# Better than Risk-Free: Reserve Premiums and Bank Lending*

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May 20, 2024

Abstract

When the Federal Reserve first paid interest on excess reserves (IOER) on October 2008, banks faced a choice to earn a "better than" risk-free rate, or lend to earn a higher, riskier rate. Evidence suggests the "reserves-lending puzzle" is not driven by endogeneity from reverse causality, flight to safety, or increased Treasury supply, but the introduction of the "reserve premium" (IOER-3MT), which reduced domestic bank-level lending by -6.7% (-$559.3B). Findings suggest the reserves risk channel can aid in restricting inflation. Additionally, recent Senior Financial Officer Surveys corroborate the conclusions presented in this paper.

***JEL classification***: G21, G24, E44, G28

***Keywords***: Excess reserves, bank lending, risk-taking channel, IOER, lending constraints

*I am thankful to my advisor Jean Helwege for her guidance, valuable mentorship, and continued support and to my committee members Richard Smith, Yawen Jiao, Alexander Barinov and Marcelle Chauvet. I am also thankful to Lisa Kim of JPMorgan Chase, Allen Berger, Scott Hein, Mark Grinblatt, Ata Can Bertay (Discussant), John Kandrac (Discussant), Stephen Miller (Discussant), Heitor Almeida (Discussant), Huberto Ennis, James McAndrews, Kyle Allen, Patrick Herb, Ivalina Kalcheva, Mike Dong, Michael Rebello, Valery Polkovnichenko, Dmitri Vayanos, JPMorgan, Virtu Financial, Coast Asset Management, Federal Reserve Bank of San Francisco, participants at FMA 2016, SFA 2018, WEAI 2019, FMA Doctoral Consortium 2019, UT Dallas, Texas Tech, UC Riverside, and Northern Arizona University for helpful comments and insights. All errors are my own.

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# 1 Introduction

In October 2008, amidst the tumult of the global financial crisis, the U.S. Federal Reserve implemented a new monetary policy tool: the payment of interest on excess reserves (IOER). This paradigm shift in the Fed's approach to managing the nation's monetary reserves introduced a novel instrument to influence the dynamics of bank lending and overall economic activity. The decision to pay IOER was underpinned by a theoretical framework posited by former Federal Reserve Chairman Ben Bernanke. He suggested that by varying the interest paid on reserves held at the Fed, "banks are unlikely to want to borrow or lend in private markets at an interest rate much different from what they can earn on the reserves they hold at the Fed." (Bernanke, 2016). Essentially, the argument held that banks would be unlikely to operate significantly outside the Fed's rate given the alternative option of earning a risk-free return on their reserves held at the Fed. Nonetheless, the critical question remains: is this theoretical framework valid?

Addressing this question is not without complexities. If IOER has a contractionary impact on lending, it is unclear whether it is due to IOER itself or a different second-order effect driven by other factors. For example, an observed relationship between IOER and lending may be driven by a "flight to safety" where banks prefer safer, more reliable investments in periods of economic uncertainty, and reduce lending as a result. Also, changes in funding costs may drive banks to take advantage of reserves arbitrage by earning the spread between the IOER rate and the cost of short-term funding. This paper examines three different financial spreads to differentiate these potential second-order effects. First, we scrutinize the spread between IOER and the 3-month Treasury bill rate (3MT), referred to as the "Reserves Premium". This spread proxies for the risk-free premium banks earn by holding reserves at the Fed over lending in the Treasury market, which can reduce bank lending. Second, we investigate the spread between the IOER and the Federal Funds rate, or "reserves arbitrage". This spread reflects potential arbitrage opportunities if the Fed Funds rate falls below the IOER rate, as banks can borrow in the Fed Funds market and earn a risk-free return by holding the funds as excess reserves at the Fed, potentially curtailing lending to the broader economy. Lastly, we study the spread between the London Interbank Offered Rate (LIBOR) and short-term U.S. government debt, otherwise known as the "TED Spread". This spread serves as a measure of credit risk and market stress. An increase in this spread could represent a 'flight to quality', with banks reducing lending in favor of holding risk-free assets when overall credit markets are stressed.

The academic literature and Wall Street commentators have long debated the true relationship between interest on reserves, excess reserves, and bank lending. In their 2018 Annual

Report, JP Morgan clarified this relationship by stating that a buildup of excess reserves meant there was less bank lending,[1] giving further awareness to a "Reserves-Lending puzzle". Regarding this puzzle, the relevant literature can be divided mainly into idiosyncratic and systematic explanations. For the former, bank preferences for reserves over lending are theorized to be driven by idiosyncrasies such as rising balance sheet costs of bank loans Martin, McAndrews, Skeie, et al. (2016) and potential shocks from deposit withdrawals, which can lead banks to prefer liquidity over lending (Bianchi and Bigio, 2022). For systematic explanations, Ennis (2018) suggests banks reduce lending when the interest on reserves exceeds a base rate, a view supported by Bernanke (2016)[2]. On the appropriate base rate, two distinct perspectives have emerged. The first perspective centers around "reserves arbitrage"(Bech and Klee, 2011), as banks can borrow at the Federal Funds rate and generate earnings through IOER. The second perspective advocates for the Treasury rate because, from an investment risk standpoint, risk-free Treasuries provide a suitable benchmark for the equally risk-free IOER. Regarding reserves arbitrage, a substantial body of research suggests banks that borrow in the Federal Funds market to earn IOER are foreign banks, not domestic banks (Keating and Macchiavelli, 2017; Banegas and Tase, 2020; Anderson, Du, and Schlusche, 2021). The evidence further suggests that "reserves arbitrage" has little impact on bank lending (Rezende, Temesvary, and Zarutskie, 2019)[3], as the majority of unsecured wholesale funding is used as arbitrage capital (Anderson et al., 2021) and not used to fund bank loans.

To glean further insights into this topic, the Federal Reserve surveyed senior bank officers in September 2020, March 2021, and November 2021 (FRS, 2020, 2021a,b), focusing on topics such as reserves, interest on reserves, and bank lending. Among their critical findings, survey responses reveal that most domestic banks consider Treasuries and bank loans as alternative investments to reserves (Figure 1 and 2). In fact, 95.5% of surveyed domestic banks do not borrow in the Federal Funds market (Figure 2), possibly due to elevated Federal Deposit Insurance Corporation (FDIC) deposit costs (Griffiths, Allen, Hein, and Winters, 2014; Banegas and Tase, 2020), aligning with Ihrig, Meade, and Weinbach (2015) who finds that EFFR has diminished in relevance as a source of unsecured wholesale funding. The

[1] In the JPMorgan Chase 2018 Annual Report (JPMorgan, 2018), it states "[During the Great Recession], the central bank could effectively create excess reserves by buying Treasuries. These excess reserves were lendable by the bank".

[2] Bernanke (2016) wrote "the Fed [varies] [IORs... because] banks are unlikely to want to borrow or lend in private markets at an interest rate much different [than IOR]".

[3] Rezende et al. (2019)'s examines the impact of the IOER spread over the effective fed funds rate (EFFR) on lending. An earlier version of this paper first examined the impact of the IOER spread over the 3-month Treasury rate on lending, which was first presented at the 2016 FMA Annual Meeting under a different title "Too Big to Lend? The 'Invisible Hand' in Banking".

survey responses from banks cast doubt on the suitability of the Federal Funds rate as the base rate for domestic institutions. They instead endorse the use of Treasury rates and the associated "reserves premium" as the more appropriate benchmark for gauging the impact of IOER on bank lending activities.

Figure 3 underscores the disparities between the effective fed funds rate (EFFR), 3MT, and IOER. Reserves, characterized by their lower volatility, lower transaction costs, and higher yields, present a clear difference from Treasuries. Conversely, Treasuries exhibit superior liquidity and reduced counter-party risk compared to the Federal Funds market. Given similar levels of risk-free counterparty risk, when IOER offers greater returns than 3MT, banks can be expected to increase excess reserves as shown in Figure 4. Inherent to market-based systems is the dual expectation of enhancing returns while simultaneously mitigating risk, whenever feasible circumstances arise.

Using Call Reports data from 2008 to 2017, this study examines 236,308 quarterly observations including large banks holding the majority of reserves and smaller community banks. The latter's inclusion introduces a bias against the reserves premium as these banks engage in relationship lending characterized by higher loan margins, greater heterogeneity, and counter-recessionary patterns, in contrast to larger banks engaged in market-based transactional lending.[4] Inclusion of small banks also mitigates concerns regarding the autonomy of banking decisions from Federal Reserve influences, particularly regarding reserve holdings. Since the Federal Reserve is the monopolistic supplier of reserves, if a bank increases its reserves, other banks must decrease their holdings by a similar amount (Ihrig et al., 2015). Since small banks hold lower reserve balances and their lending is more likely to be constrained by deposits (Jayaratne and Morgan, 2000), their reserve management and lending strategies are less likely to be constrained by reserve balances at other banks.

Empirical results across large and small banks support the hypothesis that larger reserve premiums incentivize greater bank-level holdings of excess reserves and marginally less bank-level lending. In two-stage estimations[5], results indicate reserve premiums decrease bank-level lending by -6.7%, which amounts to -\$559.3B less lending across all banks. In other words, a 1 standard deviation increase in the reserve premium is associated with -2.3% or \$186.4B decrease in total bank lending. These findings persist after controlling for time-invariant and time-varying bank characteristics such as deposits, size, profitability, and net

[4]The banking literature characterizes smaller community banks as relationship-based, using more heterogeneous soft information for lending compared to larger transactional banks (Berger, Miller, Petersen, Rajan, and Stein, 2005; Hein, Koch, and MacDonald, 2005; Berger and Udell, 2006; Stein, 2002; Liberti and Mian, 2009; Canales and Nanda, 2012; Kysucky and Norden, 2015). Relationship lending spreads are also anti-cyclical compared to transactional lending (Bolton, Freixas, Gambacorta, and Mistrulli, 2016).

[5]Since the IOER rate is only accessible to banks, the reserves premium satisfies the exclusion restriction since it can only impact lending through bank-level excess reserves.

interest margins. Results also account for systemic variables such as quantitative easing (QE)[6], risk-adjusted loan spreads, market volatility, or year-fixed effects when appropriate. All results incorporate two-way clustering of standard errors at the bank and quarter level.

Concerns about endogeneity are pervasive and given the complex nature of market-based banking,[7] each concern warrants individual attention. The initial concerns revolve around two potential instances of reverse causality: 1) the proposition that bank demand drives Treasury prices, and 2) the idea that Treasury issuances drive yields and bank holdings of Treasuries.

At first glance, it seems improbable that bank demand could drive Treasury prices. Treasury Department data indicates US financial institutions hold only 4% of the total Treasury market (Figure 7). Analysis of 1.8 million bank-panel observations from 1976-2017 reveals a positive relationship between Treasury yields and bank holdings of Treasuries, suggesting that banks tend to sell Treasuries as their prices increase. This price-taking behavior contradicts the first reverse causality concern.

The second reverse causality instance suggests that when government deficits spur Treasury issuances, this may cause yields to rise, and the augmented supply could compel banks to increase their holdings of Treasuries, potentially explaining their positive relationship. However, empirical results contradict this notion. Empirical results demonstrate that Treasury yields fall when aggregated Treasury supply increases. This result can potentially be attributed to market participants gravitating towards Treasuries during periods of economic recession. Concurrently, governments often enhance fiscal spending as a counter-cyclical measure, leading to the observed outcomes.

A third case of endogeneity is whether treasury rates drive less bank lending, or whether it drives more bank lending through the risk-taking channel. Since omitted recessionary factors embedded in Treasuries (Estrella and Mishkin, 1998; Engstrom and Sharpe, 2018) may simultaneously increase purchases of safe Treasury assets and lower bank lending, this suggests a positive relationship between the Treasury yields and bank lending. In contrast, the risk-taking channel predicts the opposite - that lower policy rates stimulate lending by incentivizing financial institutions to take on larger lending risks (Borio and Zhu, 2012; Adrian and Shin, 2010; Ioannidou, Ongena, and Peydró, 2015; Jiménez, Ongena, Peydró, and Saurina, 2014; Maddaloni and Peydró, 2011; Paligorova and Santos, 2017; Huang, Li, and

[6]QE is measured as total Federal Reserve holdings of mortgage-backed securities (MBS), divided by all outstanding MBS in the market. I use MBS purchases because Krishnamurthy and Vissing-Jorgensen (2011) finds MBS purchases were more effective at lowering MBS yields than Treasury purchases were at lowering Treasury yields.

[7]Adrian and Shin (2008, 2011); Abbassi, Iyer, Peydró, and Tous (2016) indicate the impact of lower market-based interest rates on increasing balance sheet risk, supporting the price-taking nature of bank to market conditions.

Wang, 2021). For empirical verification, I regress bank-level lending on Treasury yields and observe when Treasury yields fall, bank lending increases, consistent with the risk-taking channel. In the November 2021 SFOS surveys, 70% of respondent banks indicated that when reserve premiums decrease, they responded by increasing bank lending (Fig.1). This paper further substantiates the hypothesis of a "risk-channel transformation". Before the introduction of IOER, lower (higher) Treasury rates would stimulate (reduce) lending, while post-IOER, lower (higher) Treasury rates mechanically increase (lower) the reserves premium which inversely impacts lending. This paper contributes to resolving the "reserves-lending puzzle" by demonstrating that the opportunity cost of reserves imposes a stronger constraint on lending than deposit costs. However, it is worth noting that these findings may be specific to the examined sample period of 2008-2017, and the relative strength of these variables may change as monetary policy changes.

The insights presented in this paper may be seen as a step towards bridging the gap between monetary models and banking, as financial institutions respond in diverse ways to implementing new tools in the Federal Reserve's policy toolkit.[8] This paper utilizes a holistic approach and empirical models are characterized by a statement made by John Kanas, CEO of Bank United, during his 2016 earnings call. He described the bank's stance on risk-taking as prioritizing "resources and efforts where we can profit and where we perceive the lease amount of risk." It is worth noting that bank demand for IOER is not solely propelled by the prospect of higher returns and lower risk.[9] It is also affected by the distinctive status of IOER as an asset whose yield is not reduced by heightened demand, nor does it expose banks to erratic demand fluctuations from other market players. To truly comprehend the interaction of bank risk-taking behavior and monetary policies, the employment of a comprehensive framework akin to the "Sharpe Rati" model becomes necessary.

Overall, evidence suggests that reserve premiums are the predominant factor influencing lending decisions, while reserves arbitrage, "flight to safety", and deposit costs are secondary factors at best. Next, Section 1.1 provides a brief overview on the IOER rate, Section 2 presents the risk-adjusted framework, Section 3 and 4 introduces the data and empirical model. Section 4.1 presents empirical results from one-stage and two-stage panel regressions and tests the "reserves-lending puzzle". Section 4.2 examines reverse causality, macroeco-

[8] Open market operations, the discount rate, and reserve requirements were very effective at influencing the effective fed funds rate Poole (1968); Dotsey (1991); Guthrie and Wright (2000); Bartolini, Bertola, and Prati (2002); Bech and Klee (2011). However, the addition of IOER, supplementary leverage ratios, and overnight reverse repo facilities has potentially large implications for bank lending and private credit markets, requiring new frameworks of thought.

[9] Morrison (1966), Poole (1968), and Frost (1971) said demand for excess reserves is a function of short term interest rates. On page 13, Morrison (1966) states demand for excess reserves is not just from Treasury rates and loan rates, but also default risk.

nomic endogeneity, and predictions of the risk-taking channel and presents evidence of the "risk-channel transformation" hypothesis. Section 4.3 examines quarter-end "window dressing" concerns and Section 4.4 tests unified assumptions regarding bank asset substitution between risk-free and risky securities. Finally, Section 5 ends with the conclusion. An extended proof of the baseline model is available upon request.

## 1.1 Introduction to Bank Excess Reserves

The Federal Reserve Act authorizes the Federal Reserve Board to retain a certain percentage of deposits as reserves, currently set at zero percent effective March 26, 2020. The Financial Services Regulatory Relief Act of 2006 authorized the Federal Reserve to pay an IOER rate starting in 2011 and Section 128 of the Emergency Economic Stabilization Act of 2008 advanced this date to October 2008. FSRR Section 201 states:

> "(A) In general balances maintained at a Federal Reserve bank... may receive earnings... at a rate or rates not to exceed the general level of short-term interest rates."

However, after introducing the IOER rate, short-term Treasury rates (primarily driven by non-banking market participants) frequently dipped below the IOER rate. The Federal Reserve designed the IOER rate as a policy tool to guide short-term rates such as the federal funds rate(Ihrig et al., 2015) through bank arbitrage. However, this coincided with "quantitative easing" where the Federal Reserve purchased Treasuries and MBS in the secondary market, and banks placed the proceeds into excess reserves. Given banks already earmarked these proceeds for investment in risk-free and risky securities, it can be expected that the investment universe for excess reserves extends beyond just fed funds lending. In the November 2020 Federal Reserve SFOS Question 3D (FRS, 2020), surveyed banks indicated they were more likely to transfer excess reserves to Treasury-based reverse repos, Treasuries, or securities such as MBS, rather than the Fed Funds market.

# 2 Risk-Adjusted Framework

The underlying principle of this framework posits that banks, similar to hedge funds, weigh risk and return with equal importance (Boot and Ratnovski, 2016; Adrian and Shin, 2011), with both being equally important. This "Sharpe ratio" framework allows banks to invest in lower-yielding assets with lower risk over a higher-yielding asset with significantly higher risk. This principle is exemplified by JP Morgan's approach to allocation across risk-free excess reserves, risk-free treasuries, risky loans, and risky securities.[10] This paper integrates such practical demonstrations with theoretical assumptions derived from existing literature such as Morrison (1966) who models the decision between excess reserves and interest-bearing assets as a negative one.[11]

Section 2.1 define banks and loans. Section 2.2 discusses changes in the reserves premium. Section 2.3 describes the bank's objective function in choosing between loans and reserves by comparing risk-adjusted returns and the new equilibrium after central bank actions that lower transactional lending rates and increase reserve interest rates.

## 2.1 Lending in Small vs. Large Banks

Banking types range from smaller community banks engaged in relationship lending to large banks engaged in transactional lending. Similar to Boot and Ratnovski (2016); Bolton et al. (2016), I differentiate between smaller relationship banks (R-bank) and larger transactional banks (T-bank).

R-banks are defined by a variable monitoring cost function $S \in [0, 1]$ that processes soft information $f : S \Rightarrow C_R$ to underwrite relationship loans with fixed cost $F$ and underwriting cost $F + C_R$. T-banks are defined by a fixed monitoring cost $F$ to process loans with hard quantitative information. Each bank $i = [B_{T\text{-}Bank}$ is funded 100% by bank equity, $B_{R\text{-}Bank}]$ is endowed with $N < \infty$ units of loanable funds, scaled by unity based normalization to bring values to the range $N \in [0, 1]$. Loans cannot be funded by borrowing or sale of equity and are underwritten with hard or soft information. R-banks process relationship loans with soft information $S$, with lower default risk and higher returns. Banks maximize risk-adjusted returns of bank equity $N$ through the Objective Function as defined in Section 2.3.

**Loans** There are $j$ market participants with capital needs with an active loan application at bank $i$. For simplicity, loan applications and loanable bank equity are equal, $j = n$.

[10] In 10-Q filings for 2019Q3, JP Morgan further reduced excess reserves by $145 billion while increasing security holdings $147 billion compared to 2018Q3. JP Morgan's 2018 Annual Report is here: https://www.jpmorganchase.com/content/dam/jpmc/jpmorgan-chase-and-co/investor-relations/documents/annualreport-2018.pdf
JP Morgan's 2019Q3 10-Q SEC filing is here: https://jpmorganchaseco.gcs-web.com/node/300471/html

[11] Ennis (2018) proposes a model scenario when IOR exceeds $i^*$, a benchmark interest rate, there exists a negative relationship between the level of excess reserves and bank loans. Martin et al. (2016) also proposes a model where loans are negatively related to excess reserves and positively related to deposits. Keynes (1930) posited on the bank decision on excess reserves that "forego [profits]... in the purchase of bills and investments". In the *Treatise of Money*, J.M. Keynes' viewed a bank's decision on its reserve ratio by stating: " To let the [reserve] ratio fall below the figure which has been fixed... would be a sign of weakness... whilst to let it rise above would be to forego... profit since surplus reserves can ...purchase of bills or investments... all banks use their reserves up to the hilt; ... they seldom or never maintain idle reserves in excess..." (Keynes (1930), Volume II p.53).

A loan's risk-adjusted return $\rho_j$ is defined as $\rho_j = \frac{r_j(\theta_j,S_j,QE)-\gamma}{\lambda_{ij}(\theta_j,S_j)}$ which measures the excess returns of a loan above the opportunity cost, on a risk-adjusted basis. $\theta$ is credit risk, $r$ is the nominal lending rate, and $\gamma$ is the opportunity cost and $\theta, r, \gamma \in \mathbb{R}^+$. $\gamma$ is defined as $\gamma = \max\left[IOER, r^f\right] - r^f$ or the opportunity cost of any risk-free premiums above the Treasury rate $r^f$. $\rho$ is scaled to unity based normalization $\rho_j \in [0,1]$. Soft information ratio $S$ and quantitative easing $QE$, where $S, QE \in [0,1]$ Credit risk is normalized to $\theta_j \in (0, \hat{\theta}]$ where $\theta < \infty$, and increases as default risk increases. $S_j \in [0,1]$ is a ratio of soft information to hard transactional information where 0 signifies no soft information and 1 signifies equal parts of soft and hard information.

### 2.2 Policy Actions of the Federal Reserve

The reserves premium may change due to changes in the IOER rate or the risk-free rate. Normally, the $IOER$ rate is zero, but the Federal Reserve can increase this rate above the risk-free rate $r^f < IOER^*$ or the risk-free rate may fall below the IOER rate. The Federal Reserve also engages in asset purchases to ease confounding economic condition $z$. In the true lending model:

$$y_i = \alpha + X\beta + \gamma z_i + QE(z) + \mu_i \tag{1}$$

the Federal Reserve purchases assets until $QE(z) = -\gamma z_i$. $y$ is bank lending and $X$ is an $n \times k$ matrix where we have observations on $k$ independent variables for $n$ observations and $\beta$ is a $k \times 1$ vector of parameters we want to estimate. This model has two systematic components, $X\beta$ and $\gamma z_i + QE(z)$, and the goal is to estimate the population parameters in the $\beta$ vector.

### 2.3 Objective Function and Equilibrium Conditions

Bank $i$ maximizes *risk-adjusted returns* by investing in risky loan assets or risk-free assets $R_i = \frac{1}{n}\sum_{j=1}^{n} \max\left[\rho_{ij}, \gamma\right]$ which expands to:

$$R_i = \frac{1}{n}\sum_{j=1}^{n} \max\left[\frac{r_{ij}(\theta_j, S_j, QE) - \gamma}{\lambda_{ij}(\theta_j, S_j)}, \gamma\right] \tag{2}$$

Opportunity cost is defined as $\gamma = \max[IOER, r^f] - r^f$, and when $IOER$ is greater than $r^f$, $\gamma \to \gamma^*$ and risk adjusted returns of loans fall $\frac{\partial \rho_j}{\partial \gamma} < 0$. In conjunction with bank and loan definitions in Section 2.1, the following proposition specifies necessary framework parameters.

**Proposition 1.** *For bank $i = [B_T, B_R]$, lendable funds are fixed at $n$, banks cannot borrow funds nor sell security assets to fund loans $j = [1...n] \in \mathbb{R}^+$. Total funded+unfunded loans,* *risk-adjusted returns, and opportunity costs of loans j are scaled to a unity based normalization* $j \in [0, 1]$*,* $\rho_j \in [0, 1]$*, and* $\gamma \in [0, 1]$ *respectively. Equilibrium properties are:*

1. *Risk-adjusted returns of funded loans* $F$ *are greater than opportunity costs* $\rho_{ij} > \gamma$*.*
2. *Risk-adjusted returns of unfunded loans* $U_f$ *are lower or equal to opportunity costs* $\rho_{ij} \leq \gamma$*.*
3. $\forall\ j : [F \mid \rho_{ij} < \gamma] = \varnothing$*. All loans with lower risk-adjusted returns than opportunity costs will not be funded.*

Next, we examine the case where the opportunity cost is positive in Condition 1.

**Condition 1.** *The excess reserve interest rate* $IOER = 0$ *is increased or the risk-free rate falls so that* $0 < r^f < IOER^*$*.*

After Condition 1, the following theorem is proposed. As opportunity cost $\gamma = \max[IOER, r^f] - r^f$ increases $\gamma \to \gamma^*$ and bank $i$ will fund fewer loans.

*Proof.* Prior to Condition 1, bank $i$ funded loans where $0 \leq \rho_j$. Using Proposition 1, only loans with a risk-adjusted return exceeding $\gamma$ were funded. Funded loans $(F_i)$ range from:

$$F_i \sim U(\gamma, 1] \quad where \quad 0 \leq \gamma < 1 \tag{3}$$

After Condition 1, bank $i$ funds loans where $\rho_j > \gamma^*$. Funded loans $(F_i^*)$ range from:

$$F_i^* \sim U(\gamma^*, 1] \quad where \quad \gamma < \gamma^* \leq 1 \tag{4}$$

$$\therefore 1 - \gamma > 1 - \gamma^* \tag{5}$$

Hence, fewer loans are funded after Condition 1. □

Figure 5 shows the mechanics of Condition 1 as the set of profitable loans greater than the opportunity cost shrinks from $1 - \gamma$ to $1 - \gamma^*$. Appendix 5 extends conclusions to banks with different lending technologies in a formal proof.

## 2.4 Discussion

Empirical predictions of the main framework is summarized as follows:

1. Reserve premiums are positively related to bank-level excess reserve holdings.
2. Bank-level excess reserves are negatively related to bank-level lending.

3. Reserve premiums are negatively related to bank-level lending.

As far as I know, this paper is the first to test these three framework predictions. The first prediction is that as the IOER rate increases above the risk-free rate (or the risk-free rate falls below the IOER rate, opportunity cost increases $\gamma \rightarrow \gamma^*$ and banks maximize their risk-adjusted returns by choosing reserves over loans, at the margin. This is similar to Morrison (1966) where excess reserves are negatively related to the cost of holding cash[12]. The second prediction is that excess reserves are negatively related to total bank lending. As bank $i$ chooses between lending and reserves, this implies a negative relationship between the two investments. The third prediction is that reserve premiums are negatively related to bank lending. As the opportunity cost increases, lending will decrease from $[1-\gamma] \rightarrow [1-\gamma^*]$ as shown in Figure 5. This negative relationship between reserve premiums and bank lending is estimated using one-stage and two-stage panel regressions. An additional robustness test due to "window dressing" concerns finds similar results using weekly time series data. This negative relationship is further discussed in Section 4.

# 3 Data

This paper primarily uses panel data from the Call Reports issued by the Federal Financial Institutions Examination Council (FFIEC) consisting of quarterly financial data from all depository banking institutions in the US. Call Reports provide greater detail, such as excess reserves (RCON 0090) from Schedule RC-A. This paper uses 2008Q4-2017Q3 Call Report data from the RC, RC-A, RCCI, RCCII, and RC-B files.

Summary statistics in Table 1 are split into R-banks and T-banks using the community banking identifier from the FDIC which are merged with bank observations as of 2017Q3. Community Banking identifiers (FDIC, 2012) classify banks as community banks (R-banks) and non-community banks (T-banks) based on size, geographical, and relationship banking characteristics (FDIC, 2012)[13]. Afterward, all non-matched bank observations are dropped from the sample. The community banking identifier includes 330 banks with over $1 billion in assets (FDIC, 2012).

QE is constructed by dividing Federal Reserve holdings of agency mortgage-backed se-

[12] Morrison (1966) calls the cost of holding cash to be the short term money market interest rate measured by the call money rate from 1874-1929, and the average yield on U.S. Treasury short term obligations, represented by various yields on the three to six month Treasury bills, notes and certificates from 1930-1955.

[13] The FDIC (2012) study on community banks describes the process to identify a community bank in detail.

curities by the total agency mortgage-backed securities outstanding obtained from SIFMA:

$$QE_t = \frac{\text{Federal Reserve Holdings of MBS}_t}{\text{Total Outstanding MBS in the Market}_t}$$

This variable focuses on agency MBS because Krishnamurthy and Vissing-Jorgensen (2011) finds that QE was more successful at lowering MBS rates than Treasury rates. Loan premiums consist of lending rates minus the 10Y Treasury rate divided by the loan delinquency rate. Loan rates are obtained from Freddie Mac, Prime Mortgage Market Survey, and the FFIEC. 10Y Treasury rates are obtained from the US Treasury and loan delinquency rates are obtained from the Federal Reserve. VIX data is obtained from the Chicago Board of Options Exchange while Tier 1 Ratios are extracted from the Call Reports. Stress test data is from the SCAP, CCAR, and Dodd-Frank Act.

T-banks have higher average excess reserves ($1.5B vs. $8.25M), loan volumes, and total assets than R-banks. The median $\frac{Loans}{Assets}$ ratio is similar for T-banks and R-banks (66% vs. 65%). The reserves premium has ranged from 4 to 34 basis points and QE ranges from 6% to 24%. These summary statistics exhibit enough variation to control for bank lending due to banking type and QE in panel regressions.

H8 aggregated weekly data consists of the top 25 domestic banks ranked by size and all other domestic banks. These top 25 rankings are based on total domestic assets in the last available Call Report. If a commercial bank acquires a large bank or if a large bank leaves the commercial bank universe, then it is replaced with the bank next in line, typically the bank ranked number 26. The weekly data set also includes time series data consisting of domestically chartered commercial banks that are not in the top 25 ranking by size. This balance sheet data is collected weekly by the FR 2644 Report by the Federal Reserve. The main advantage in using this data is the high frequency of data.

# 4 Empirical Methodology and Results

The empirical methodology proceeds in four steps. First, Section 4.1 uses panel data to test the three empirical predictions of this paper's framework using one-stage and two-stage panel data regressions. The "reserves lending puzzle" is examined by estimating the impact of factors such as the reserves premium, reserves arbitrage, and "flight to safety" on bank-level reserves and lending. This also enables differentiation between first and second-order concerns. Robustness checks further include an analysis focused solely on small community banks, whose reserve holdings are arguably less restricted by monetary policies. Also, tests are repeated using different Treasury maturities to account for balance sheets with differing maturity transformations. Section 4.2 delves into the predictions made by endogeneity, which seemingly contradicts the risk-taking channel. This section further examines reverse causality, considering how factors such as bank demand and Treasury issuances could influence the results obtained in this study. The possibility of omitted variable bias, where economic conditions drive outcomes, is also considered. Next, Section 4.3 examines potential quarter end "window dressing" issues by examining aggregated time series weekly and comparing results with panel data outcomes. Finally, Section 4.4 examines the assumption that banks dynamically allocate capital across assets of differing risk-profiles, such as substituting risk-free excess reserves for risky loans.

## 4.1 Main Hypothesis: Empirical Model and Results

Figure 6 outlines the empirical strategy and the respective regressions used to support the hypothesis of this paper. The following three hypotheses are tested using empirical modeling premises from this paper's framework. All empirical results incorporate bank fixed effects due to potentially omitted time-invariant bank-specific characteristics that impact lending, and standard errors are two-way clustered at the bank and quarter level.

**4.1.1 Hypothesis 1: Reserve premiums are positively related to bank decisions on excess reserves.** Greater risk-free premiums in excess reserves should incentivize bank-level decisions to hold more excess reserves. The basic panel data empirical model is as follows:

$$\begin{aligned}\frac{\text{Excess Reserves}_{i,t}}{\text{Assets}_{i,t}} &= \alpha_i + \beta_1 \times \Phi_t + \beta_2 \times \left[\Phi \times \text{Transactional}_{i,t}\right] \\ &\quad + \beta_3 \times \Theta_t + \beta_4 \times \text{QE}_t + X'\Gamma + \epsilon_{i,t}\end{aligned} \tag{6}$$

This estimation measures the impact of the reserves premium $\Phi$ on excess reserves after controlling for bank-level deposits $\theta$ and quantitative easing $QE$. $X$ represents additional bank-level control variables such as log of assets, return on equity, and net interest margins as well as macro control variables such as risk-adjusted loan spreads and market volatility. Bank type controls use FDIC Community Banking Study to assign a value of 1 for large, transactional banks (non-community banks) and a value of 0 for small community banks. $\alpha_i$ are bank-fixed effects.

Table 2 (1) indicates when reserve premiums rise by 100 bps, excess reserves increase by 0.031 (t-stat of 3.90) of total assets. (2) adds bank-level and macro-level controls and the reserves premium coefficient remains primarily unchanged at 0.028 (t-stat of 2.67). The coefficients on QE is positive and significant as banks increase reserves due to monetary actions as found in Kandrac and Schlusche (2021); Rodnyansky and Darmouni (2017). The inclusion of bank-level controls in the analysis ensures that observed effects on the reserves premium coefficient are not due to customer deposit demand, bank size, or bank profitability. Additional macro controls ensures that results are not due to monetary policies and market factors. Next, we address potential constraints on reserve levels by examining only small banks whose reserve levels arguably do not interfere with amounts from other small banks. (3) restricts the sample to small banks and finds a reserve premium coefficient of 0.025 (t-stat of 3.26) which is very similar to (2). In (4), the transactional dummy is insignificant, suggesting that lending technology does not add explanatory value to bank-level decisions on excess reserves. (5) uses the reserves arbitrage (IOER-EFFR) and its coefficient is statistically insignificant. These results are not surprising as 95.5% of domestic banks do not actively borrow in the federal funds markets (Figure 2). Additionally, EFFR contains bank counter-party risk which is absent from Treasury rates, potentially resulting in greater measurement error. In unreported results, I account for banks with differing maturity transformations by using 10Y Treasury rates in the reserves premium and also find significantly positive reserve premium coefficients. Overall, findings from Table 2 support Hypothesis 1. Next are one-stage panel regressions that test Hypothesis 2.

**Hypothesis 2: Excess reserves are negatively related to bank lending.** Bank-level decisions that allocate capital between excess reserves and loan assets imply a negative relationship. However, this relationship may be driven by omitted variables, as deposit withdrawal shocks may drive demand for reserves (Bianchi and Bigio, 2022), and bank decisions on asset allocations may be driven by monetary policies. Therefore, any relationship between reserves and bank lending may disappear after controlling for cross-sectional deposits and time-varying monetary actions. A one-stage panel regression that tests Hypothesis 2 is:

$$\frac{\text{Loans}_{i,t}}{\text{Assets}_{i,t}} = \alpha_i + \lambda_t + \gamma_1 \times \frac{\text{Excess Reserves}_{i,t}}{\text{Assets}_{i,t}} + \gamma_2 \times \left[\frac{\text{Excess Reserves}_{i,t}}{\text{Assets}_{i,t}} \times \text{Transactional}_{i,t}\right] + \gamma_3 \times \Theta_t + \gamma_4 \times \text{QE}_t + X'\Gamma + \varepsilon_{i,t} \tag{7}$$

This empirical model accounts for bank-level deposits $\Theta$ as bank lending is traditionally funded by deposits (Jayaratne and Morgan, 2000) and deposit withdrawal shocks may drive demand for bank reserves (Bianchi and Bigio, 2022), driving the banking trade-off between lending and liquidity risk. $\lambda_t$ is time-fixed effects as time-varying monetary policies may also be driving the relationship between lending and bank funding (Keister and McAndrews, 2009). Specifications also include bank fixed effects $\alpha_i$, bank-level controls, and standard errors that are two-way clustered at the bank and quarter level.

In Table 3 (1) and (2), the coefficient for excess reserves and deposits is -0.526 (t-stat

-12.86) and -0.19 (t-stat -6.63) respectively, suggesting both variables individually curb lending. In (3), the inclusion of both excess reserves and deposits demonstrates a dollar of reserves has over 3x more impact than a dollar of deposits (-0.505 vs -0.154). However, (1)-(3) does not include time-varying monetary actions, leaving the possibility that this relationship is driven by monetary actions on total reserves. Columns (4)-(6) replicate these three columns, this time incorporating time-fixed effects. In (4), the coefficient for excess reserves drops to -0.426 and remains significant; in (5), the coefficient for deposits drops to -0.049 and loses significance. In (6) the inclusion of both deposits and time-fixed effects verifies that reserves play a more substantial role than deposits in constraining lending, the latter becoming insignificant after controlling for time-varying monetary actions. These results further support the premise that banks' decisions to deploy reserves for lending may be autonomous from time-varying factors, while the deployment of deposits for lending appears to be more influenced by such factors. (7) repeats (6) with a restricted sample of small community banks whose reserve management and lending are arguably less restricted by reserve holdings of other banks. Finding similar results after controlling for monetary policies and sample restrictions supports the independence of bank decisions inherent in this paper's framework. It also echoes similar findings from the SFOS bank surveys in Figure 1 and 2 where bank reserve management strategies indicate autonomy from monetary policies. (8) further adds a control for large transactional banks which is insignificant, suggesting the relationship between excess reserves and lending is not explained by bank type or size. Next are one-stage panel regressions that test Hypothesis 3.

**Hypothesis 3: Reserve premiums are negatively related to bank lending.** If empirical results support Hypothesis 1 and 2, falling (rising) reserve premiums may disincentivize (incentivize) excess reserves, further influencing bank decisions between excess reserves and lending. This suggests a negative relationship between reserve premiums and bank-level lending. The basic panel data empirical model to test Hypothesis 3 is:

$$\begin{aligned} \frac{\text{Loans}_{i,t}}{\text{Assets}_{i,t}} = \alpha_i + \lambda_1 \times \Phi + \lambda_2 \times \Big[\Phi \times \text{Transactional}_{i,t}\Big] \\ + \lambda_3 \times \Theta + \lambda_4 \times \text{QE}_t + X'\Gamma + \varepsilon_{i,t} \end{aligned} \tag{8}$$

Bank fixed effects, bank-level and macro controls are similar to Equation 6 and standard errors are two-way clustered at the bank and quarter level. Alternative measures, such as the reserves arbitrage and TED Spread, can be employed as substitutes for the reserves premium to assess its influence.

Table 4 (1) has a reserves premium coefficient of -0.096 (t-stat -2.09) and (4) adds bank-level and macro controls and finds a reserve coefficient of -0.203 (t-stat -3.23). Due to concerns over the independence of bank decisions on reserves, (7) examines the prior specification with only small community banks and finds a similar coefficient of -0.206 (t-stat -3.22). Specification (8) controls for lending technology, which is insignificant as in Table 2 and 3. Column (2) uses reserves arbitrage (IOER-EFFR) to estimate its impact on lending, and the coefficient is -0.097 and insignificant, in line with Rezende et al. (2019) which finds insignificant results when using EFFR. However, when adding bank-level and macro controls in (5), the coefficient on reserves arbitrage is -0.136 (t-stat -2.15) and significant. However, this may be due to the inclusion of excess reserves as a firm-level control variable. On the whole, there is some support for the reserves arbitrage, although it is economically and statistically weaker than support for the reserves premium and does not seem to be meaningful by itself. Next in Column (3), the TED Spread (LIBOR-3MT) measures "flight to safety", as Treasury premiums may rise when credit markets are stressed. In (3), the coefficient is 0.041 (t-stat 5.11), which contradicts the expectation that the TED Spread would negatively influence lending. In (6), the inclusion of firm-level and macro controls turns the coefficient statistically insignificant and negative, suggesting some negative impact on lending, but it is not statistically significant. Findings support the notion that the reserves premium is the predominant factor influencing lending decisions. Meanwhile, reserves arbitrage and a "flight to safety" appear second-order concerns.

An additional concern is that measurement error $\eta$ may exist if the true reserves premium $\Phi^*$ is observed with an independent measurement error $\eta \sim (0, \sigma_\eta^2)$: $\Phi = \Phi^* + \eta$, then the least squares estimator on the reserves premium $\gamma_1$ in Eq. 8 is inconsistent. Using the 3MT in the reserves premium may reduce measurement error, but further measurement error may be due to a duration mismatch in premiums. Bank loans may have a longer duration than the 3M Treasury yield, so Table 4 is redone with the 10Y Treasury rate in the reserves premium and the results are very similar. For the sake of brevity, those results are not reported in this paper.

Overall, the three single-stage panel regressions support the three hypotheses based on this paper's framework, and the opportunity cost of reserves seems to be a larger lending constraint than reserves arbitrage, "flight to safety", and deposit costs. Results are robust when restricting the sample to small banks and accounting for bank balance sheets with longer loan maturities. Next, Section 4.1.2 uses two-stage estimations to address potential measurement error and non-economic omitted variable bias in the relationship between bank-level excess reserves and bank-level lending.

**4.1.2 Two-Stage Instrumental Variable Analysis.** It is possible that insufficient demand may be forcing banks to hold excess reserves. In order to address endogeneity and omitted variable bias, further, I revisit prior frameworks to employ a two-stage estimation that instruments the reserves premium for bank-level reserves. This analysis requires two important assumptions, and the first is that the reserves premium should clearly impact the potentially endogenous regressor, excess reserves, which is clearly supported by Table 2. Second is the exclusion restriction where the reserves premium only affects lending through the first stage estimation of excess reserves. This exclusion restriction is met as only depository institutions can access the IOER-3MT spread, and non-banks such as Fannie Mae can not access IOER (Bech and Klee, 2011; Griffiths et al., 2014). Also, Nagel (2016) finds that IOR has not been transmitted to deposit rates, which satisfies the exclusion restriction that the reserves premium is only available to banks. For the two-stage estimation, the following empirical model is estimated:

$$\text{Excess Reserves}_{i,t} = \alpha_i + \beta \times \text{Reserves Premium}_t + \varepsilon_{i,t} \qquad \text{(1st Stage)}$$
$$\text{Total Loans}_{i,t} = \lambda_i + \gamma \times \widehat{\text{Excess Reserves}}_{i,t} + X'\Gamma + \mu_{i,t} \qquad \text{(2nd Stage)}$$
$$(9)$$

The first stage estimates excess reserves, which is then used as an independent variable in the second stage. Table 5 employs 4 different specifications, all using bank-fixed effects and standard errors that are two-way clustered at the bank and quarter level. These specifications in (1)-(4) reject under-identification with a Chi-squared p-value of (0.01, 0.00, 0.04,0.01) and the Kleinbergen-Paap rk Wald F Statistics of (15.2, 10.0, 10.6, 44.7) satisfies weak identification thresholds under Stock and Yogo (2005) as well as the threshold of 10 for Staiger and Stock (1994). (3) reports only small community banks and (4) has only large transactional banks in its sample. Due to its limited sample size, (4) partially out risk-adjusted lending premiums and VIX because the estimated covariance matrix of moment conditions is not of full rank.

Across (1)-(4) in the 2nd stage, $\gamma$ is significantly negative. In (1), $\gamma$ is -3.096 (t-stat -3.24) and (2) adds bank level controls and macro controls and $\gamma$ is -7.725 (t-stat -6.04). Deposits have a positively significant coefficient of 0.363 (t-stat 2.66), in line with the deposits funding lending model of banking. QE also has a coefficient of 0.095 (t-stat 2.28), suggesting that QE increased lending, confirming Kandrac and Schlusche (2021); Rodnyansky and Darmouni (2017). It is likely the two-stage estimation removed bias found in the negative coefficients of deposits and QE in Table 3 In (3), the sample is restricted to small community banks whose reserve amounts arguably do not interfere with the reserve amounts of other small banks. $\gamma$ is -8.677 (t-stat -5.65). In (4), the sample is restricted to large transactional banks and $\gamma$ is -2.882 (t-stat-7.07).

In the sample, the mean level of reserve premiums is 18 basis points, the average total assets of banks is \$2.19B, and the average loan assets of banks are \$1.18B. Using specifications from Table 5 (2), the average bank reduced lending by -\$85.2M or 6.69% of original loan volumes [14]. Given an average of 6,565 banks per quarter, this translates into a total reduction in lending of \$559.27B in lending due to the reserves premium[15]. Overall, two-stage estimations verify prior one-stage results but address endogenous concerns that loan demand may drive excess reserves. The next section tests for reverse causality and examines cases where endogeneity and the risk-taking channel predict opposite results, further clarifying this paper's results.

## 4.2 Endogeneity and the Risk-Taking Channel

This section tests for two broad categories of endogeneity. First, I test for reverse causality where bank demand for Treasuries may drive the Treasury rate portion of the reserves premium and where Treasury issuances simultaneously drive yields and bank holdings of Treasuries. Second, macroeconomic endogeneity predicts that recessionary conditions drive market participants to safe harbor in Treasuries and drive banks to reduce lending, predicting a positive relationship with yields and bank loans. However, the risk-taking channel theorizes that lower policy rates actually incentivize increased bank-risk taking, predicting a negative relationship between Treasury rates and bank lending. These two theories predict opposing outcomes, providing fertile grounds for empirical testing. An additional concern is that results are driven by monetary policies such as QE designed to offset adverse economic conditions. To account for monetary policies, Section 2.2 outlines the true lending process as $y_i = \alpha + X\beta + \gamma z_i + QE(z) + \mu_i$ where $y$ is bank lending and $QE(z)$ is a monetary function based on economic conditions $z$. The monetary function offsets negative economic conditions, so $QE(z) = -\gamma z_i$. The empirical model separately examines the two cases where the monetary function successfully and unsuccessfully offsets negative economic condition $z$, and the relevant tests for endogeneity for each case.

**4.2.1 Case 1: QE Success.** When $QE(z)$ successfully offsets economic conditions, $QE(z) = -\gamma z_i$, we can use $y_i = \alpha + X\beta + \mu_i$ to estimate the impact of the reserves premium on lending

[14] $0.18 \times 0.028 \times -7.725 = -0.0389$ of bank assets. For the average bank with \$2.188B in assets, $-0.0389 \times \$2.188B = -\$85.189M$ in potentialy reduced lending. Banks average \$1.189B of loans, $\frac{-85.189}{1{,}189+85.189} = -6.688\%$ reduction in average loan volumes if there was no reserve premium.

[15] $6,565 \times -85.189M = -559.27B$

through coefficient $\beta$. In Case 1, results from Table 4 and 5 are valid as confounding economic factors are not driving the results where higher (lower) reserve premiums negatively (positively) factor on lending.

**Reverse Causality: Bank Demand Driving Treasuries** If lower bank risk appetites increase bank demand for Treasuries, this may drive Treasury yields lower which mechanically increases the reserves premium, further incentivizing reserves over lending. How likely is this scenario? Table 6 examines the possibility of bank demand for Treasuries driving our results. The central assumption is whether bank demand drives Treasury prices (price-setting), or do banks take advantage of Treasury price spikes and profit take (price-taking).

Table 6 Columns (1), (2), and (4) uses 1,818,651 bank holding company observations from 1976-2017 to estimate the following model:

$$\frac{[\text{Treasury Holdings}]_{i,t}}{\text{Total Assets}_{i,t}} = \alpha_i + \beta_1 \text{Risk Free Rate}_t + \varepsilon_{i,t} \tag{10}$$

If $\beta_1$ is negative and significant, this indicates bank demand increases Treasury prices (yields $\downarrow$), supporting reverse causality. If $\beta_1$ is positive and significant, this indicates banks' profit take when Treasury prices rise, contradicting reverse causality. Column (1) uses 1,818,651 bank-quarter observations to find a positive and significant coefficient of 0.003 (t-stat 4.42) on the 3M Treasury rate, suggesting banks take advantage of price spikes, contradicting reverse causality. Column (2) repeats (1) using the 10Y Treasury rate and finds similar results while (4) uses all bank-observations in 2008-2017 and also finds a positive and significant coefficient of 0.003 (t-stat 3.88). Results contradict bank price setting, consistent with banks holding only 4% of the Treasury market (Figure 7), suggesting they lack significant market power. Overall, results significantly contradict reverse causality.

**Reverse Causality: Treasury Issuances Driving Results** Another concern is that supply-side reverse causality may drive the prior positive relationship between bank Treasury holdings and Treasury yields. If governments run large fiscal deficits, the accompanying increase in Treasury issuances can simultaneously increase Treasury yields and the amount of Treasuries held by banks. Table 6 (3) tests that possibility by regressing panel bank Treasury holdings on total Federal debt, and Federal debt has a coefficient that is significantly negative at -0.019 (t-stat -8.38), suggesting increased Federal debt is associated with lower bank Treasury holdings. This contradicts reverse causality, and this trend indicates bank Treasury holdings declining over time. (5) further tests reverse causality by regression 3M Treasury yields on total Federal debt, and the coefficient on Federal debt is -2.936 (t-stat

-13.87), suggesting increased Federal debt is associated with lower Treasury yields. This also contradicts reverse causality as Federal debt is likely driven by increased fiscal spending during recessions, and recessions are associated with lower Treasury yields due to market debt for safe assets. Both results suggest that endogeneity driven by Treasury issuances is not likely. Next, I examine the case when QE does not fully offset negative economic factors.

**4.2.2 Case 2: QE Failure.** If QE does not offset negative economic conditions, $QE(z) \neq -\gamma z_i$, the primary endogeneity concern is the confounding economic residual $\nu = \gamma z_i + QE(z_i)$. This residual $\nu$ may influence variation in the reserves premium and bank-level lending over time, causing omitted variable bias. Variation in the reserves premium is likely driven by Treasury rates, as Figure 3 demonstrates greater variation in the 3M Treasury rate than the IOER rate. This suggests a closer look at the relationship between Treasury rates and bank lending for potential macroeconomic endogeneity.

**Endogenous Treasuries vs. Risk-Taking Channel** Treasuries generally contain information about the probability of recessions in the near future (Estrella and Mishkin, 1998; Engstrom and Sharpe, 2018), so endogeneity means that recessionary conditions may simultaneously drive market participants into safe Treasury assets and drive bank lending down, which implies a positive relationship between the 3MT and lending. However, the risk channel predicts the opposite as lower policy rates should incentivize more bank lending. The following empirical model tests for endogeneity and the risk-taking channel:

$$\frac{\text{Loans}_{i,t}}{\text{Assets}_{i,t}} = \alpha_i + \gamma_1 \text{Risk Free Rate}_t + \gamma_2 [\text{Risk Free Rate}_t \times \text{IOER Dummy}_t] + \varepsilon_{i,t} \qquad (11)$$

If endogeneity dominates and Treasuries indicate a recession where bank lending falls, then $\gamma_1$ should be positive as recessions spur lower Treasury rates and bank-level lending. Endogeneity also suggests the dominant drivers of this relationship are recessionary conditions, so the introduction of IOER and the reserves premium will have no impact on $v$ and $\gamma_2$ should be insignificant. If the risk channel dominates, $\gamma_1$ should be negative as banks increase loan risk-taking when Treasury rates fall. Also, $\gamma_2$ should become significant as the introduction of IOER transforms the incentive mechanism of the risk-taking channel as lower Treasury rates will increase the reserves premium, which will reduce bank risk-taking.

Table 7 (1) use 1,675,056 bank holding company observations from 1976-2017 to regress bank-level loans on Treasury rates to show the coefficient $\gamma_1$ is -0.005 (t-stat -6.21) This suggests when rates fall, bank-level lending increases, supporting the risk-taking channel. In (2), $\gamma_1$ is -0.005 (t-stat -5.53) and the 3M Treasury Rate × $IOER$ coefficient $\gamma_2$ is 0.17

(t-stat 3.89). $\gamma_2$ strengthens support for the "risk-channel transformation" hypothesis as the introduction of the IOER rate means lower Treasury rates mechanically increase the reserves premium, which likely incentivizes less lending. IOER inverted the traditional negative relationship between treasuries and bank lending into a positive one. The risk-taking channel and the importance of the reserves premium is likely the reason for this inversion. (3) and (4) further split the sample into 1976-2008 and 2008-2017 and in (3) $\gamma_1$ is significantly negative with a value of -0.004 (t-stat -4.97) and it is significantly positive with a value of 0.0304 (t-stat 5.18) in (4). These results broadly support the risk-taking channel and the risk-channel transformation hypothesis, while contradicting endogeneity predictions. Next, Section 4.3 conducts a robustness check that examines potential quarter-end "window dressing" issues.

## 4.3 Time Series Robustness Check: "Window Dressing"

"Window dressing" is when banks materially adjust their balance sheets to meet quarter-end regulatory requirements. While Call Report data is recorded quarterly, aggregated H8 banking data from the Federal Reserve is reported weekly. If prior results were due to "window dressing", then results would not be replicated using weekly data.

Overall, Table 8 verifies prior results, suggesting "window dressing" motives are not the driving factor. Table 8 (1) and (2) replicates 2 and finds the reserve premium coefficient is 0.013 (t-stat 4.47) and 0.011 (t-stat 4.66) for large and small banks, respectively. (3) and (4) replicates Table 3 and find an excess reserves coefficient of -0.653 (t-stat -26.28) and -1.536 (t-stat -26.19) respectively. (5) and (6) replicates Table 4 and find a reserve premium coefficient of -0.011 (t-stat -4.61) and -0.012 (t-stat -3.02) respectively.

The reserves premium coefficients in (1) and (2) based on weekly data are significantly smaller in magnitude (-0.013 and -0.011) than the coefficients of -0.203 based on quarterly data in Table 4 (2). This may be due to differences in the dependent variable (loan-to-asset ratio) at the weekly vs. quarterly level. Table 9 compares their standard deviations and finds that weekly Loan/Assets ratios for Big (Small) banks have standard deviations of 0.015 (0.018), which is significantly smaller than the standard deviation of 0.24 (0.16) for quarterly panel data. Table 9 also shows that macro variables do not display significant differences in standard deviations between weekly and quarterly data. This suggests differences in coefficients between aggregated weekly and quarterly panel data are due to higher cross-sectional variation in panel loan ratios compared to weekly aggregated loan ratios.

Overall, findings suggest panel results are robust to concerns over regulatory manipulation such as "window dressing". Next, Section 4.4 examines whether banks substitute between assets of different risk levels and maturities due to concerns about whether banks are structurally prevented from risk-substituting between excess reserves and loan assets.

### 4.4 Risk Substitution in Banks with Large Excess Reserves

Do banks with large excess reserves (BLER) substitute risky and risk-free assets? Some observers stipulate that banks do not substitute risk-free and risky assets due to differences in risk and maturity. Figure 8a and 8b demonstrates that excess reserves are concentrated in transactional banks with excess reserve balances over $1B. This suggests that BLER and non-BLER may differ in its respective risk-substitution behavior.

Eq. 12 examines potential risk-substitution behavior by estimating sensitivities of treasuries and debt with excess reserves.

$$\frac{\text{Excess Reserves}_{i,t}}{\text{Total Assets}_{i,t}} = \alpha_i + \lambda_t + \gamma_0 \times \frac{[\text{Treasuries, Non-Treasury Debt Securities}]_{i,t}}{\text{Total Assets}_{i,t}} + \varepsilon_{i,t} \tag{12}$$

If $\gamma_0$ is negative and significant, this suggests banks increase excess reserves by selling securities such as treasuries and mortgage-backed securities. Table 10 uses subsamples of BLER and non-BLER banks to examine excess reserve sensitivities to treasury holdings (RCON0211 + RCON1286) and non-Treasury debt securities (RCON1754 + RCON1772 - RCON0211 - RCON1286). The two asset classes are not structurally segregated if banks sell treasuries and place proceeds in excess reserves. If banks sell risky debt securities and place proceeds in excess reserves, then banks substitute risk-free and risky securities, strengthening this paper's findings. (1) and (3) show coefficients on Treasury securities (-0.016 and -0.349) are insignificant and negative while (2) and (4) show coefficients on non-Treasury debt securities (-0.04 and -0.294) are significant and negative for non-BLER and BLER respectively. Specifications include bank and time fixed effects and standard errors are two-way clustered at the bank and quarter level.

Table 10 results also support Kandrac and Schlusche (2021) and Chakraborty, Goldstein, and MacKinlay (2017) who also find that banks substitute risk-free and risky assets such as reserves, MBS, and loans.

## 5 Conclusion

In conclusion, this paper examines the validity of the theoretical framework posited by former Federal Reserve Chairman Ben Bernanke and finds evidence that the reserves premium contributes more to resolving the "reserves-lending puzzle" than reserves arbitrage or "flight to safety" mechanisms. These findings underscore the value of the reserves premium as an influential determinant for bank lending decisions, and thus, a vital piece in the complex jigsaw of monetary transmission mechanisms.

One-stage and two-stage panel estimations suggest reserve premiums may decrease bank-level lending by -6.7%, amounting to a reduction of -$559.3B across all banks. The implication is that a decrease in reserve premiums may lead to increased bank-level lending. These findings control for lending based on time-invariant and time-varying bank characteristics, monetary policies that influence reserves and lending over time, and incorporate conservative two-way clustering of standard errors. Issues related to endogeneity are individually resolved. Results also survive restricted samples with greater independence from monetary policies, balance sheets with differing maturity transformations, and window dressing concerns.

The paper further explores the reserves lending puzzle, and results suggest that the opportunity costs of reserves plays a more significant role in lending than deposit costs, regardless of changes in monetary policies. However, these findings are limited to data from 2008-2017, acknowledging that the dynamics between variables could shift in different periods. Findings suggest that reverse causality scenarios, where bank demand influences treasury yields and treasury issuances steer the results, are deemed implausible. Evidence supports the risk-taking channel (Adrian and Shin, 2008, 2011; Abbassi et al., 2016) where lower policy rates increase bank risk-taking. This leads to a transformation of the risk-channel initiated by the introduction of IOER. The premises behind this paper's unified setup predate findings from the Federal Reserve's Senior Financial Officer Surveys (FRS, 2020, 2021a) that indicates banks independently make decisions on excess reserves and lending based partly on reserve premiums (Figure 1 and 2).

In the intricate world of monetary policy, it is inevitable that policymakers cannot anticipate every potential outcome. Treasury yields are embedded with economic conditions (Estrella and Mishkin, 1998; Engstrom and Sharpe, 2018), such as market participants buying Treasuries for safety during recessions, which drives yields lower. Prior to IOER, lower Treasury yields spurred bank lending through the risk-taking channel, expanding credit during recessions. After IOER, lower Treasury yields mechanically increases the reserves premium, which negatively impacts bank lending during recessions. Given that Treasury yields exhibit greater volatility than IOER, monetary policy during recessions should promptly reduce IOER to bridge the gap with declining Treasury yields. The framework suggested by this paper could serve as one such tool for refining the understanding of these complex dynamics.

**Figure 1. Bank Surveys on Excess Reserves and Alternative Investments**

The Federal Reserve distributed the Senior Financial Officer Survey to senior financial officers of 80 banks, 46 domestic banks and 34 U.S. branches of foreign banks. Responses were received from all 80 banks who hold roughly three-fourths of total reserves in the banking system.

(a) **Lack of Attractive Investments Led to Excess Reserves Buildup (Sept. 2020 Q:2B)**

Banks that increased their average reserve balances from March/April 2020 to August 2020 were asked the following: Please rank in order of importance, the drivers that led to higher reserve balances at your institution from 1 (least important) to 5 (most important).

i. Lack of attractive alternative investment opportunities

| | All respondents | | Domestic | | Foreign | |
|---|---|---|---|---|---|---|
| | Banks | Percent | Banks | Percent | Banks | Percent |
| 1 (Least important) | 1 | 3.7 | 1 | 4.0 | 0 | .0 |
| 2 | 2 | 7.4 | 1 | 4.0 | 1 | 50.0 |
| 3 | 3 | 11.1 | 2 | 8.0 | 1 | 50.0 |
| 4 | 5 | 18.5 | 5 | 20.0 | 0 | .0 |
| 5 (Most important) | 16 | 59.3 | 16 | 64.0 | 0 | .0 |
| Total | 27 | 100.0 | 25 | 100.0 | 2 | 100.0 |

Note: 1 respondent did not provide an answer.

(b) **Smaller Reserves Premium Reduces Excess Reserves (Sept. 2020 Q:3C)**

Banks that expect to reduce excess reserves were asked: What factors do you anticipate could prompt your bank to seek to reduce the level or growth of your reserve balance... Please rank, in the order of their importance, the factors from 1(least important) to 6(most important).

ii. An increase in the expected return on alternative HQLA Level 1 investments relative to IOER

| | All respondents | | Domestic | | Foreign | |
|---|---|---|---|---|---|---|
| | Banks | Percent | Banks | Percent | Banks | Percent |
| 1 (Least important) | 9 | 24.3 | 9 | 25.7 | 0 | .0 |
| 2 | 1 | 2.7 | 1 | 2.9 | 0 | .0 |
| 3 | 4 | 10.8 | 4 | 11.4 | 0 | .0 |
| 4 | 6 | 16.2 | 6 | 17.1 | 0 | .0 |
| 5 | 7 | 18.9 | 7 | 20.0 | 0 | .0 |
| 6 (Most important) | 10 | 27.0 | 8 | 22.9 | 2 | 100.0 |
| Total | 37 | 100.0 | 35 | 100.0 | 2 | 100.0 |

**Figure 2. Bank Surveys on Reserves, Treasuries, and Federal Funds**
The Federal Reserve distributed the Senior Financial Officer Survey to senior financial officers of 80 banks, 46 domestic banks and 34 U.S. branches of foreign banks. Responses were received from all 80 banks who hold roughly three-fourths of total reserves in the banking system. In (a) and (b), responses from domestic banks in the Federal Reserve's SFOS bank surveys were summarized for ease of exposition.

(a) **What is the smallest spread above IOER at which your institution would be willing to invest reserve balances into the following HQLA (March 2021 Q:4)**

| | Domestic Bank Respondents | | | | | |
|---|---|---|---|---|---|---|
| | Short Term Treasuries | | 1-5 Year Treasuries | | 5+ Year Treasuries | |
| | Banks | % | Banks | % | Banks | % |
| 0-10 bps | 25 | 54.3 | 5 | 11.9 | 2 | 4.8 |
| 11-25 bps | 15 | 32.6 | 7 | 16.7 | 4 | 9.5 |
| 26-50 bps | 5 | 10.9 | 12 | 28.6 | 3 | 7.1 |
| 51 bps or more | 1 | 2.2 | 18 | 42.9 | 33 | 78.6 |
| Total | 46 | 100.0 | 42 | 100.0 | 42 | 100.0 |

(b) **In the last 6 months, if your bank reduced excess reserves due to [the reserves premium and net interest margins], please indicate whether the following asset adjustment actions were a component of your bank's reserve management strategy on a scale of 1 (not important) to 5 (very important) (Nov. 2021 Q:1C)**

| | Domestic Bank Respondents | | | | | |
|---|---|---|---|---|---|---|
| | Increase Fed Funds | | Increase Treasuries | | Increase Lending | |
| | Banks | % | Banks | % | Banks | % |
| 1 (Not important) | 11 | 100.0 | 4 | 18.2 | 3 | 15.0 |
| 2 | 0 | 0.0 | 1 | 4.5 | 2 | 10.0 |
| 3 | 0 | 0.0 | 3 | 13.6 | 1 | 5.0 |
| 4 | 0 | 0.0 | 7 | 31.8 | 6 | 30.0 |
| 5 (Very important) | 0 | 0.0 | 7 | 31.8 | 8 | 40.0 |
| Total | 11 | 100.0 | 22 | 100.0 | 20 | 100.0 |

(c) **95.5% of Surveyed Domestic Banks Do Not Use Federal Funds (Nov. 2021 Q:5C)**

A. Is your bank an active borrower in unsecured (federal funds, Eurodollars, or commercial paper) overnight wholesale funding markets (Yes or No)? For the purposes of this question, consider an active borrower as a bank that borrows for non-test purposes at least once a month.

| | All Respondents | Domestic | Foreign |
|---|---|---|---|
| Yes | 28 | 2 | 26 |
| No | 51 | 43 | 8 |
| Total | 79 | 45 | 34 |

**Figure 3. Components of the Reserves Premium**

IOER is interest on excess reserves, 3MT is the 3 Month Treasury rate, and EFFR is the effective federal funds rate. EFFR is higher than 3MT due to counter-party risk in the fed funds market. IOER provides a higher risk-free rate, lower volatility, and lower transaction costs than 3MT.

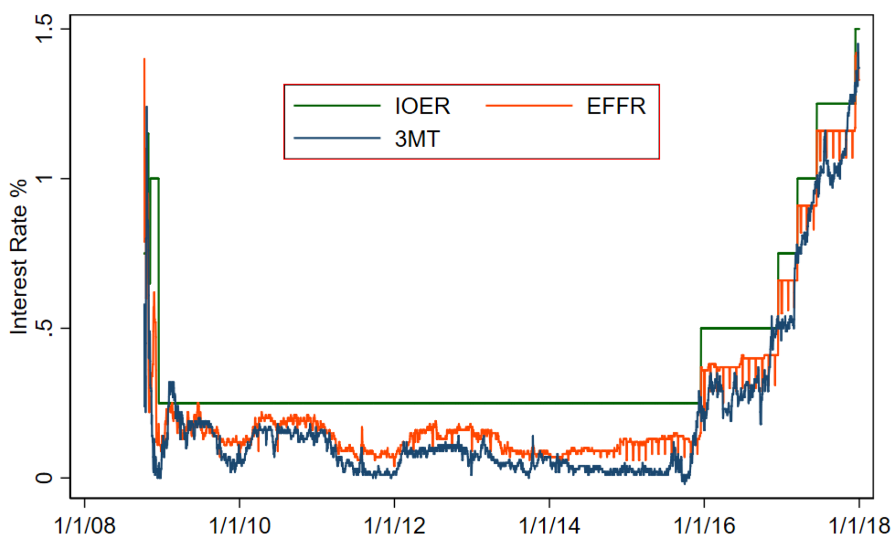


**Figure 4. Aggregate Excess Reserves and the Reserves Premium**
Excess reserves ($ Trillions) are on the left y-axis while reserve premiums (IOER-3MT) are on the right y-axis. All data points are at the weekly frequency. Excess reserve data is from the H8 series from the Federal Reserve, interest rates on excess reserves is from the Federal Reserve, and 3M Treasury rates are from the US Treasury.

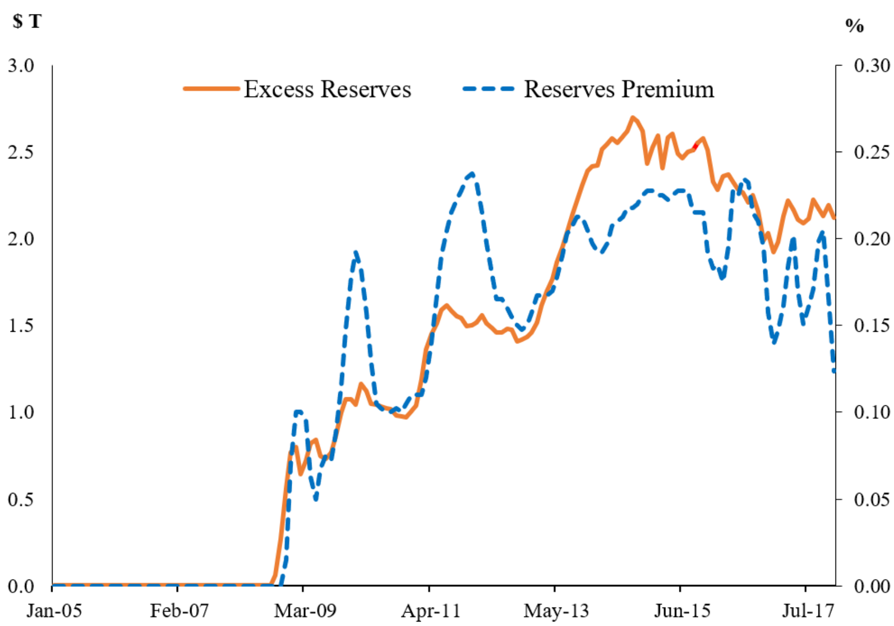


**Figure 5. Increase in Reserves Premium and Bank Lending**
Before Condition 1, banks fund loans with risk-adjusted returns $F_i \sim U(\gamma, 1]$. When the risk-free rate is below the IOER rate so that $0 < r^f < IOER^*$, this results in $\gamma \rightarrow \gamma^*$ due to higher opportunity costs defined as $\gamma = \max[r^f, IOER^*] - r^f$. Banks only fund loans with risk adjusted returns greater than the opportunity cost $\rho_{ij} > \gamma^*$ as in Proposition 1, banks will fund fewer loans after Condition 1.

(a) Funded Loans $F_i$ when $IOER = 0$

(b) Funded loans $F_i^*$ when $IOER > r^f$ increases so that $\gamma \rightarrow \gamma^*$

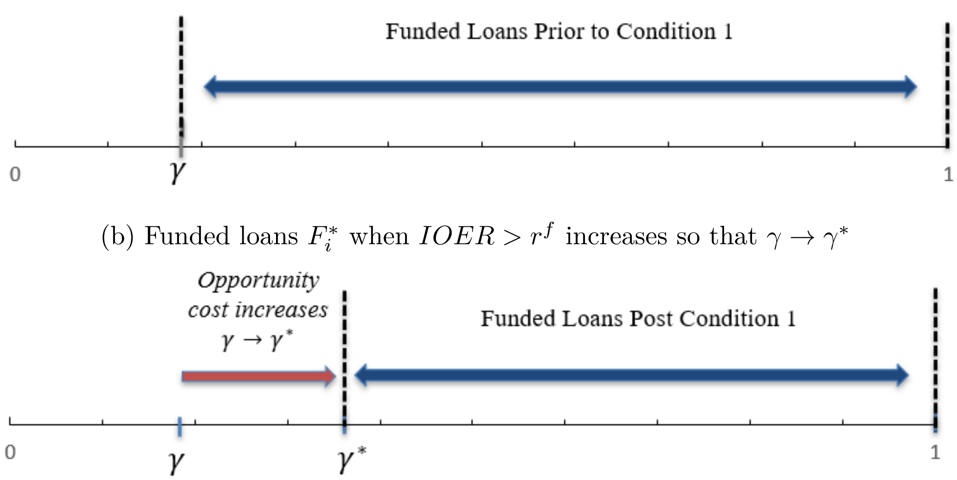


**Figure 6. Empirical Framework**
This outlines the main panel data empirical tests of the first three predictions of this paper's framework and the predicted signs of the variables in question.

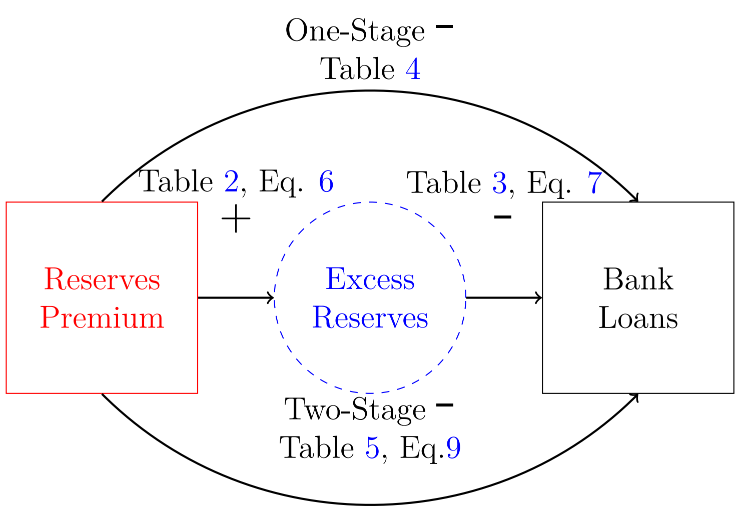


**Figure 7. Banks Hold 4% of Treasuries 2008-2017: Banks Driving Treasury Prices Unlikely**
Category of holders of US Treasuries, including all public debt securities except for savings bonds and local government municipal series. Individuals are households and nonprofit organizations while Mutual Funds are mutual funds, money market funds, and closed-end funds. Holdings are averaged over the 2008-2017 period using year end annual data from the Federal Reserve.

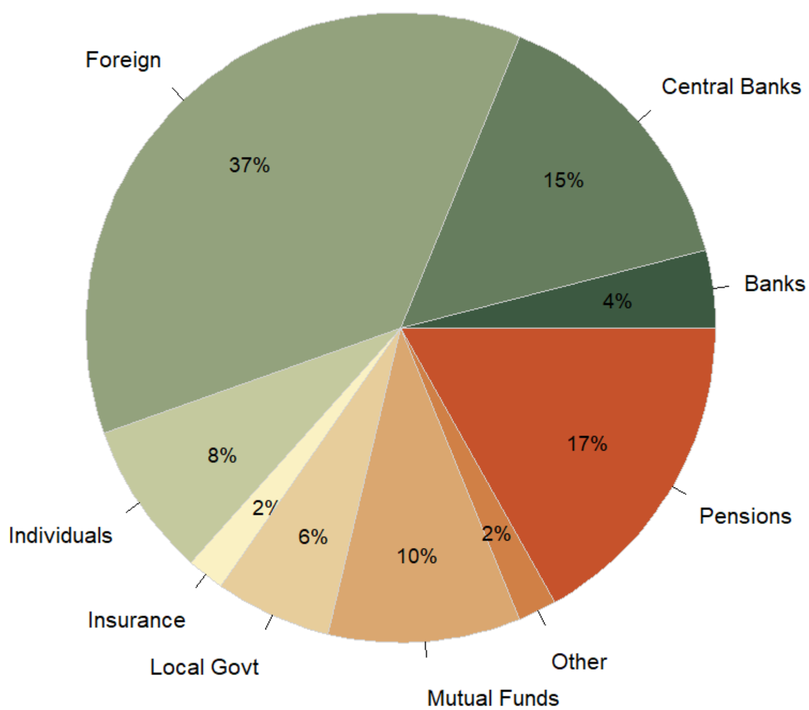
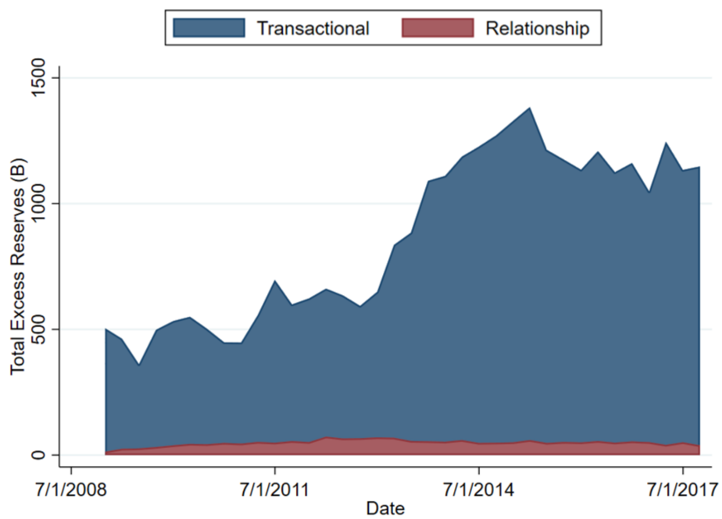


**Figure 8. Excess Reserves by Lending Technology and Size of Holdings**
Call Report data is aggregated at the quarter level. In (a), banks are classified by using the FDIC Community Banking identifier. In (b), excess reserves are aggregated by bank size of holdings. For instance, the dark blue bar indicates aggregated holdings of banks with balances over $1 billion.

(a) Excess Reserves by Lending Technology




(b) Excess Reserves by Size of Holdings

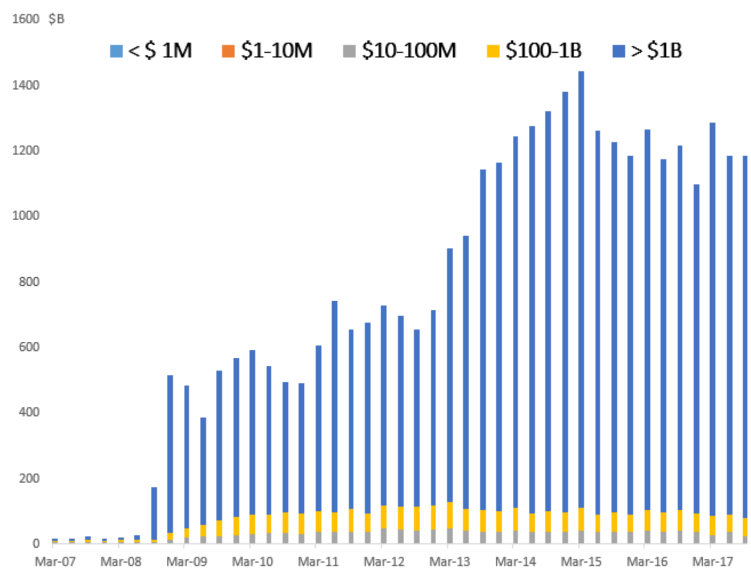


**Table 1. Panel Data Summary Statistics**
Summary statistics are quarterly Call Report data. Relationship (Transactional) banks are identified using Community Banking (Non-Community Banking) identifiers from the Federal Deposit Insurance Corporation. MBS holdings are from the Federal Reserve and total outstanding MBS is from SIFMA. Net interest margins are from the Federal Reserve and lending premiums are spreads between lending rates and the 10Y Treasury rate. Data ranges from 2008Q4 - 2017Q3.

**Summary Statistics of Panel Data Variables 2008Q4-2017Q3**

| **Transactional Banks** | **N** | **Mean** | **Std** | **Min** | **P25** | **P50** | **P75** | **Max** |
|---|---|---|---|---|---|---|---|---|
| Loans/Assets | 20,193 | 0.59 | 0.24 | 0.00 | 0.50 | 0.66 | 0.76 | 1.06 |
| Reserves($M) | 20,194 | 1,500 | 13,000 | 0.00 | 0.00 | 23.29 | 180.00 | 450,000 |
| Excess Reserves/Assets | 20,193 | 0.05 | 0.09 | 0.00 | 0.00 | 0.01 | 0.05 | 1.00 |
| Total Loans ($M) | 20,194 | 12,000 | 62,000 | 0.00 | 200 | 900 | 4,000 | 950,000 |
| Loans for Sale ($M) | 20,194 | 210 | 1,600 | 0.00 | 0.00 | 0.31 | 10.58 | 42,000 |
| Investment Loan ($M) | 20,194 | 11,000 | 60,000 | 0.00 | 190 | 860 | 3,900 | 920,000 |
| C&I Loans ($M) | 20,194 | 2,100 | 11,000 | 0.00 | 11.38 | 100 | 500 | 210,000 |
| Total Assets ($M) | 20,194 | 22,000 | 130,000 | 0.00 | 400 | 1,500 | 6,100 | 2,200,000 |

| **Relationship Banks** | **N** | **Mean** | **Std** | **Min** | **P25** | **P50** | **P75** | **Max** |
|---|---|---|---|---|---|---|---|---|
| Loans/Assets | 221,510 | 0.63 | 0.16 | 0.00 | 0.53 | 0.65 | 0.75 | 1.04 |
| Reserves($M) | 221,510 | 8.25 | 44 | 0.00 | 0.00 | 0.00 | 0.11 | 7,000 |
| Excess Reserves/Assets | 221,510 | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.99 |
| Total Loans ($M) | 221,510 | 210.00 | 480 | 0.00 | 44.21 | 96.31 | 210.00 | 32,000 |
| Loans for Sale ($M) | 221,510 | 2.60 | 58 | 0.00 | 0.00 | 0.00 | 0.10 | 18,000 |
| Investment Loan ($M) | 221,510 | 200.00 | 460 | 0.00 | 43.25 | 94.02 | 210.00 | 31,000 |
| C&I Loans ($M) | 221,510 | 28.38 | 98 | 0.00 | 3.65 | 9.84 | 25.04 | 5,800 |
| Total Assets ($M) | 221,510 | 320.00 | 690 | 0.11 | 77.70 | 150.00 | 320.00 | 41,000 |

| **Macro Variables** | **N** | **Mean** | **Std** | **Min** | **P25** | **P50** | **P75** | **Max** |
|---|---|---|---|---|---|---|---|---|
| Reserves Premium | 36 | 0.18 | 0.06 | 0.04 | 0.15 | 0.20 | 0.23 | 0.34 |
| Risk Adj. Loan Premium | 36 | 0.49 | 0.24 | 0.16 | 0.30 | 0.41 | 0.70 | 0.93 |
| IOER | 36 | 0.35 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 1.25 |
| QE | 36 | 0.17 | 0.06 | 0.00 | 0.12 | 0.16 | 0.23 | 0.24 |
| 3M T-Bills | 36 | 0.17 | 0.24 | 0.00 | 0.04 | 0.09 | 0.18 | 1.06 |
| 10Y Treasury | 36 | 2.49 | 0.64 | 1.49 | 1.94 | 2.40 | 2.97 | 3.85 |
| Net Interest Margin | 36 | 3.29 | 0.25 | 2.95 | 3.09 | 3.20 | 3.47 | 3.83 |
| Loan Delinquency Rate | 36 | 4.38 | 1.84 | 1.83 | 2.49 | 4.65 | 5.96 | 7.40 |

**Table 2. Panel Data: Reserves Premium on Bank Excess Reserves**
This table estimates Equation 6 and measures whether the reserves premium is significantly associated with bank-level excess reserves. Columns (1)-(4) use the 3M Treasury rate in the reserves premium while Column (5) uses the effective fed funds rate for the reserves arbitrage (IOER-EFFR). Bank level controls include deposits, log of assets, ROE, and NIM. Macro controls include QE, risk-adjusted loan spreads, and the VIX. Transactional equals 1 for transactional banks and 0 for relationship banks according to the FDIC Community Banking Study. Panel data is from the 2008Q4-2017Q3 Call Reports. Fixed effects are at the bank level. Standard errors are two-way clustered at the bank and quarter level. *, ** and *** denote significance at a 0.10, a 0.05 and a 0.01 levels, respectively. T-statistics are in parenthesis.

| | **Panel Data:** Excess Reserves$_{i,t}$ | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Reserves Premium$_t$ | 0.031*** | 0.028*** | 0.025*** | 0.027*** | |
| | (3.9) | (3.16) | (3.26) | (3.17) | |
| Reserves Arbitrage$_t$ | | | | | 0.012 |
| | | | | | (1.10) |
| Reserves Premium$_t$ × Transactional$_{i,t}$ | | | | 0.012 | |
| | | | | (0.47) | |
| Deposits$_{i,t}$ | | 0.061*** | 0.047*** | 0.061*** | 0.063*** |
| | | (4.67) | (6.56) | (4.68) | (4.87) |
| Quantitative Easing$_t$ | | 0.016* | 0.012 | 0.016* | 0.022** |
| | | (1.76) | (1.56) | (1.76) | (2.26) |
| Small Banks Only | | | ✓ | | |
| Observations | 236,308 | 236,264 | 216,129 | 236,264 | 236,264 |
| Bank Level Controls | | ✓ | ✓ | ✓ | ✓ |
| Macro Controls | | ✓ | ✓ | ✓ | ✓ |
| Bank FE | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bank Clusters | ✓ | ✓ | ✓ | ✓ | ✓ |
| Time Clusters | ✓ | ✓ | ✓ | ✓ | ✓ |
| Adjusted $R^2$ | 0.64 | 0.64 | 0.62 | 0.64 | 0.64 |
| Within $R^2$ | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 |

**Table 3. Panel Data: Excess Reserves and Bank Lending**

This table estimates Equation 7 and measures whether bank-level excess reserves are significantly associated with bank-level lending. Bank level controls include deposits, log of assets, ROE, and NIM. Macro controls include QE, risk-adjusted lending premiums, and the VIX. Transactional equals 1 for transactional banks and 0 for relationship banks according to the FDIC Community Banking Study. Panel data is from the 2008Q4-2017Q3 Call Reports. Fixed effects are at the bank level. Standard errors are two-way clustered at the bank and quarter level. *, ** and *** denote significance at a 0.10, a 0.05 and a 0.01 levels, respectively. T-statistics are in parenthesis.

| | **Panel Data:** Total Loans$_{i,t}$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Excess Reserves$_{i,t}$ | -0.526*** | | -0.505*** | -0.426*** | | -0.424*** | -0.424*** | -0.427*** |
| | (-12.86) | | (-13.13) | (-11.5) | | (-11.6) | (-14.51) | (-14.95) |
| Excess Reserves$_{i,t}$ | | | | | | | | 0.007 |
| × Transactional$_{i,t}$ | | | | | | | | (0.09) |
| Deposits$_{i,t}$ | | -0.19*** | -0.154*** | | -0.049 | -0.026 | -0.049 | -0.026 |
| | | (-6.63) | (-5.9) | | (-1.68) | (-0.92) | (-1.33) | (-0.93) |
| Small Banks Only | | | | | | | ✓ | |
| Observations | 236,264 | 236,264 | 236,264 | 236,264 | 236,264 | 236,264 | 216,129 | 236,264 |
| Bank Level Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bank FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Time FE | | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bank Clusters | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Time Clusters | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Within $R^2$ | 0.06 | 0.03 | 0.07 | 0.06 | 0.03 | 0.06 | 0.05 | 0.06 |

**Table 4. Panel Data: Reserves Premium, Reserves Arbitrage, and the Ted Spread on Bank Lending**

This table estimates Equation 8 and examines the associations between bank-level lending and three variables - the reserves premium, reserves arbitrage, and the TED Spread. Columns (1), (4), (7), and (8) examines the reserves premium (IOER-3MT), Column (2) and (5) uses the reserves arbitrage (IOER-EFFR), and Column (3) and (6) uses the TED Spread (LIBOR-3MT). Bank-level controls include deposits, log of assets, ROE, and NIM. Macro controls include QE, risk-adjusted lending premiums, and the VIX. Transactional equals 1 for transactional banks and 0 for relationship banks according to the FDIC Community Banking Study. Panel data is from the 2008Q4-2017Q3 Call Reports. Fixed effects are at the bank level. Standard errors are two-way clustered at the bank and quarter level. *, ** and *** denote significance at a 0.10, a 0.05 and a 0.01 levels, respectively. T-statistics are in parenthesis.

| | **Panel Data:** Total Loans$_{i,t}$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Reserves Premium$_t$ | -0.096** | | | -0.203*** | | | -0.206*** | -0.207*** |
| | (-2.09) | | | (-3.23) | | | (-3.22) | (-3.27) |
| Reserves Arbitrage$_t$ | | -0.097 | | | -0.136** | | | |
| | | (-1.25) | | | (-2.15) | | | |
| TED Spread$_t$ | | | 0.041*** | | | -0.014 | | |
| | | | (5.11) | | | (-0.35) | | |
| Reserves Premium$_t$ | | | | | | | | 0.042 |
| $\times$ Transactional$_{i,t}$ | | | | | | | | (1.3) |
| Excess Reserves$_{i,t}$ | | | | -0.461*** | -0.474*** | -0.478*** | -0.478*** | -0.461*** |
| | | | | (-12.16) | (-12.72) | (-12.54) | (-15.16) | (-12.14) |
| Quantitative Easing$_t$ | | | | -0.018 | -0.049 | -0.127 | -0.013 | -0.018 |
| | | | | (-0.33) | (-0.81) | (-0.87) | (-0.23) | (-0.32) |
| Small Banks Only | | | | | | | ✓ | |
| Observations | 236,308 | 236,308 | 236,308 | 236,264 | 236,264 | 236,264 | 216,129 | 236,264 |
| Bank Level Controls | | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Macro Controls | | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bank FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bank Clusters | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Time Clusters | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Adjusted $R^2$ | 0.86 | 0.87 | 0.86 | 0.87 | 0.87 | 0.87 | 0.86 | 0.87 |
| Within $R^2$ | 0.01 | 0.12 | 0.02 | 0.12 | 0.11 | 0.10 | 0.11 | 0.12 |

**Table 5. Two Stage Panel Estimation**

This table estimates the two-stage ordinary least squares regression in Equation 9. Bank level controls include deposits, log of assets, ROE, and NIM. Macro controls include QE, risk-adjusted lending premiums, and the VIX. $\widehat{\textit{Excess Reserves}}$ is a predicted value from the first stage. Panel data is from the 2008Q4-2017Q3 Call Reports. Fixed effects are at the bank level. Standard errors are two-way clustered at the bank and quarter level. *, ** and *** denote significance at a 0.10, a 0.05 and a 0.01 levels, respectively. T-statistics are in parenthesis.

| | **Panel Data:** Excess Reserves$_{i,t}$ | | | |
|---|---|---|---|---|
| **1st Stage** | (1) | (2) | (3) | (4) |
| Reserve Premiums$_t$ | 0.031*** | 0.028*** | 0.025*** | 0.064*** |
| | (3.96) | (3.2) | (3.3) | (6.68) |
| | **Panel Data:** Total Loans$_{i,t}$ | | | |
| **2nd Stage** | (1) | (2) | (3) | (4) |
| $\widehat{\text{Excess Reserves}}_{i,t}$ | -3.096*** | -7.725*** | -8.677*** | -2.882*** |
| | (-3.24) | (-6.04) | (-5.65) | (-7.07) |
| Deposits$_{i,t}$ | | 0.363** | 0.257** | 0.246*** |
| | | (2.66) | (2.44) | (4.11) |
| Quantitative Easing | | 0.095** | 0.085** | 0.043 |
| | | (2.28) | (2.41) | (1.11) |
| Bank Type | All | All | Small | Large |
| Observations | 236,308 | 236,264 | 216,129 | 20,135 |
| Bank Level Controls | | ✓ | ✓ | ✓ |
| Macro Controls | | ✓ | ✓ | |
| Bank FE | ✓ | ✓ | ✓ | ✓ |
| Bank Clusters | ✓ | ✓ | ✓ | ✓ |
| Time Clusters | ✓ | ✓ | ✓ | ✓ |
| Kleinbergen-Paap (p-value) | 0.01 | 0.01 | 0.01 | 0.00 |
| First Stage Wald F Statistic | 15.2 | 10.0 | 10.6 | 44.7 |

**Table 6. Reverse Causality: Bank Demand & Treasury Issuances**

If bank purchases (Treasury issuances) drive Treasury prices up (down), a negative (positive) relationship between Treasury holdings (federal debt) and Treasury yields is expected. This table uses Eq. 10 to test the relationship between bank-level holdings of Treasuries (1, 2, 4) and the 3M Treasury rate in (1) and (4) and the 10Y Treasury yield in (2). (3) examines the impact of the log of Federal debt. (1)-(3) uses all Bank Holding Company observations as constructed in Drechsler et al. (2018) while (4) uses all bank observations from the Call Reports. (5) examines the relationship between 3M Treasury rates and Federal debt. Dependent variables in (1)-(4) are scaled by total assets. Fixed effects are at the bank level while standard errors are clustered at the bank level and quarterly level independently. T-statistics are in parenthesis.

| | BHC Treasury Holdings 1976-2017 | BHC Treasury Holdings 1976-2017 | BHC Treasury Holdings 1976-2017 | All Treasury Holdings 2008-2017 | 3-Month Treasury Yields 1976-2017 |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Risk Free Rate$_t$ | 0.003*** | 0.005*** | | 0.003*** | |
| | (4.42) | (7.43) | | (3.88) | |
| Log(Federal Debt)$_t$ | | | -0.019*** | | -2.936*** |
| | | | (-8.38) | | (-13.87) |
| Data Type | Panel | Panel | Panel | Panel | Time Series |
| Risk Free Rate | 3MT | 10Y | NA | 3MT | 3MT |
| Observations | 1,818,651 | 1,818,651 | 1,818,651 | 236,076 | 167 |
| Bank FE | ✓ | ✓ | ✓ | ✓ | |
| Bank Cluster | ✓ | ✓ | ✓ | ✓ | ✓ |
| Time Cluster | ✓ | ✓ | ✓ | ✓ | |
| Adjusted $R^2$ | 0.58 | 0.59 | 0.59 | 0.76 | 0.69 |
| Within $R^2$ | 0.01 | 0.02 | 0.02 | 0.00 | NA |

**Table 7. The "Risk-Channel Transformation" Hypothesis**

If lower policy rates incentivize increased bank lending, a negative relationship between lending and Treasury rates is expected. The introduction of IOER should reverse this relationship as lower Treasury yields increase the reserves premium, which disincentivze bank lending. This table estimates Eq. 11 to test for the risk-taking channel and for omitted variable bias $\nu$. This panel data regression uses bank fixed effects and clusters standard errors at the bank and quarter level independently. The 1976-2017 sample period uses bank holding companies constructed using the same methodology found in Drechsler et al. (2018). Interest on Excess Reserves (IOER) Dummy takes a value of 1 from 2008Q4-2017Q3 and 0 otherwise. T-statistics are in parenthesis.

| | **Panel Data:** Loans$_{i,t}$ | | | |
|---|---|---|---|---|
| | 1976-2017 | 1976-2017 | 1976-2008 | 2008-2017 |
| | (1) | (2) | (3) | (4) |
| 3M Treasury Rate$_t \times$ IOER Dummy$_t$ | | 0.17*** (3.89) | | |
| 3M Treasury Rate$_t$ | -0.005*** (-6.21) | -0.005*** (-5.53) | -0.004*** (-4.97) | 0.0304*** (5.18) |
| Observations | 1,675,056 | 1,675,056 | 1,593,706 | 81,231 |
| Bank FE | ✓ | ✓ | ✓ | ✓ |
| Bank Cluster | ✓ | ✓ | ✓ | ✓ |
| Time Cluster | ✓ | ✓ | ✓ | ✓ |
| Adjusted $R^2$ | 0.59 | 0.56 | 0.56 | 0.91 |
| Within $R^2$ | 0.02 | 0.02 | 0.01 | 0.01 |

**Table 8. Robustness Check: Quarter End "Window Dressing"**
This table uses the Federal Reserve's aggregated weekly H8 data from October 2008 to September 2017. Reserves/Assets is line item 29 divided by line item 33 and Loans/Assets is line item 9 divided by line item 33. "Large" consists of aggregated data from the top 25 domestically chartered commercial banks ranked by domestic assets as of the previous Call Reports. "Small" includes all domestically chartered commercial banks not in the top 25. Bank controls include deposits scaled by assets and log of assets. Macro controls include quantitative easing, risk-adjusted lending premiums, and the VIX. Standard errors are Huber-White. *, ** and *** denote significance at a 0.10, a 0.05 and a 0.01 levels, respectively. T-statistics are in parenthesis.

| | Table 2 Check Reserves/Assets | | Table 3 Check Loans/Assets | | Table 4 Check Loans/Assets | |
|---|---|---|---|---|---|---|
| | Large | Small | Large | Small | Large | Small |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Reserves Premium$_t$ | 0.013*** | 0.011*** | | | -0.011*** | -0.012*** |
| | (4.47) | (4.66) | | | (-4.61) | (-3.02) |
| Reserves$_{i,t}$ | | | -0.653*** | -1.536*** | | |
| | | | (-26.28) | (-26.19) | | |
| Deposits$_{i,t}$ | -0.246*** | 0.133*** | -0.076*** | -0.2*** | 0.079** | -0.408*** |
| | (-5.99) | (13.77) | (-3.53) | (-13.28) | (2.28) | (-25.51) |
| QE$_t$ | 0.292*** | 0.112*** | 0.035*** | 0.083*** | -0.155*** | -0.088*** |
| | (21.31) | (12.37) | (3.05) | (6.74) | (-12.57) | (-6.76) |
| $R^2$ | 0.90 | 0.80 | 0.93 | 0.93 | 0.81 | 0.80 |
| Observations | 470 | 470 | 470 | 470 | 470 | 470 |
| Bank Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Macro Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Robust Standard Errors | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

**Table 9. Weekly Aggregated Data vs. Quarterly Panel Data**
This table compares weekly aggregated banking data with quarterly panel data. Weekly aggregated data is from weekly H8 data released by the Federal Reserve while quarterly panel data is from Call Reports.

| | Mean | | Standard Deviation | |
|---|---|---|---|---|
| | Weekly Aggregated | Quarterly Panel | Weekly Aggregated | Quarterly Panel |
| Loan/Assets | | | | |
| Big Banks | 0.554 | 0.59 | 0.015 | 0.24 |
| Small Banks | 0.656 | 0.63 | 0.018 | 0.16 |
| | | | | |
| Macro Variables | | | | |
| Reserves Premium | 0.184 | 0.18 | 0.112 | 0.06 |
| QE | 0.169 | 0.17 | 0.065 | 0.06 |

**Table 10. Bank Substitution of Risk-Free and Risky Assets**

This table estimates Eq. 12. All variables are scaled by total assets in the same period. Specification (1) and (2) covers all bank level data in Call Reports while (3) and (4) only use bank observations where excess reserve holdings exceed \$1B. Panel data covers the period from 2008Q4-2017Q3. T-statistics are in parenthesis.

| | **Panel Data:** | | Excess Reserves$_{i,t}$ | |
|---|---|---|---|---|
| | Non-BLER | | BLER > \$1B | |
| | (1) | (2) | (3) | (4) |
| Treasuries$_{i,t}$ | -0.016 | | -0.349 | |
| | (-1.04) | | (-1.24) | |
| Non-Treasury Securities$_{i,t}$ | | -0.04*** | | -0.294*** |
| | | (-8.72) | | (-3.56) |
| Observations | 234,127 | 234,127 | 1,924 | 1,924 |
| Bank FE | ✓ | ✓ | ✓ | ✓ |
| Time FE | ✓ | ✓ | ✓ | ✓ |
| Bank Clusters | ✓ | ✓ | ✓ | ✓ |
| Time Clusters | ✓ | ✓ | ✓ | ✓ |
| Adjusted $R^2$ | 0.64 | 0.64 | 0.80 | 0.80 |

# Extended Proof of Baseline Model

Available upon request.

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