mathcal{L}_t = \left[ r^L_t L_t + r^S_t (D_t + B_t + \bar{E}_t - L_t - V_t) + r^V_t V_t - (r^D_t + \theta)D_t - (r^B_t + \theta')B_t \right] + \lambda^V_t (V_t - \phi D_t - B_t) + \lambda^E_t \left[ \bar{E}_t - \kappa (D_t + B_t - (1 - \mu) V_t)/(1 - \kappa) \right] \tag{7}
\]
FOCs:

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

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

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

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. 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 market, \( B_t \), at rate \( r_t^B \) and holds these funds as reserve balances, \( V_t \) at rate \( r_t^B \). The rate of return from this activity is then, \( (r_t^V - r_t^B) \).

We 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).
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 FDCI 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 vs. 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):

\[
\text{DDIs : } r_t^D - r_t^B = \theta' - \theta + (1 - \phi) \lambda_t^V
\]
\[
\text{FBOs : } r_t^D - r_t^B = (1 - \phi) \lambda_t^V
\]
a decrease in short-term borrowing versus long-term borrowing for DDIs.

**Asset allocation: High risk vs. low risk**

We look at the effect of regulation on the spread between the interest on loans and interest on reserves, \((r^L_t - r^V_t)\) 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).

\[
\begin{align*}
\text{DDIs : } r^L_t - r^V_t &= \lambda_t^V + \frac{\kappa \lambda_t^E (1 - \mu)}{1 - \kappa} \\
\text{FBOs : } r^L_t - r^V_t &= \lambda_t^V + \frac{\kappa \lambda_t^E (1 - \mu)}{1 - \kappa}
\end{align*}
\]  

(11)

The decision to allocate assets between lending and 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 are faced with the same constraints. With the capital requirement on reserves, captured by \(\mu = 1\) under the non-risk weighted Basel III leverage ratio, the spread \((r^L_t - r^V_t) = \lambda_t^V\) 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 test the following hypotheses:

_Hypothesis 1_: The widening of the FDIC assessment base leads to a permanent decrease in demand for reserves by DDIs.
Hypothesis 2: The leverage ratio constraint decreases the demand for reserves by FBOs on reporting dates.

6 Empirical testing

6.1 FDIC assessment base and the reserve balances of domestic banks

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 are affected by the new policy, as the treatment group and FBOs as the control group.

We estimate the following specifications.

\[ \frac{Res}{Asset}_{i,t} = \beta_0 + \gamma(Domestic_i \times FDIC_t) + \beta_1 Domestic_i \]
\[ + \beta_2 Large_{i,t} + \beta_3 Medium_{i,t} + c_i + \lambda_t + \epsilon_{i,t} \]  

\[ (12) \]

\[ \frac{Res}{Asset}_{i,t} = \beta_0 + \gamma(Domestic_i \times FDIC_t) + \beta_1 Domestic_i + \alpha_i + \lambda_t + \epsilon_{i,t} \]

\[ (13) \]

\( Res/Asset_{i,t} \) is the share of reserve balances to total assets, \( Domestic \) equals 1 for domestic banks affected by the policy change, \( FDIC \) equals 1 for the treatment period (from 2011Q2). The difference-in-difference coefficient, \( \gamma \), shows the change in reserve balance for domestic banks after the widening of the FDIC assessment base compared to the foreign banks. As the evolution of reserves varied with bank size, we also include the following of controls: \( Large_{i,t} \) and \( Medium_{i,t} \) are indicator variables to identify large, medium, and small institutions. In addition, \( \alpha_i \) controls for bank fixed effects, \( c_i \) controls for country-specific effects and \( \lambda_t \) controls for time fixed effects that could have affected reserve holdings by foreign and domestic banks. Our sample comprises bank-level balance sheet data from the Call Report for a total of 1,948 banks.

\[ ^{31} \]

\[ ^{31} \]Specifically, the sample includes institutions that fill out the FFIEC 031, FFIEC 041, FFIEC 002, and FR 2886b report forms.
Our model suggests that $\gamma$ should be positive and significant.

[INSERT TABLE 3 HERE]

As shown in Table 3, results suggest that the widening of the FDIC base had an economically and statistically significant effect on demand for reserve balances and that the effect is robust across different specifications. More specifically, the negative sign of the estimated coefficient for $(Domestic \times FDIC)$ suggests that, with the introduction of the new FDIC assessment base, the share of reserves over total assets held by domestic banks was 4.3 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 regression at the bank level. We estimate two specifications shown in 14 and 15.

$$QuarterEndEffect_{i,t} = \beta_0 + \alpha_i + \delta Basel_t + \gamma (Foreign_i \times Basel_t) + \epsilon_{i,t} \quad (14)$$
QuarterEndEffect\(_{i,t}\) = \(\beta_0 + \alpha_i + \lambda_t + \gamma(Foreign_i \times Basel_t) + \epsilon_{i,t}\) \hspace{1cm} (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.\(^{32}\)

The data is from FR 2900 for the period December 2010 to June 2017.\(^{33}\)

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 (Basel \(\times\) 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

\(^{32}\)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.

\(^{33}\)See https://www.federalreserve.gov/apps/reportforms/default.aspx for details.
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.

\[ \text{QuarterEndEffect}_{i,t} = \beta_0 + \alpha_i + \delta_1 \text{Reported}_i + \delta_2 \text{Disclosed}_i \]
\[ + \gamma_1 (\text{Foreign}_i \times \text{Reported}_i) + \gamma_2 (\text{Foreign}_i \times \text{Disclosed}_i) + \epsilon_{i,t} \] (16)

\[ \text{QuarterEndEffect}_{i,t} = \beta_0 + \alpha_i + \lambda_t + \delta_2 \text{Disclosed}_t \]
\[ + \gamma_1 (\text{Foreign}_i \times \text{Reported}_i) + \gamma_2 (\text{Foreign}_i \times \text{Disclosed}_i) + \epsilon_{i,t} \] (17)

Reported equals 1 for the period when the ratio was reported to supervisors (January 2013 to December 2014) and 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 banks’ reserve balances held at Federal Reserve, 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 reserve balances in the banking system. This unconventional monetary policy, along with changes in banking regulations, changed the incentives for financial institutions to participate in the federal funds market. At its December 2015 meeting, the FOMC decided to raise the target range for the federal funds rate for the first time since December 2008. The FOMC has also stated that it anticipated reducing the quantity of reserve balances, over time, to a level appreciably below that seen in recent years but larger than before the financial crisis.\(^{34}\) Given the new regulatory framework, estimates of the long-run level of reserve balances should also include demand for reserves for the purpose of regulatory ratios. Our paper provides some of the drivers of long-run demand for reserves and dynamics in the federal funds market under the new regulatory framework. Future research could explore reporting date dynamics to derive estimates of the long-run demand for reserve balances.

\(^{34}\) For details on FOMC communications related to policy normalization see https://www.federalreserve.gov/monetarypolicy/policy-normalization.htm.

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References


and Instruments, 8, 24-44.
Figure 1: Evolution of Federal Reserve 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 Reserve's 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: 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 9: 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 (Furine, 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

<table>
<thead>
<tr>
<th>Leverage Ratio</th>
<th>Banks borrowing in the federal funds market</th>
<th>&lt;30-day maturity</th>
<th>&gt;30-day maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>decrease</td>
<td>decrease</td>
<td>likely no change</td>
<td>increase</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>European Banks</th>
<th>Average</th>
<th>Stddev</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before (2009:Q1-2012:Q4)</td>
<td>2.00%</td>
<td>5.90%</td>
<td>0.00%</td>
<td>70.10%</td>
</tr>
<tr>
<td>Reported to supervisors (2013:Q1 - 2014:Q4)</td>
<td>0.70%</td>
<td>2.80%</td>
<td>0.00%</td>
<td>28.20%</td>
</tr>
<tr>
<td>Disclosed to the public (2015:Q1 - 2015:Q4)</td>
<td>0.90%</td>
<td>3.00%</td>
<td>0.00%</td>
<td>31.10%</td>
</tr>
<tr>
<td>Reported to supervisors/Before</td>
<td>0.4</td>
<td>0.5</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Disclosed to the public/Reported to supervisors</td>
<td>1.2</td>
<td>1.1</td>
<td>1.1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>European Banks</th>
<th>Average</th>
<th>Stddev</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before (2009:Q1-2012:Q4)</td>
<td>3.00%</td>
<td>10.80%</td>
<td>0.00%</td>
<td>98.70%</td>
</tr>
<tr>
<td>Reported to supervisors (2013:Q1 - 2014:Q4)</td>
<td>2.20%</td>
<td>8.30%</td>
<td>0.00%</td>
<td>95.80%</td>
</tr>
<tr>
<td>Disclosed to the public (2015:Q1 - 2015:Q4)</td>
<td>1.90%</td>
<td>7.70%</td>
<td>0.00%</td>
<td>92.00%</td>
</tr>
<tr>
<td>Reported to supervisors/Before</td>
<td>0.74</td>
<td>0.76</td>
<td>0.97</td>
<td></td>
</tr>
<tr>
<td>Disclosed to the public/Reported to supervisors</td>
<td>0.84</td>
<td>0.94</td>
<td>0.96</td>
<td></td>
</tr>
</tbody>
</table>

Note: This table shows the ratio of federal funds borrowing to total liabilities 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 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.

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Reserves/Assets</td>
<td>Reserves/Assets</td>
</tr>
<tr>
<td>Domestic x FDIC</td>
<td>-0.044***</td>
<td>-0.045***</td>
</tr>
<tr>
<td></td>
<td>(-4.34)</td>
<td>(-4.26)</td>
</tr>
<tr>
<td>Domestic</td>
<td>-0.070</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-1.1)</td>
<td></td>
</tr>
<tr>
<td>Large</td>
<td>0.120***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.75)</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>0.100***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(5.45)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
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<td>-0.002</td>
</tr>
<tr>
<td></td>
<td>(2.43)</td>
<td>(-1.56)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of obs.</td>
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<td>29186</td>
</tr>
<tr>
<td>Number of entities</td>
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<td>1948</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
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<td>0.74</td>
</tr>
<tr>
<td>Country FE</td>
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<td>no</td>
</tr>
<tr>
<td>Time FE</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Bank FE</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>

Notes: This table shows estimated coefficients and t-statistics for difference-in-difference regressions for the share of reserves to total assets. *Domestic* equals 1 for the institutions affected by the new FDIC policy, *FDIC* equals 1 for the period from 2011Q2. The difference-in-difference coefficient is $Domestic \times FDIC$ which equal 1 for domestic banks in the post treatment period. *Size* is a measure of relative size based on total assets, and *Large* and *Medium* are dummies for large and medium banks. Standard errors are clustered by entity.
Table 4: Reserve Balances and Basel III Leverage Ratio.

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quarter-End/Average</td>
<td>Quarter-End/Average</td>
</tr>
<tr>
<td>Basel x Foreign</td>
<td>-0.143***</td>
<td>-0.143***</td>
</tr>
<tr>
<td></td>
<td>(-4.67)</td>
<td>(-4.63)</td>
</tr>
<tr>
<td>Basel</td>
<td>-0.002</td>
<td>-0.002</td>
</tr>
<tr>
<td></td>
<td>(-0.48)</td>
<td>(-0.48)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.097***</td>
<td>1.009***</td>
</tr>
<tr>
<td></td>
<td>(279.44)</td>
<td>(80.21)</td>
</tr>
<tr>
<td>Number of obs.</td>
<td>49543</td>
<td>49543</td>
</tr>
<tr>
<td>Number of banks</td>
<td>1855</td>
<td>1855</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.156</td>
<td>0.165</td>
</tr>
<tr>
<td>Bank FE</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Time FE</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>

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 $\text{Foreign}_i$ and $\text{Basel}_t$ 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, https://www.federalreserve.gov/apps/reportforms/default.aspx.
Table 5: Reserve Balances and Basel III Leverage Ratio: Reported to Supervisors, Disclosed to the Public

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quarter-End/Average</td>
<td>Quarter-End/Average</td>
</tr>
<tr>
<td>Reported</td>
<td>-0.019***</td>
<td>-0.093***</td>
</tr>
<tr>
<td></td>
<td>(-3.37)</td>
<td>(-2.73)</td>
</tr>
<tr>
<td>Disclosed</td>
<td>0.011**</td>
<td>-0.092***</td>
</tr>
<tr>
<td></td>
<td>(2.00)</td>
<td>(-2.72)</td>
</tr>
<tr>
<td>Reported x Foreign</td>
<td>-0.093***</td>
<td>-0.183***</td>
</tr>
<tr>
<td></td>
<td>(-2.73)</td>
<td>(-5.53)</td>
</tr>
<tr>
<td>Disclosed x Foreign</td>
<td>-0.183***</td>
<td>-0.183***</td>
</tr>
<tr>
<td></td>
<td>(-5.49)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>1.097</td>
<td>1.009***</td>
</tr>
<tr>
<td></td>
<td>(279.44)</td>
<td>(80.21)</td>
</tr>
<tr>
<td>Number of obs.</td>
<td>49543</td>
<td>49543</td>
</tr>
<tr>
<td>Number of banks</td>
<td>1855</td>
<td>1855</td>
</tr>
<tr>
<td>Adj. $R^2$</td>
<td>0.156</td>
<td>0.165</td>
</tr>
<tr>
<td>Bank FE</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Time FE</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>

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.