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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 leverage ratio. Using a novel data set that includes FDIC fees and balance sheet data for depository institutions, we find 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 bank federal funds borrowing at reporting dates.

Keywords: Reserve balances, IOER arbitrage, federal funds market, FDIC fees, 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. In this paper, we study developments in reserve balances and the federal funds market in the context of two changes in banking regulations: 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 data set that includes FDIC fees and balance sheet data for depository institutions, we find that foreign banking organizations (FBOs), which are not subject to the FDIC fee, absorbed increasing amounts of reserve balances over recent years.[1] Furthermore, FBOs experienced positive and improving conditions for arbitraging between borrowing reserve balances in the federal funds market and holding those reserves at the Federal Reserve Banks to earn interest on excess reserves (IOER), 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 FBO federal funds borrowing at reporting dates.

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

[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. 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 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.[2] 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.[3] Intuitively, IOER is expected to influence market rates by discouraging DIs from lending federal funds at rates below the IOER rate. Second, beginning in November 2008, the FOMC directed the FRBNY to expand the size of the Federal Reserve System's balance sheet through large-scale asset purchases (LSAPs) of Treasury debt, agency debt, and agency mortgage-backed securities (MBS).[4] These LSAP programs led to an exceptionally high level of reserve balances in the banking system, far exceeding the aggregate amount of reserves that DIs are required to hold, which, 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 the case of market segmentation, Bech and Klee (2011) show that if GSEs command low interest rates and their share is sufficiently

[2]For a detailed explanation see Ehrig, Meade, and Weinbach (2015).

[3]https://www.federalreserve.gov/monetarypolicy/20081006a.htm

[4]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).

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: that is, to borrow funds below IOER and hold those funds in their reserve accounts to earn IOER on them.

These trading dynamics and incentives for IOER arbitrage were altered by two banking regulatory changes: the widening of the FDIC assessment base and the Basel III leverage ratio. Our study shows that the new FDIC assessment base fee changed the relative funding costs and incentives for depository institutions to hold reserve balances. We document that while domestic institutions held the large majority of reserve balances in the system before the crisis, FBOs not subject to the FDIC fee absorbed increasing amounts of liquidity over recent years. Consistent with this finding, and using a novel data set that includes confidential FDIC fees and balance sheet data for depository institutions, our analysis provides empirical evidence that the new FDIC assessment base is an important factor in explaining the changes in bank holdings of reserve balances.

Building on these results, we examine the funding models of both domestic depository institutions (DDIs) and FBOs and evaluate their incentives for IOER arbitrage, with a special focus on their reserve positions funded through the federal funds market. Our analysis shows that 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 federal funds borrowing by foreign banks relative to domestic banks.

The implementation of the Basel III regulatory ratios also induced changes in FBOs participation in the federal funds market, with FBOs federal funds borrowing decreasing at reporting dates.[5] For example, from January 2013 to December 2015, when the leverage

[5]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 (Revised Basel III leverage ratio framework and disclosure requirements, June 2013, paragraph 6). On October 10, 2014, the European Commission amended the regulation with regard to the leverage ratio: The leverage ratio would be re-

ratio was reported to the supervisors, FBO federal funds borrowing fluctuated around 40 percent lower at month-end compared with the average daily amount during the corresponding month. 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 dropped from 2 percent to 0.7 percent.[6] During this period, FBOs aligned their end-of-month federal funds positions sufficiently for the purpose of satisfying the regulatory ratios, and month-end balance sheet dynamics were largely unchanged following the public disclosure of the leverage ratio in January 2015.

This paper is organized as follows. The next section gives an overview of the Federal Reserve LSAP programs and the evolution of reserve balances. Section 3 discusses the April 2011 changes to the FDIC fee and its effect on the demand for reserve balances. Section 4 follows with a discussion of incentives for IOER arbitrage and indicators of participation in arbitrage by FBOs. Section 5 looks at the effect of Basel III on demand for federal funds by FBOs. And Section 6 concludes.

2 LSAP programs and reserve balances

In response to the financial crisis, the Federal Reserve implemented a series of LSAP programs to provide monetary policy accommodation intended to support the economic recovery. Since then, these programs have 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

ported at the end of the quarterly reporting period, rather than on the basis of a three-month average (http://ec.europa.eu/finance/bank/docs/regcapital/acts/delegated/141010_delegated-act-leverage-ratio_en.pdf, page 9, paragraph 9.)

[6]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.

was largely due to securities purchases. As the asset side of the balance sheet increased dramatically through the asset purchase programs, 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 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.

2.1 Required versus excess reserve balances

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.[7] 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.[8] As shown in figure 1, although the level of both required and excess balances has continued to increase

[7]Required reserves are calculated as a share of a banks transaction deposits less vault cash. This share can vary between 0 and 10 percent depending on the level of net transaction accounts.

[8]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.

significantly since then, the ratio of excess to total reserve balances has remained steady.[9]

[INSERT FIGURE 1 HERE]

2.2 Foreign versus domestic accumulation of reserves

The distribution of reserve holdings between domestic and foreign institutions also changed significantly over the past several years. 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 2, 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.[10] The widening of the FDIC assessment base implemented on 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.[11]

[9] By the end of the second quarter of 2014, required and excess reserve balances reached $81 billion and $2.6 trillion, respectively.

[10] 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.

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

[INSERT FIGURE 2 HERE]

2.3 Reserve balances by institution size

Among domestic institutions, larger banks have been the main drivers of demand for reserves.[12] Figure 3 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.[13] 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 3, 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 liquidity coverage ratio (LCR) ahead of the implementation scheduled for January 2015.[14] Under this new liquidity framework, excess reserve balances are classified as level 1

[12]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.

[13]Note that pre-crisis averages are calculated using weekly data from 07-02-2008 to 09-17-2008.

[14]The appendix provides details on the implementation timeline and the calculation of the ratios. 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.

high-quality liquid assets (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.[15] As shown in figure 4, 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.

[INSERT FIGURE 3 HERE]

[INSERT FIGURE 4 HERE]

3 April 2011 FDIC fee and demand for reserve balances

Before the April 2011 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. 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. Specifically, while FBOs continued to earn the full IOER rate on their holdings at the Federal Reserve, the payoff from IOER arbitrage for domestic institutions was reduced by the corresponding

[15] 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 are 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.

FDIC fee. Since then, the distribution of reserves between domestic and foreign institutions has changed substantially.

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.[16] 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 banks CAMELS rating and its ability to withstand asset- and funding-related stress.[17] 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.[18]

As depicted in figure 5, domestic banks have been 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

[16]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.

[17]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.

[18]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).

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.

Consequently, while the maximum return domestic banks could earn on IOER less FDIC fees shifted from 25 basis points initially to an average of 13.6 basis points at the inception of the base change, the subsequent reductions in their FDIC assessment rates translated into better terms for IOER arbitrage. As of the end of 2013, domestic banks were able to earn, after accounting for the corresponding FDIC fee rate, an average of 17.6 basis points on their excess reserve balances held at the Federal Reserve.[19]

[INSERT FIGURE 5 HERE]

To formally assess the effect of the widening of the FDIC base on demand for reserve balances, we next perform a regression analysis using a difference-in-difference identification strategy. Our sample comprises bank-level balance sheet data from the Call Report for a total of 1,948 banks.[20] We define FBOs as the control group and DDIs, which are affected by the new policy, as the treatment group. We consider the share of reserve balances to total assets as the dependent variable and regress it on a dummy that identifies the universe of domestic banks affected by the policy change; time dummies that capture the post-treatment period, from the second quarter of 2011 through the third quarter of 2013; the interaction

[19]Note that these estimates do not take into account other balance sheet costs involved in IOER arbitrage trades.

[20]Specifically, the sample includes institutions that fill out the FFIEC 031, FFIEC 041, FFIEC 002, and FR 2886b report forms.

term of the treatment and the time dummies, which will be set to 1 for institutions affected by the FDIC fee in the post-treatment period; and a set of controls intended to capture other factors that might have affected banks demand for reserve balances. Specifically, these controls include a measure of balance sheet size, defined as the deviation of the total assets of bank i from the industry average at time t; an interaction term between our variable of interest and our proxy for size; dummies to identify large, medium, and small institutions; and country dummies to control for country-specific effects.

[INSERT TABLE 1 HERE]

As shown in table 1, results suggest that the widening of the FDIC base had an economically and statistically significant effect on demand for reserve balances. More specifically, the negative sign of the difference-in-difference estimator in the regression suggests that, all else equal, the share of reserves over total assets held by domestic banks after the implementation of the new base is 4.3 percent 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. Interestingly, except for the United Kingdom and Scandinavia, we find no country-specific effects that can help explain demand for FRB reserve balances.

Overall, these findings support the characterization of the evolution of reserve balances presented in the previous sections. In particular, we find empirical evidence that the increase in balance sheet costs due to the new FDIC fee negatively affected demand for reserve balances by domestic institutions. In particular, we find empirical evidence that the increase in balance sheet costs resulting from the new FDIC assessment base negatively affected demand for reserve balances by domestic institutions.

4 IOER arbitrage

There is a general agreement that this environment of elevated excess reserves, along with the IOER paid by FRBs, appears to have created a new trading dynamic in the federal funds market. 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. 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. As the widening of the FDIC base fee significantly reduced incentives for domestic institution to fund IOER arbitrage trades through wholesale market funding, we continue our analysis of participation in IOER arbitrage by focusing on FBOs.[21]

4.1 Incentives for IOER arbitrage

In understanding 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, 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.[22] We then use these series together with

[21]Our balance sheet data points to a reduction in large domestic banks wholesale market funding as captured by a decline in their "borrowings" and "net due" positions.

[22]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

FDIC fee data to calculate 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; starting in 2011, their profits dropped significantly. As shown in figure 6, 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 (an average of 3 basis points).[23] 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.[24]

Economic incentives for IOER arbitrage appear to be substantially stronger for the universe of FBOs. As depicted in figure 7, 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

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, month-end dynamics, which is the focus of the analysis in section 5, are similar across data sets.

[23]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.

[24]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.

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 7, 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.

[INSERT FIGURE 6 HERE]

[INSERT FIGURE 7 HERE]

4.2 Participation in IOER arbitrage

Building on our findings on FBOs' payoffs from IOER arbitrage, in this section we use daily reserve balances along with federal funds borrowing data to further explore the dynamics of their arbitrage trades. We argue that if the general motivation for FBOs' participation in the federal funds market were IOER arbitrage, then we would observe (1) a continuous participation in the federal funds market, (2) a positive correlation between federal funds borrowing and reserves, and (3) a higher correlation for banks that are more present in the federal funds market. We further explore these three implications in this section.

First, once a bank reveals its preference to benefit from this arbitrage opportunity, we should observe a continuous presence of that bank in the federal funds market. Figure 8 shows the time consistency of banks borrowing in the federal funds market. For each bank, we create a numerical indicator. A continuous presence by the bank is illustrated by a horizontal line at the value of the numerical indicator corresponding to that bank. As shown in figure 8, our results provide evidence that most foreign banks are not consistently borrowing in the federal funds market. For instance, of the 243 banks, only 30 banks have been

present in the market for at least one-third of the days from January 2009 to February 2016.[25]

[INSERT FIGURE 8 HERE]

Second, if banks use federal funds borrowing to finance reserves, then an increase in federal funds borrowed would be associated with an increase in reserves, and we would observe a positive correlation between federal funds borrowing and reserves.[26] Finally, if participating in this arbitrage was the main motivation for a bank to borrow in the federal funds market, then the correlation between federal funds borrowed and reserves (a proxy for the use of this arbitrage by the bank) would be higher when the participation of the bank in the federal funds market (a proxy for the frequency of the use of this arbitrage) is more time consistent.

To explore these last two implications, figure 9 plots the correlation between daily reserves and federal funds borrowing for each bank against the number of trading days for banks that are active at least 30 percent of days. We also distinguish between two periods: before and after the introduction of the new FDIC assessment base in April 2011. As depicted in figure 9, the correlation between reserve balances and federal funds borrowed is positive for most banks, suggesting that in the current environment of excess reserves, these banks could be engaging in this arbitrage.[27] Furthermore, conditional on the correlation being positive, this correlation is also, in general, stronger for the more-frequently present banks, as shown by the upward sloping lines. As the slopes of these lines are about the same, the introduction of the FDIC base does not appear to have changed this relation.

[25] Another source of funding would be to borrow in longer term unsecured instruments (such as certificate of deposit, commercial paper) and hold those funds in reserves accounts to earn IOER. The focus on this paper is on federal funds as the source of funding.

[26] Note that this activity leads to an increase in the bank's balance sheet as reserves are funded by borrowing.

[27] Most of the negative correlations are very small.

[INSERT FIGURE 9 HERE]

5 Basel III and federal funds borrowing by foreign banks

Basel III introduced both capital and liquidity ratios. In this section, we will focus on the leverage ratio (LR), the liquidity coverage ratio, and their implications for banks borrowing in federal funds markett.[28]

Leverage ratio:

Borrowing in the federal funds market causes reserve balances to increase, and as explained in the previous section, when used for arbitrage purposes it also boosts on-balance-sheet exposure, leading to a reduction in the leverage ratio. Reducing participation in this arbitrage would reduce the corresponding excess reserves held at the Federal Reserve, which in turn would decrease the exposure measure and increase the leverage ratio. Furthermore, as the exposure measure is not risk weighted, the 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 and 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 base), which financed these reserves by recalling advances from their affiliates abroad. McCauley and McGuire 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

[28]Details on the implementation schedule and definition of ratios are provided in the appendix.

rather than holdings of Treasury securities. These changes in foreign banks' balance sheets reveal that given current market conditions, their preference is to hold reserves rather than other assets.

Liquidity coverage ratio:

The effect of borrowing in the federal funds market would depend on the maturity of the borrowing and the current value of the LCR. 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 as a result, the denominator and the numerator of the LCR increase by the same amount. Depending on the banks 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.[29] 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.

[29]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.

Table 2 summarizes likely changes in banks' borrowing in the federal funds market to meet the LR and LCR requirements. The LR and LCR point to different effects for borrowing for longer maturities. In this paper, we focus on the overnight market.

[INSERT TABLE 2 HERE]

The literature on the effect of Basel III regulatory changes on the federal funds market is limited.[30] While the banks' likely response would be to decrease their overnight federal funds borrowing, there are certain challenges in our empirical assessment of this response. First, changes in foreign banks' borrowing behavior to meet the regulatory ratios are a derivative of the consolidated balance sheet of the parent company. As such, banks with similar federal funds activity might adjust their activity differently depending on the parent company's strategy in meeting the regulatory ratio requirements. Second, we cannot assess the foreign banks' current standing with respect to the LR and LCR, and as such we cannot link changes in a bank's federal funds borrowing to its current standing in meeting the requirements. As a result, we can only look at changes in the foreign banks' borrowing behavior without controlling for where the parent company stands in meeting the LR and LCR requirement or the U.S. branch's contribution to the parent company.

In our approach, we document changes in federal funds borrowing made by foreign banks that are likely in response to Basel III regulatory changes. Specifically, we compare the borrowing activity at the end of the month with the daily average for the correspond-

[30] On the theoretical side, Bech and Keister (2013) introduce term funding and an 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 from Bonner and 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, which is defined by using a time dummy variable equal to 1 after the failure of Lehman Brothers.

ing month. End-of-month deviations in federal funds borrowing are calculated from daily Fedwire-identified federal funds transactions. 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.

Figure 10 plots total borrowing by foreign banks in the federal funds market at month-end compared with the average for the corresponding month. The time axis corresponds to month-end dates. From 2013 to 2015 when the ratio was publicly disclosed, borrowing was consistently lower at month-end, dropping on average to 40 percent of the month-average.

[INSERT FIGURE 10 HERE]

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 3. 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 month-end dynamic before the public disclosure of the leverage ratio on January 1, 2015, suggests that banks had already adjusted their month-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 McGuire (2014), who shows 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 at reporting dates rather than permanent decreases in federal funds borrowed by foreign banks.

[INSERT TABLE 3 HERE]

6 Conclusion

The federal funds market is at the core of monetary policy implementation, as the FOMC sets the target for the federal funds rate. To counteract the financial crisis, the FOMC 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. Understanding the dynamics of the federal funds market in the context of the operational framework of the monetary policy is important to steering the federal funds rate to the target rate set by the FOMC.

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Appendix

This appendix lists the Basel III capital and liquidity ratios and their implementation schedule and provides the definitions for the leverage ratio and the liquidity coverage ratio.

Leverage ratio:[31]

The Basel III 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 has begun with the bank-level reporting to national supervisors of the leverage ratio and its components from January 1, 2013, and will proceed 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:

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

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 banks total exposure measure is the sum of the following exposures: (a) on-balance sheet exposures; (b) derivative exposures; (c) securities financing transaction exposures; and

[31]The definition of the Leverage Ratio is based on "Basel III leverage ratio framework and disclosure requirements", BIS, January 2014, and "Consultative document: Revised Basel III leverage Ratio Framework and Disclosure Requirement", BIS, June 2013.

(d) off-balance sheet items.

Liquidity Coverage Ratio:[32]

The objective of the Liquidity Coverage Ratio is to promote short-term resilience of a banks liquidity risk profile. This standard aims to ensure that a bank has an adequate stock of unencumbered high quality liquid assets (HQLA) which 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 will be introduced on January 1, 2015, but the minimum requirement will be set at 60 percent and rise in equal annual steps to reach 100 percent on January 1, 2019.

The LCR has two components: 1) the value of the stock of HQLA; and 2) total net cash outflows and is expressed as:

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

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 banks stock of HQLA.

[32]The definition of the Liquidity Coverage Ratio is based on "Basel III: The Liquidity Coverage Ratio and liquidity risk monitoring tools", BIS, January 2013.

Total net cash outflows are defined as:

$$\text{Total net cash outflows over the next 30 calendar days} = \text{Total expected cash outflows} - \text{Min (Total expected cash inflows; 75 percent of total expected cash outflows)} \tag{3}$$

Different types of outflows are weighted by their run-off factors. Borrowing from banks falls "Unsecured wholesale funding provided by other legal entity customers" and it has a run-off factor of 100 percent.[33] 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.

[33]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 (20percent or 40percent).

Basel III phase-in arrangements

(All dates are as of 1 January)

Basel Committee on Banking Supervision

BANK FOR INTERNATIONAL SETTLEMENTS

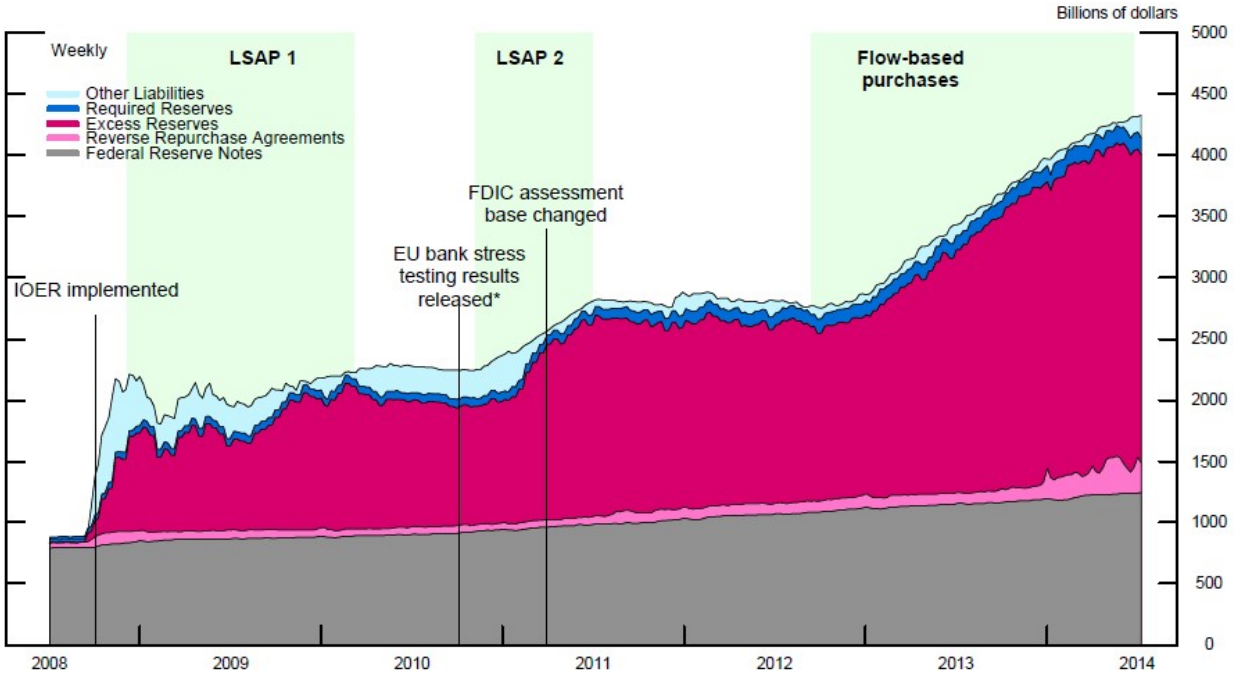
	Phases	2013	2014	2015	2016	2017	2018	2019
Capital	Leverage Ratio		Parallel run 1 Jan 2013 – 1 Jan 2017 Disclosure starts 1 Jan 2015				Migration to Pillar 1	
	Minimum Common Equity Capital Ratio	3.5%	4.0%	4.5%				**4.5%**
	Capital Conservation Buffer				0.625%	1.25%	1.875%	**2.5%**
	Minimum common equity plus capital conservation buffer	3.5%	4.0%	4.5%	5.125%	5.75%	6.375%	**7.0%**
	Phase-in of deductions from CET1*		20%	40%	60%	80%	100%	**100%**
	Minimum Tier 1 Capital	4.5%	5.5%	6.0%				**6.0%**
	Minimum Total Capital		8.0%					**8.0%**
	Minimum Total Capital plus conservation buffer		8.0%		8.625%	9.25%	9.875%	**10.5%**
	Capital instruments that no longer qualify as non-core Tier 1 capital or Tier 2 capital		Phased out over 10 year horizon beginning 2013					
Liquidity	Liquidity coverage ratio – minimum requirement			60%	70%	80%	90%	**100%**
	Net stable funding ratio						Introduce minimum standard	

* Including amounts exceeding the limit for deferred tax assets (DTAs), mortgage servicing rights (MSRs) and financials.

– – transition periods

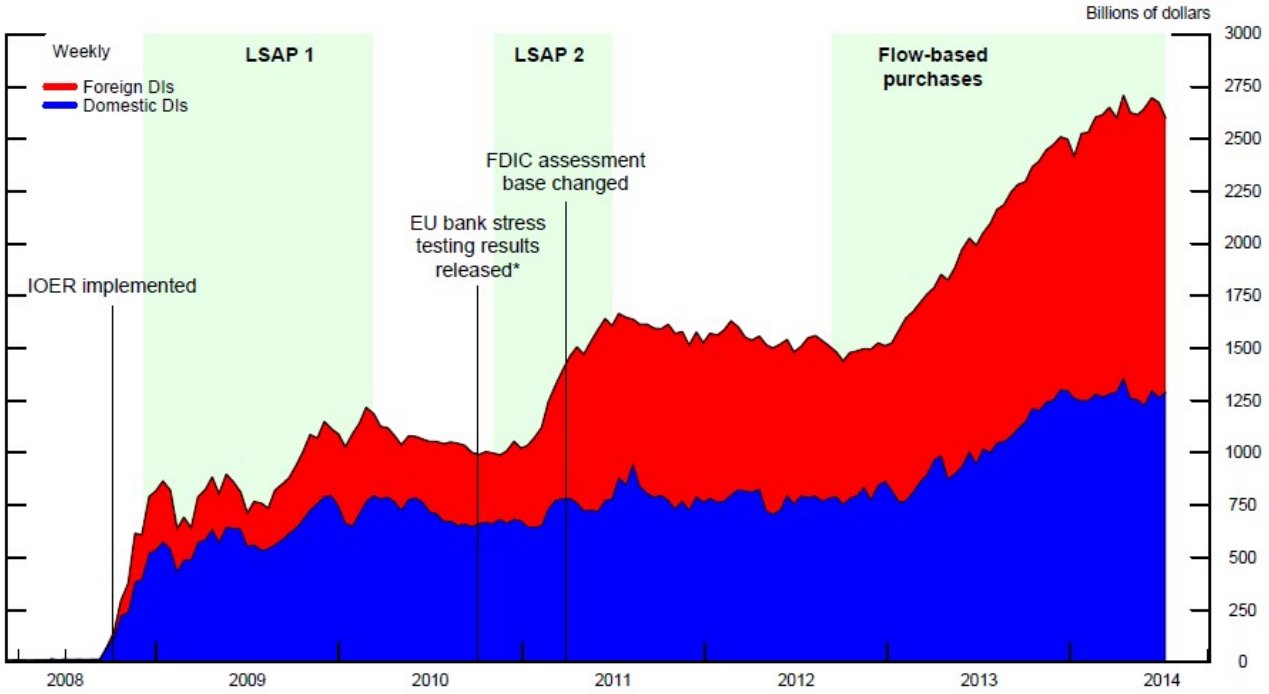
Source: http://www.bis.org/bcbs/basel3/basel3_phase_in_arrangements.pdf

Figure 1: Evolution of Federal Reserve Liabilities



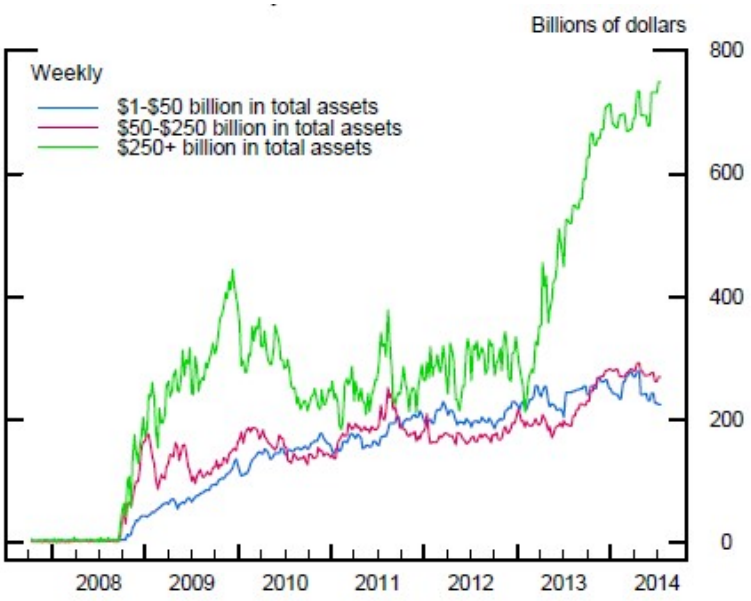
Source: Board of Governors of the Federal Reserve System. 2016. "Factors Affecting Reserve Balances." http://www.federalreserve.gov/releases/h41/.

Figure 2: Foreign versus Domestic Reserve Holdings



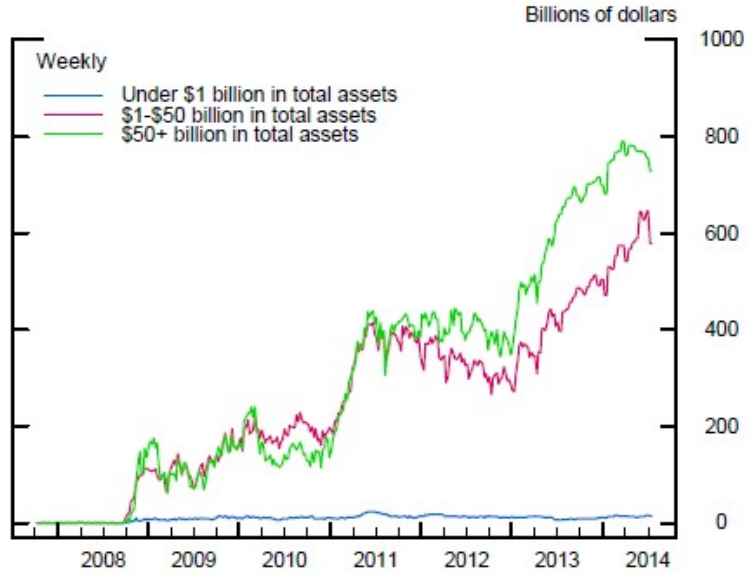
Source: FR 2900

Figure 3: Reserve Balances by Institution Size - DDIs



Source: FR 2900

Figure 4: Reserve Balances by Institution Size - FBOs



Source: FR 2900

Figure 5: Effective FDIC Rates (Basis Points)

Source: Federal Deposit Insurance Corporation

Figure 6: IOER Net Returns for Federal Funds Borrowing by DDIs (by Institution Size, Net of FDIC fees)

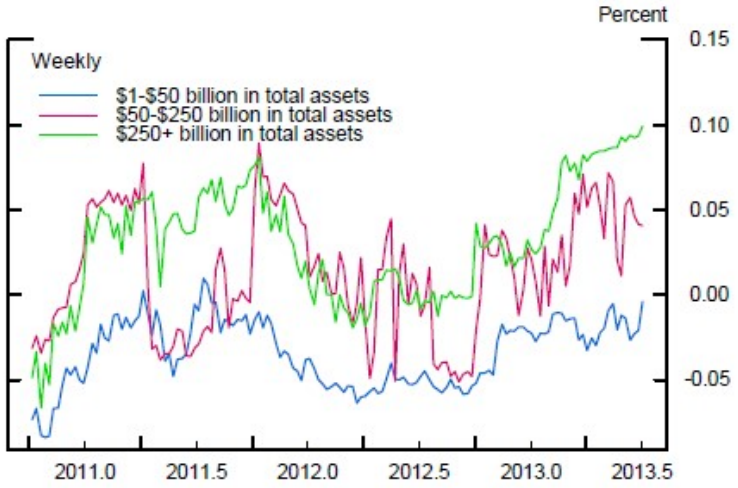


Figure 7: IOER Net Returns for Federal Funds Borrowing by FBOs (by Institution Size)

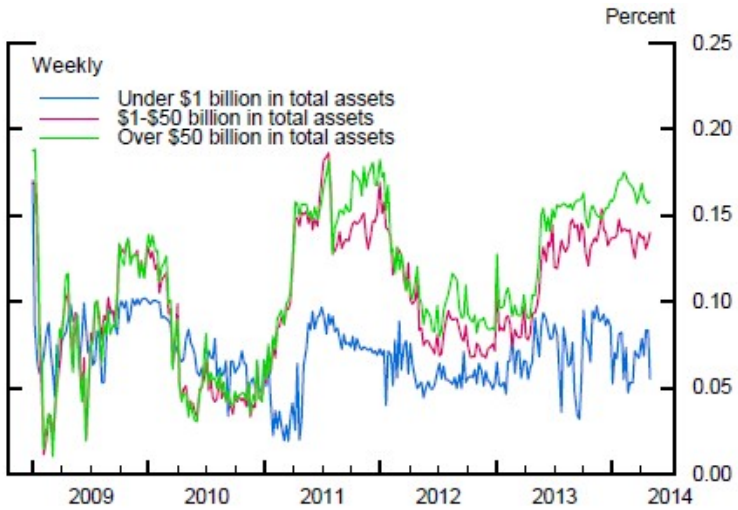
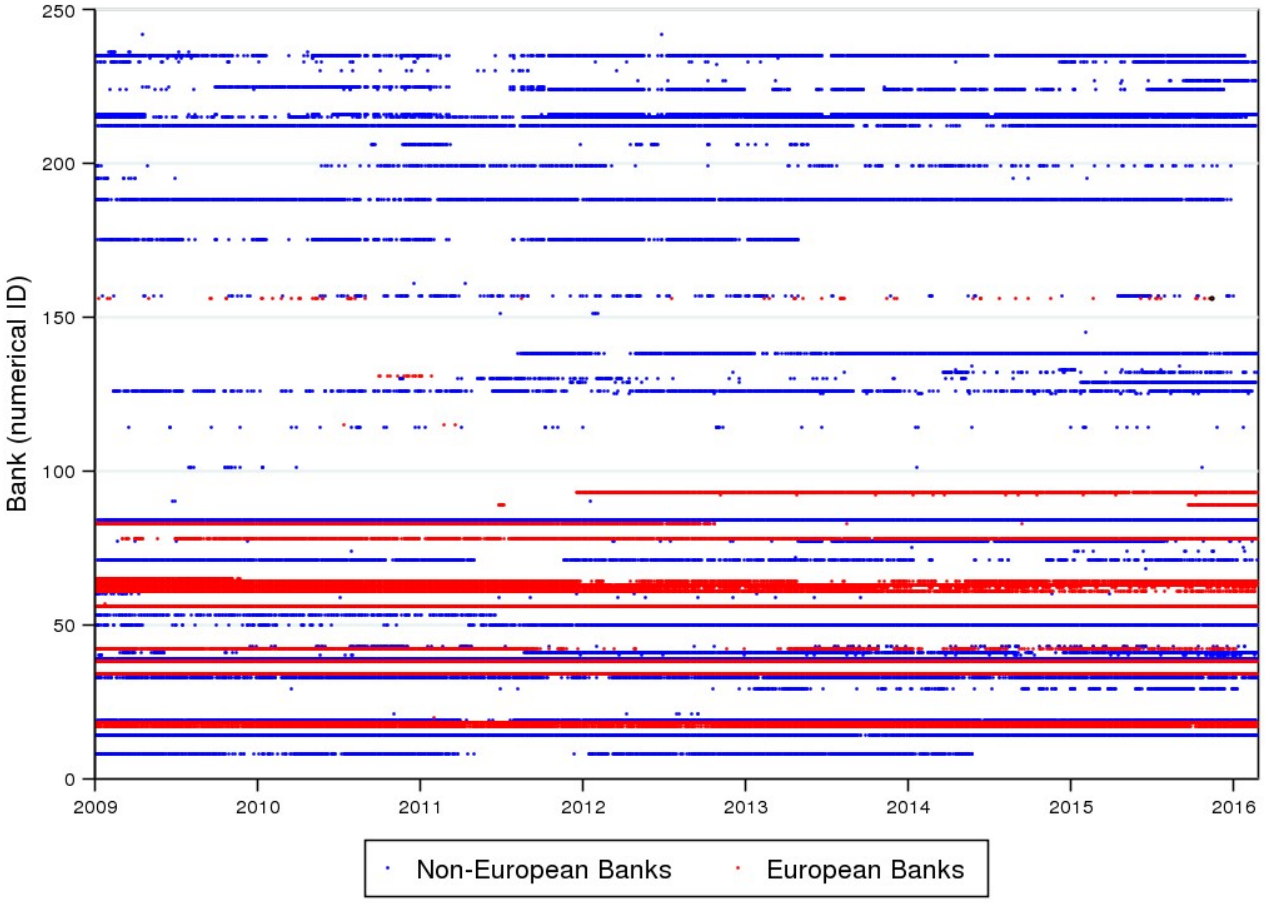
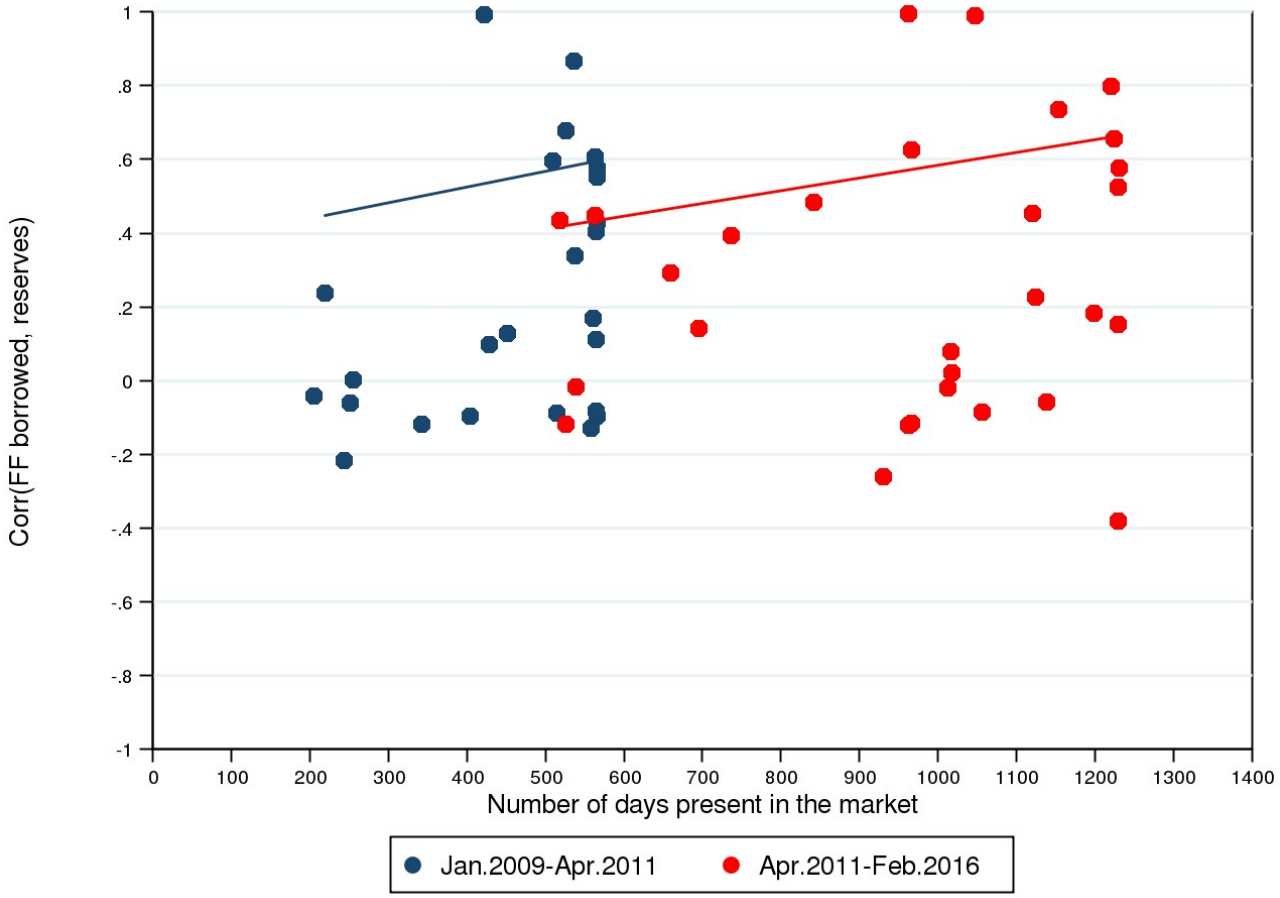


Figure 8: Time Consistency of Participation



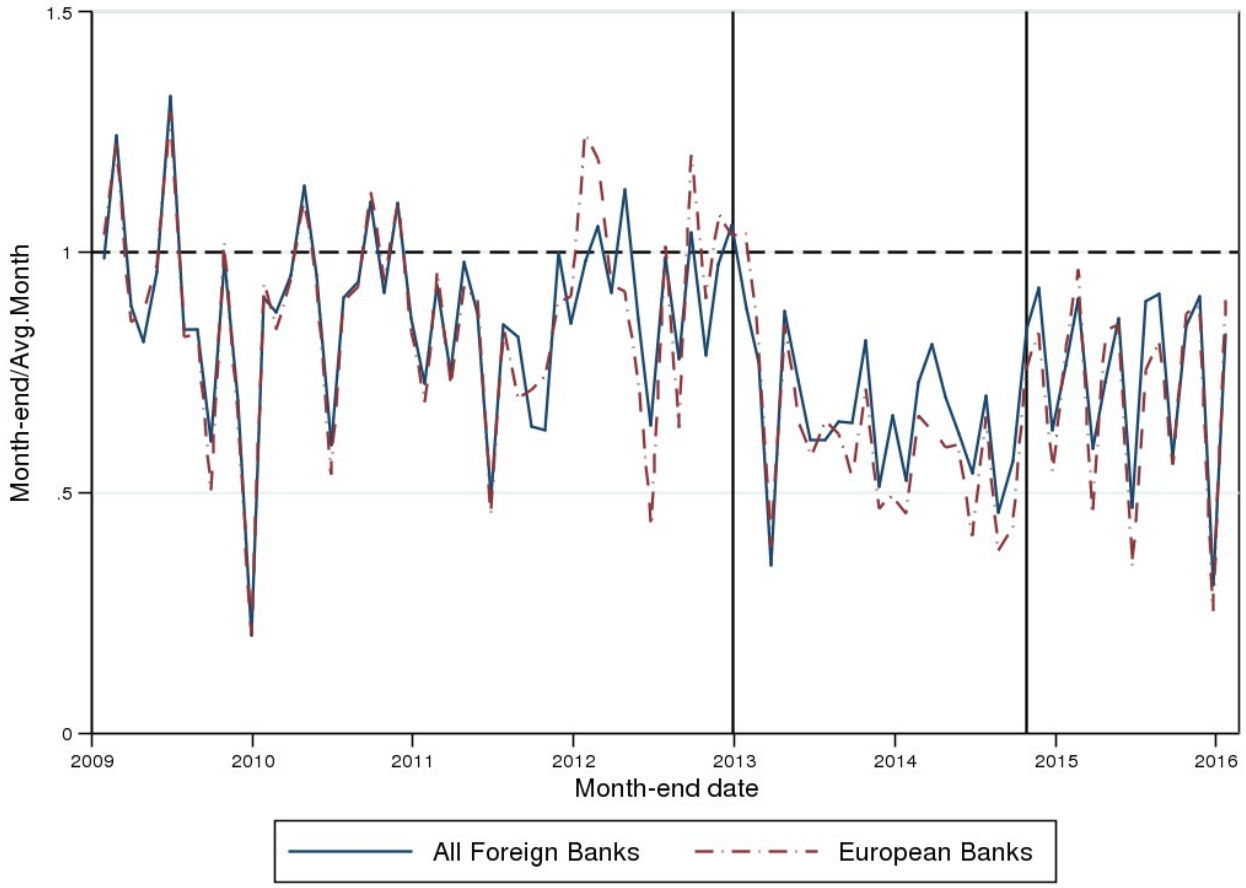
Source: Fedwire-identified trades

Figure 9: Correlation between Reserves and Federal Funds Borrowed



Source: Reserve balances database, Fedwire-identified transactions.

Figure 10: Total Borrowing by Foreign Banks at Month-end Compared to Month-average



Source: Fedwire-identified trades

Table 1: Reserve Balances and the FDIC Fee

	Reserves/Assets
D-D FDIC	-0.043
	-4.25
Domestic dummy	-0.070
	-0.99
Size	0.00
	-4.25
D-D FDIC x size	0.000
	-1.40
Large	0.188
	4.57
Medium	0.112
	5.92
Country dummies	Yes
Time dummies	Yes
Constant	0.163
	2.29
Number of obs.	*29186*
Number of entities	*1948*
Adjusted R-squared	*0.26*

Notes: This table shows estimated coefficients and t-statistics for difference-in-difference (D-D) regressions on reserve balances and on the share of reserves to total assets. D-D FDIC is the dummy for domestic banks in the post treatment period, Domestic dummy identifies those institutions affected by the new policy, Size is a measure of relative size based on total assets, and Large and Medium are dummies for large and medium banks. We also include country dummies for France, Germany, the United Kingdom, Switzerland, Scandinavia, Japan, Canada, Australia, other Europe, other America, other Asia, Africa and the Middle East. Standard errors are clustered by entity.

Table 2: Basel III Ratios and Their Impact on Banks Borrowing in Federal Funds Market

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

Table 3: Share of Fed Funds Borrowing in Liabilities

European Banks	**Average**	**Stdev**	**Min**	**Max**
Before (2009:Q1-2012:Q4)	2.00%	5.90%	0.00%	70.10%
Reported to supervisors (2013:Q1 - 2014:Q4)	0.70%	2.80%	0.00%	28.20%
Reported to the public (2015:Q1 - 2015:Q4)	0.90%	3.00%	0.00%	31.10%
Reported to supervisors/Before	0.4	0.5		0.4
Reported to the public/Reported to supervisors	1.2	1.1		1.1

Non- European Banks	**Average**	**Stdev**	**Min**	**Max**
Before (2009:Q1-2012:Q4)	3.00%	10.80%	0.00%	98.70%
Reported to supervisors (2013:Q1 - 2014:Q4)	2.20%	8.30%	0.00%	95.80%
Reported to the public (2015:Q1 - 2015:Q4)	1.90%	7.70%	0.00%	92.00%
Reported to supervisors/Before	0.74	0.76		0.97
Reported to the public/Reported to supervisors	0.84	0.94		0.96

Source: Report of assets and liabilities of U.S. branches and agencies of the foreign banks - FFIEC 002