Safe Asset Migration

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Abstract

Post-crisis reforms changed the location of safe asset production. I propose a pair of tests to identify who issues safe assets and which safe asset issuers opportunistically time issuance when the price of safe assets is high. Federal agency issuance both (1) responds to day-to-day fluctuations in demand for safe assets—measured via the convenience yield—and (2) is an important determinant in the subsequent price of safe assets. Agencies issue more the day after an unexpected increase in the convenience yield, and an unexpectedly large agency issue decreases the convenience yield the next day. The Federal Home Loan Bank system is a newly crucial safe asset producer. The FHLBs' ability to produce safe assets depends on their implicit government backing, a potential source of concern for future policymakers.

1 Introduction

The greatest comparative advantage of the U.S. financial system is its ability to produce—and export—money in the form of "safe assets." Money provides a store of value and a transaction medium: essential ingredients of a well-functioning financial system. What qualifies as money is a question of what is safe, but which assets are safe change over time. This paper measures how issuers' safe asset production abilities change over time by examining the link between candidate safe asset issuance and the price of safe assets as measured by the convenience yield.

I classify safe asset issuers along two dimensions: first, what happens to the price of safe assets after a candidate safe asset issuer produces more debt? The subsequent price of safe assets should fall after a safe asset issuer manufacturers more safe assets. Second, does the safe asset issuer opportunistically time their issuance when the price of safe assets is high? I find that the Federal Home Loan Bank (FHLB) system is a newly crucial component in safe asset production: the price of safe assets falls after FHLBs' issuance, and the FHLBs opportunistically time their issuance when the price of safe assets is high. Post-crisis, no other potential safe asset issuer displays both characteristics.

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We need to know what is safe and how it changes because it is painful when safe assets become unsafe. The recent financial crisis is a prime example. When investors started questioning the collateral underlying their safe assets—repurchase agreements (repo) collateralized by asset-backed securities, for example—the safe asset production machine broke down; markets and institutions which depended on safe assets shortly followed. Just as economists diligently measure the size of the economy and construct the national accounts, they should also measure the production of safe assets.

The most obvious safe assets are U.S. Treasurys and debt from similarly-positioned sovereigns. Bernanke et al. (2011) and Pozsar (2011) show global appetite for safe assets grew in lockstep with cash pools like pensions, endowments, corporations, and sovereign wealth funds. Safe asset demand also increased because safe assets are valuable collateral, particularly for repo, a widely-used form of collateralized financing. Sometimes there are not enough safe assets, and sometimes safe assets become unsafe: Greek sovereign debt and asset-backed commercial paper both lost their safe asset status in the past decade.

When there are not enough safe assets, cash pools push into the next-best option: agency debt from Fannie Mae, Freddie Mac, and the FHLB system. Unlike the U.S. Treasury, the agencies have profit motives and an implicit guarantee from the U.S. taxpayer. In 2008, the implicit guarantee for Fannie and Freddie became explicit after the government placed them into conservatorship.

This paper adds to the safe asset literature in three ways: first, I propose a pair of tests to identify who issues safe assets and which safe asset issuers opportunistically time issuance when the price of safe assets is high. Second, I propose a new proxy for the price of safe assets using the magnitude of Treasury auction tails. I combine the auction tails measure with existing measures of the convenience yield—the OIS-Tbill and GCF-Tbill—to proxy the price of safe assets. I perform the empirical tests using these measures of the convenience yield.

Third, I document the changing role that agency issuers occupy in the production of safe assets. My discussion focuses on the effect of the changes in the regulatory landscape—the conservatorship of the GSEs in 2008, Basel III, and the 2014 money-market mutual fund reforms—and how the changes created a boom in FHLB short-term debt and the relative decline of Fannie Mae and Freddie Mac as short-maturity issuers.

I find the convenience yield responds to agency issuance on a day-to-day basis. Pre-crisis, Freddie Mac and Fannie Mae debt issuance in the day before pushes down the subsequent day's seasonally-adjusted convenience yield. Post-crisis, Freddie Mac and FHLB short-maturity issuance in the day before drives down the seasonally-adjusted convenience yield; Fannie issuance no longer displays this effect. Explicitly, a one standard deviation increase in FHLB issuance of $4.8 billion reduces the following day's convenience yield between 0.71 and 1.70 basis points. The top half of Table 1 summarizes this result.

I also find that the FHLBs—and many other private safe asset issuers—issue debt opportunistically to time fluctuations in the convenience yield and thereby earn the convenience

Result 1: Effect of σ increase in Issuance_{t-1} on ConYield_t^{SA}		
(basis points)	OIS-Tbill Measure	GCF-Tbill Measure
$\text{FHLB}^{\text{Disco}}$	-0.71^{**}	-1.70^{***}
$\text{Freddie}^{\text{Disco}}$	-0.66	-9.02^{**}
$\text{Freddie}^{\text{Overnight}}$	-0.05^{***}	-0.03

Result 2: Effect of σ increase in $\text{ConYield}_{t-1}^{SA}$ on Issuance_t		
($ millions)	OIS-Tbill Measure	GCF-Tbill Measure
$\text{FHLB}^{\text{Disco}}$	548.9^{***}	322.6^{**}
$\text{FHLB}^{\text{Overnight}}$	196.4^{***}	113.3^{***}
$\text{FHLB}^{>1yr}$	55.3^{***}	38.0^{***}
Non-financial CP	44.7^{*}	76.0^{***}
Asset-backed CP	31.1	94.1^{**}
$\text{Freddie}^{\text{Disco}}$	1.2	17.6^{**}

Table 1: **Summary of Results**. Result 1 shows the effect of a one standard deviation increase in the detrended issuance of the listed issuers on the subsequent day's seasonally adjusted convenience yield in the post-reform period from July 2014 to year-end 2018. Calculated from results in Table 21. Result 2 shows the effect of a one standard deviation increase in the seasonally adjusted convenience yield on issuance of the issuers on the subsequent day; calculated from the results in Table 30. Disco is discount notes, which have maturities greater than overnight. CP is commercial paper. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

yield. A one standard deviation increase in the seasonally adjusted convenience yield of 9.4 basis points leads to an increase in FHLB issuance of $113 million with overnight maturity, $322 million with 4-week to 26-week maturity, and $38 million with longer than one-year maturity. Freddie and commercial paper issuers also opportunistically time issuance, but the effect is not significant across both measures of the convenience yield. The FHLBs, Freddie and certain commercial paper issuers issue more debt across all maturity buckets when the price of safe assets is unseasonally high. The bottom half of Table 1 summarizes this result.

This paper builds on two threads of the incipient safe asset literature: the first strand studies how the supply of safe assets changes over time. Gorton et al. (2012) document the changing composition of safe assets since the 1970s, shifting from traditional safe assets (bank deposits) to private safe assets (asset-backed securities and repurchase agreements).

The paper also builds on a series of papers which study the incentives for private safe asset producers to satisfy growing safe asset demand. Krishnamurthy and Vissing-Jorgensen (2012) show a scarcity of safe assets relative to GDP—measured by U.S. Treasurys outstanding—push the spread between USTs and highly-rated corporate bonds higher as investors place a more significant premium on the safety and liquidity uniquely provided by USTs. Gorton (2010), Stein (2012), Sunderam (2015) and Xie (2012) discuss the incentives of private safe asset producers to create short-term money-like liabilities when the demand for money is high, which they empirically confirm in asset-backed commercial paper and asset-backed securities markets. Stein (2012) and Carlson et al. (2016) examine the monetary policy and financial stability implications of safe asset supply and demand.

The paper is organized as follows. Section 2 reviews the literature. Section 3 discusses the institutional context of the FHLBs, other agency debt issuers, and the post-crisis reforms. Section 4 discusses the changing sources of safe assets. Section 5 discusses the data. Section 6 discusses the convenience yield and issuance measures. Section 7 discusses the empirical strategy and results. Section 8 concludes.

2 Literature Review

A safe asset as an asset that is information-insensitive, thereby facilitating the security's use as a store of value and a medium for transactions. Safe assets require government guarantees (e.g., Treasurys or agency debt) or collateral (e.g., mortgage-backed securities). Gorton and Pennacchi (1990) explain that banks exist to create safe debt to be used as an information-insensitive medium of exchange. Dang et al. (2015) show that information-insensitive assets are the most efficient transaction media because they give people the lowest incentive to acquire private information. Therefore, uninformed people can comfortably trade information-insensitive assets without concern for adverse selection, that the counterparty has produced private information on the asset. Dang et al. (2017) show banks are optimally opaque to keep their debt trading at par, and thereby keep their debt useful for conducting transactions.

Pozsar (2011) and Bernanke et al. (2011) empirically document the increased demand for safe assets. As the demand for safe assets increased over time, the private sector stepped into the gap to produce *private* safe assets to help meet the growing demand. Private safe assets include repo, asset-backed commercial paper, and some forms of securitized debt. Gorton et al. (2012) find a constant safe asset share relative to the size of the economy over time, although the composition of safe assets has shifted largely toward privately produced safe assets, reflecting the gradual transition from traditional banking to shadow banking.

Safe assets are securities which earn the "convenience yield." As the supply and demand for safe assets fluctuate, the relative price of safe assets varies as well. The price of safe assets is related to the convenience yield, which is the non-pecuniary return to products that are useful in providing liquidity or safety. Issuers of safe assets can earn the convenience yield: Gourinchas and Rey (2005) show that the annualized difference between the return on assets and the return paid on liabilities for the U.S. in aggregate—an exporter of safe assets—exceeds two percent. The U.S. engages in a massive carry trade; The U.S. finances higher-yielding assets by issuing safe debt, and since the debt is information-insensitive it earns the convenience yield. Nadauld and Weisbach (2012) show a similar phenomenon at the corporate issuer level: loans that can be securitized cost 17 basis points less to the borrower because highly-rated securitizations are private safe assets and earn the convenience yield. Xie (2012) shows that private securitizations are sold into the market when the convenience yield is high, on a day-to-day basis.

Safe assets play an important role in financial crises and bank runs, as described in Gorton (2016). Historical safe assets include free bank notes backed by state bonds, chartered bank notes backed by loan portfolios, national bank notes backed by Treasurys, and national bank demand deposits backed by bank assets and the creditworthiness of a specific person. Modern private safe assets include commercial paper, asset-backed commercial paper repos, and money-market funds. Modern safe assets also include agency debt, the focus of this paper. All forms of money and short-term debt are socially useful creations: everyday life depends on the routine use of "almost-riskless" claims. Bank money and short-term claims are vulnerable to runs precisely because these claims are so useful and because many of these claims are *almost* riskless. As the supply of genuinely safe assets (Treasurys) diminishes relative to the size of the economy, financial vulnerabilities can build when private safe assets are riskier than expected.

Several papers measure the empirical shortage of safe debt by examining trends in the price of safe assets as measured via the convenience yield. Krishnamurthy and Vissing-Jorgensen (2012) show a scarcity of USTs relative to GDP pushes spreads between USTs and highly-rated corporate bonds higher as investors place a more significant premium on the safety and liquidity uniquely provided by USTs. Gorton and Muir (2015) show that repo fails are highest when the convenience yield is high. Laarits and Gorton (2018) show the contraction of post-crisis safe asset supply using the GCF-Tbill convenience yield measure.

Researchers have recently focused on the FHLBs. The first paper to discuss the FHLBs in their current context is Ashcraft et al. (2010). They find the FHLBs acted as a lender of "next-to-last-resort" during the financial crisis. They show FHLBs members often preferred to borrow from the FHLBs rather than via the Federal Reserve's discount window. Anadu and Baklanova (2017), Gissler and Narajabad (2017a), Gissler and Narajabad (2017b), and Gissler and Narajabad (2017c) show the effect of the money-market mutual fund reforms on flows to FHLBs and the FHLBs' increased reliance on the short-term financing provided by money-market funds. Gissler and Narajabad (2018) also document the expansion of FHLB short-term debt and show banks use FHLB borrowing as a substitute for deposit funding. Tarullo (2019) mentions the effect of money-market fund reforms on FHLBs, noting it as a concerning point for policymakers. The FHLB literature constitutes a collective hand-ringing: that there should be some consternation about where maturity transformation has moved after the crisis, and that the FHLB channel still ultimately depends on implicit government support. This paper contributes to the literature by estimating the relationships between agency issuance and the price of safe assets to pin down which issuers help determine the price of safe assets, which issuers opportunistically issue in response to a high price of safe assets, and how these two phenomena have changed from pre-crisis to post-crisis.

3 Institutional Context

3.1 Agency Debt

Agency debt stands between USTs and privately produced safe assets on the pecking order of safe assets. Several federal agencies issue debt: the most critical agency issuers include the Federal Home Loan Banks (FHLBs), the Federal National Mortgage Association (FNMA or Fannie Mae), and the Federal Home Loan Mortgage Corporation (FHLMC or

Freddie Mac). Other agencies also issue securities, including the Federal Farm Credit Bank System (FFCB), the Tennessee Valley Authority (TVA) and the Government National Mortgage Association (GNMA). While the government guarantees Treasury debt with full faith and credit, most federal agencies' securities are not guaranteed. GNMA mortgage-backed securities carry an explicit guarantee backed by the full faith and credit of the U.S. government; other agencies' debt only carries the implicit backing of the government. Total agency debt outstanding was approximately $1.9 trillion in Q3 2018.

Fannie, Freddie and the FHLBs issue debt with a maturity less than 12 months, and some issue overnight debt as well. Table 3 shows the outstanding amount of short-term debt from various agency issuers compared to Treasury bills. Pre-crisis, both Freddie and Fannie became relatively large issuers of short-term debt, together peaking at approximately $430 billion compared to a total of $1 trillion of Treasury bills outstanding.[1] Post-crisis, Fannie and Freddie debt outstanding fell to less than $100 billion whereas the FHLB system surged past pre-crisis levels with outstanding of $425 billion in 2018 Q3.

3.2 The Federal Home Loan Bank System

The Federal Home Loan Banks are a set of closely related but independently owned and operated banks with the goal of financing housing-related assets to its members which include banks, credit unions, thrifts, and some insurance companies. Gissler and Narajabad (2017a), Gissler and Narajabad (2017b), and Gissler and Narajabad (2017c) provide a detailed discussion of the FHLB system's history and operations, which I summarize here. There are eleven FHLB banks across the country: there were twelve until recently, but the FHLB Seattle merged with FHLB Des Moines in 2015 after residual losses from the financial crisis. The FHLBs' member institutions own each FHLB, and the member institutions must reside within that FHLB's district. Large bank holding companies with operating subsidiaries spanning multiple FHLB districts, however, may belong to many FHLBs.[2] Owners of the FHLBs—the members—retain ownership in the FHLB in the form of six-month or five-year redeemable equity states. Voting rights are not proportional to equity capital: each shareholder has a single vote.[3]

A system-wide balance sheet is presented in Tables 4 and 5 which show the balance sheet in 2007 and 2018, respectively. At the peak in 2007, the entire system held about $1.3 trillion in assets, and in 2018 held approximately $1.1 trillion. Simple leverage in 2018 was

[1] The dramatic increase in outstanding debt for Fannie, Freddie, the FHLBs and the Treasury in 2008 and 2009 is an artifact of actions during the financial crisis.

[2] For example, Bank of America Rhode Island is a member at FHLB Boston, Bank of America California belongs to FHLB San Francisco, and Bank of America Oregon belongs to the FHLB Des Moines (which, in 2015, acquired FHLB Seattle).

[3] Table A3 shows the number of FHLB members by institution type. The majority are depository institutions, of which commercial banks and credit unions are the largest groups. Insurance companies represented about eight percent of total members in 2018. Figure A3 provides the number of institutions by branch and Figure A2 provides the share of commercial bank assets by district. The FHLBs of New York, Cincinnati, Des Moines, and Atlanta are the largest. The large fluctuations in Figure A2 are due to shifting membership of the largest members. For example, the change in 2011 is Citibank N.A. moving from FHLB San Francisco bank to FHLB New York; the dip in 2012 is JP Morgan Chase Bank N.A. moving from the FHLB New York to FHLB Cincinnati.

19, with a simple capital ratio (with no risk-weighting) of 5.3 percent.

This paper focuses on the liability side of the FHLBs. Investors consider FHLB debt safe for three reasons: (1) the FHLBs overcollateralize loans to members, (2) the "statutory super-senior lien" places FHLBs above all other creditors including the FDIC and Federal Reserve Banks, and (3) FHLB debt carries an implicit government guarantee.[4]

FHLB debt carries an implicit government guarantee in part due to the FHLBs' unique legislatively-granted properties. FHLBs are exempt from federal, local and state taxes.[5] The Federal Reserve acts as the fiscal agent for the FHLBs. The FHLBs are considered a "federal instrumentality" and therefore are exempt from the bankruptcy code. The Treasury is allowed to purchase up to $4 billion of FHLB securities. Moreover, regulators allow government money-market funds to purchase FHLB debt.

The FHLB Office of Finance's credit rating webpage includes a discussion of "Strong U.S. Government Support," noting that FHLB debt issuance is subject to U.S. Treasury approval, that FHLB debt is eligible for collateral for public deposits and investment by national banks and thrifts. Moody's rating of FHLB debt states "any rating actions on the U.S. Government would likely result in all individual FHLBanks' long-term deposit ratings and the FHLBank System's long-term bond rating moving in step with any U.S. sovereign rating action." S&P's rating notes the FHLBs are a "government-related entity with an almost certain likelihood of extraordinary government support." Combined, these unique characteristics of the FHLB system reinforce its implicit government guarantee.

FHLB liabilities—the focus of this paper—are debt issued by the FHLB system at a variety of maturities, from overnight to many years. Debt with a maturity less than one year are discount notes ("discos"), whereas debt with a maturity greater than one year are bonds. FHLBs issue debt via a consolidated obligation (CO) joint with all other FHLBs: if a single FHLB cannot pay its CO debt, then the lender has recourse to other FHLB branches. All CO debt is issued centrally by the FHLB Office of Finance and lenders do not know to which FHLB bank they are specifically lending. For this reason, all FHLBs pay the same rate on their CO debt. In 2018, roughly forty percent, $400 billion, of the aggregate FHLB system's liabilities were discount notes with maturities less than one year, whereas sixty percent, about $600 billion, were consolidated obligation bonds.

Figure 1 shows the progression of outstanding FHLB debt. Maturities less than six months, but excluding overnight, grew from approximately $50 billion the early 2000s, dramatically spiking to $250 billion as the FHLB system ramped up its efforts to act as lender of "next-to-last" resort, then collapsed in 2008/2009 due to Fannie and Freddie related GSE fatigue. FHLB debt surged post-crisis, moving to a peak of almost $300 billion, although falling from that high through 2018. Figure 2 shows the issuance data for similar-maturity FHLB discount notes. The growth in FHLB overnight debt from 2015 in light of the money-market fund reforms motivates the analysis of this paper.

[4] Although the super-lien applies to the collateral pledged to the Federal Reserve Banks by FHLB members, the Federal Reserve and FHLBs traditionally agree to preserve the Federal Reserve Banks' seniority position. Gissler and Narajabad (2017a).

[5] Despite the special tax treatment, the Financial Institutions Reform, Recovery and Enforcement Act of 1989 imposed system-wide assessments of approximately twenty-five percent.

There are two types of FHLB assets: advances and investments. The first type is loans to its member institutions via advances, representing seventy percent of FHLB assets. The FHLBs offer these loans at various rates and structures, and each bank sets the rates and haircuts of its advances. The advances are subject to the statutory super-lien. The second type of FHLB assets is investments, which represent twenty-five percent of assets. Investments focus primarily on housing-related assets (agency and private-label mortgage-backed securities) but include other categories including repurchase agreements (repo), Federal Funds sold, and commercial paper.[6]

The FHLBs perform regular bank services, although their customers are different from a traditional bank. They borrow at short maturities from creditors—including money-market funds, which will be discussed later in the paper—and they lend those proceeds to members in the form of longer-term advances and also invest in other investment securities. FHLBs are in the traditional bank business of maturity transformation.

3.3 FHLBs' Systemic Importance

Can an FHLB fail? It's not unimaginable. Gissler and Narajabad (2017c) discusses the question extensively. There are three candidate mechanisms: losses in the advances book, losses in the investment portfolio, or failure to roll-over financing. It is unlikely that losses in the advances book pose material risk given the haircuts and super-senior lien FHLBs hold on collateral. Losses in the investment portfolio represent a potential worry spot, but generally is only a small share of assets. FHLBs underlying business of borrowing short and lending via advances involves significant maturity transformation, and FHLBs may have trouble funding their assets if they lost the ability to issue debt regularly and cheaply. Indeed, in 2008 the FHLBs' creditors pulled back from FHLB debt as they were "guilty by association" with other government agencies—namely, Fannie and Freddie.

The unlikely failure of an FHLB would be particularly concerning since many FHLBs advances go to members without access to the discount window, so members without access to wholesale funding markets could struggle. Ashcraft et al. (2010) describe the FHLB system's role as a lender of "next-to-last" resort, as many banks and thrifts relied on advances from the FHLB system rather than going to the Federal Reserve's traditional lender-of-last-resort discount window.

One episode is worth mentioning: capital levels at both FHLB Seattle and FHLB Chicago fell from roughly five percent pre-crisis to less than one percent in 2008 as their investment portfolios, composed in part of private-label MBS, sustained losses.[7] FHLBs have two choices to shore up capital levels: they can retain earnings or they can raise capital if more banks become members of their branch. The main mechanism to increase capital levels is via retained earnings since the latter choice is largely out of the FHLBs' control. The FHLB Chicago retained earnings and recovered from its portfolio losses. FHLB Seattle, however, struggled to retain earnings as Washington Mutual simultaneously withdrew

[6] Tables A1 and A2 and Figure A1 provide information on the types of collateral the FHLBs accept in their advances, the haircuts for the collateral, and the concentration of advances to the largest members.

[7] Staring at Figure A2 long enough, an astute reader might notice FHLB Seattle has no commercial bank assets after 2015.

both its capital and its business from the bank. After six years of struggling to raise capital, FHLB Seattle merged with FHLB Des Moines. Gissler and Narajabad (2017c) provides additional discussion of this episode.

3.4 Post-Crisis Reforms

Two post-crisis reforms in financial regulations have changed the relative position of the FHLB system in money markets, and have elevated FHLB debt as a new critical safe asset producer. The two recent changes in money market structure are Basel III and the money-market mutual fund reforms of 2015/2016. I now briefly describe the critical components of these reforms as they related to the FHLBs.

3.4.1 Money-market mutual fund Reforms

In the aftermath of the Reserve Primary Fund breaking the buck in September 2008 and the Treasury's subsequent money-market fund guarantee, financial regulators sought to limit the systemic risk of money-market mutual funds (MMFs). Beginning in late 2016, the SEC required funds to report floating net asset values (NAV) unless the fund imposed gates and fees, or invested only in government securities. The gate structure allows the fund to temporarily prevent investors' redemptions to cash in times of stress, and would (in principle) limit a run from the money fund. Liquidity fees work toward a similar goal by charging a withdrawal fee to slow a run and prevent the money-market fund from fire-selling assets to satisfy panicky redemptions. Retail and government funds can keep $1 NAVs, but institutional funds must have floating NAVs unless they invest in government securities or impose gates and fees.

As discussed in Anadu and Baklanova (2017), the effect of the reform has been a marked shift from prime funds, which invest primarily in commercial paper, toward government funds, since government funds have a fixed $1 NAV but no gates or fees. FHLB debt is eligible for purchase from government funds, along with Treasurys and other agency securities. Pre-reform, prime funds had $1.7 trillion in assets compared to government funds' assets of less than $1 trillion, as shown in Figure 3. Figure 4 shows the magnitude of the shift caused by the money-market fund reforms, with almost $1.5 trillion—nearly ninety percent of prime funds' pre-reform assets—moving from prime funds to government funds. As government funds have absorbed this massive inflow, they expanded purchases of government securities, particularly of FHLB debt.

Gissler and Narajabad (2017b) show that the weighted average rate on FHLB debt is ten basis points lower than that of prime money funds after the money fund reforms. Thus, some banks prefer intermediation via FHLB advances rather than commercial paper issuance to money-market funds. Indeed, Figure 5, compiled by Gissler and Narajabad (2017b), shows that the share of MMF assets in FHLB debt has increased from ten percent to nearly forty percent from 2012 to 2017 and that MMFs hold more than half of FHLB debt.

3.4.2 Basel III

Basel III's Liquid Coverage Ratio (LCR) requires that banks hold thirty days equivalent of net cash outflows in high-quality liquid assets (HQLAs), among many other changes. HQLAs must offset any liability with maturity shorter than thirty days. A bank faces the choice of increasing the number of HQLAs they have to cover thirty days of outflows or otherwise push their liabilities' tenor beyond thirty days. The overall effect increases the cost for banks to borrow short. For this reason, banks are less motivated to expand their balance sheet by producing commercial paper and performing matched book repo, which are vital sources of marginal private safe assets.

Gissler and Narajabad (2017b) describe a second, related, effect of Basel III: "collateral upgrading." Large commercial banks increasingly rely on FHLB advances instead of commercial paper because FHLBs provide cheaper financing via collateral upgrading. A simple example: the bank posts a less-liquid asset, like a whole mortgage loan, as collateral for an FHLB advance. The bank then uses the cash proceeds of the FHLB advance to purchase HQLAs. So long as the advance has a maturity greater than thirty days the bank has increased its LCR.

4 Changing Sources of Safe Assets

A useful way to show the changing sources of safe assets in the post-crisis world is to enumerate the most important paths for cash to flow from cash pools to the ultimate cash user, either on deposit at the Federal Reserve or as use in leverage provision for speculators. I summarize the paths in Figure 6 via a series of asset/liability T-charts; The figure is the most critical figure in the paper, which shows how FHLBs, MMFs, broker-dealers (BDs), and banks intermediate cash flows.

Pozsar (2017) classifies cash pools into two types: "passive" and "active." Active cash pools take serious two mandates "do not lose" and "make money"; the active pools include aggressively managed corporate treasuries or hedge funds. Passive pools—pensions, many corporate treasuries—focus on the "do not lose" mandate and use convenient financial products for cash management.

It is helpful to walk through each path listed in Figure 6 with a brief description:

1. Pre-Crisis Path 1: Passive cash pools use prime money-market funds, and the money-market fund uses the cash proceeds to purchase bank certificates of deposit or commercial paper of various flavors. Banks hence use the MMFs as a source of funding.

2. Pre-Crisis Path 2: Passive cash pools use prime money-market funds, which in turn conducts tri-party repo with their broker-dealer; the broker-dealer uses the repo as the liability side of its matched booked repo book and passes the funding on to its levered clients, like hedge funds, which in turn use the cash proceeds to speculate.

3. Pre-Crisis Path 3: Active cash pools speculate across Tbills, bilateral repo, and

FX swaps; the last two of which end up as a liability to a broker-dealer which then intermediates the flows on toward fast money investors.

The most important parts of this most important figure are the green balance sheet items: these represent *private safe asset production*. The basic function of banks is to produce an information-insensitive liability that is useful as a transaction medium and store of value, just as described in Gorton and Pennacchi (1990). The production of information insensitivity assets in this figure takes the form of banks' commercial paper, tri-party, and bilateral repo. The passive cash pools are not performing serious information production (i.e., credit/market risk analysis) on the collateral or counterparty in these transactions (and may not even have the ability to do so). Instead, passive cash pools use the products because they are information-insensitive and thus are simple to use. Describing how these green line-items have relocated in the financial system is the main focus of this paper.

The post-crisis paths correspond to their pre-crisis equivalents, but now reflect the various changes caused by new financial regulations. There is also a new path, Post-Crisis Path 4, which is a result of the Federal Reserve's new monetary policy framework.

1. Post-Crisis Path 1: Passive cash pools use government money-market funds instead of prime funds due to the gates and fees requirement of the money market reforms; the government money-market fund uses the cash proceeds to purchase, among other things, FHLB debt; FHLBs use this funding to provide advances to banks, which in turn use the advances as a source of funding. *Government MMFs and FHLBs have replaced prime MMFs; and—just like prime MMFs before the reforms—government MMFs and FHLBs ultimately fund banks.*

2. Post-Crisis Path 2: Passive cash pools use government money-market funds, which in turn enter into tri-party repo with their BDs; the BD uses the repo as the liability side of its matched booked repo book and passes the funding on to its levered clients, like hedge funds, which in turn use the cash proceeds to speculate. This path is unchanged from its pre-crisis equivalent, except that it is more expensive for the BD to expand its balance sheet and so the transaction is less appealing ceteris paribus to the MMF.

3. Post-Crisis Path 3: Active cash pools speculate across Tbills, bilateral repo, and FX swaps; the last two of which end up as a liability to a BD which then intermediates the flows toward fast money investors. Again, this path is unchanged from its pre-crisis equivalent except that it is more expensive for the BD to expand its balance sheet.

4. Post-Crisis Path 4: Passive cash pools use government money-market funds, which can sidestep their BD counterparties and directly use the Federal Reserve's repo facility. This transaction was not available pre-crisis due to changes in the Federal Reserve's monetary policy implementation. The transaction is, all else equal, not preferred by money funds because tri-party repo is relationship based and therefore MMFs would prefer to intermediate via their traditional counterparties.

(Pozsar, 2017)

The orange and red boxes in post-crisis path two through four show the precise link which is more expensive–or otherwise disfavored—and therefore limits that path's relative importance. Contrast the colored boxes on the bottom of the figure with where private safe assets are produced, shown in green. The reforms severely diminished tri-party repo, bilateral repo, and commercial paper. Post-crisis, FHLB debt plays a new and crucially important role in private safe asset production.

Government money funds do not only buy FHLB debt: they Treasurys, other agencies debt, and engage in repo backed by government debt. However, FHLB debt has experienced the most substantial growth in volume. Additionally, the majority of agency debt—namely Fannie and Freddie—do not use their debt issuance proceeds to finance banks, or do so only indirectly, as Fannie and Freddie guarantee mortgages rather than provide advances to banks.

Table 6 shows the changing role of the FHLBs compared against Fannie and Freddie by showing the debt outstanding by tenor by agency. Pre-crisis in 2007, Fannie and Freddie had debt outstanding of approximately $1.5 trillion compared to FHLB debt of $1 trillion. In 2017, Fannie and Freddie debt outstanding fell more than sixty percent to $632 billion, with more significant drops in short-term debt. FHLBs, however, issue approximately the same amount, having doubled short-term issuance while reducing long-term debt. Producing safe assets is profitable so long as you can time the convenience yield and use the proceeds to invest in higher-yielding assets. The overall amount of debt outstanding and the creation of short-term agency debt point in the direction of the FHLBs ramping up safe asset production.

One way to see the changing position of the FHLBs in the money market is to examine the window-dressing pattern in their debt. At month-ends, private safe asset producers (banks, BDs) pay down repo, commercial paper, and other short-term liabilities to lower their reported leverage ratios. This reduction in the supply of private safe assets means that cash-pools must search elsewhere for short-term stores of value for their cash. After the reforms, the FHLBs absorbed a larger share of these month-end flows, which is evident when comparing the difference between the average non-month-end and month-end rate the FHLBs pay on overnight discount notes. If there is no search for safety at month-ends flowing to FHLBs, I would expect this spread to be zero. Beginning in 2016 the spread noticeably jumps as month-end FHLB overnight discount note yields are pushed down as much as thirty basis points by flows from cash-pools seeking safety, as shown in Figure 7.

5 Data

The Federal Reserve provides commercial paper data. Price data on when-issued securities is from GovPX. Repo, overnight indexed swap, benchmark Treasury, swap, exchange, and interbank offered rates are from Bloomberg. Issuance and rate data on FHLB discount notes are from the FHLB Office of Finance. Freddie reserve note data is from Freddie

Mac. Issuance for agencies longer than one year maturity and corporate bond issuance is from Mergent Fixed Income Securities Database. Markit provides credit default swap data. CRSP provides equity and Treasury return data. ABS data is from the Asset-Backed Alert Database. The Treasury's website provides Treasury issuance data.

6 The Convenience Yield

Correctly measuring the price of safe assets, as reflected by the convenience yield, is key to analyzing the issuance patterns of safe asset producers. I consider two benchmark definitions of the convenience yield, and I use both throughout the remaining empirical analysis. To test the validity of these measures I enumerate expectations for the behavior of the convenience yield based on straightforward comparative statics in the supply and demand for safe assets, and then check that each behavior is confirmed empirically with the two proposed measures of the convenience yield.

6.1 Measures of the Convenience Yield

Measuring the convenience yield is an effort of finding two instruments in which the only difference is their "money-ness" or "collateral-iziability." For this reason, the short leg should be a Treasury rate, as Treasurys can both be "spent" as money and are also useful as collateral. The challenge of measuring the convenience yield is finding another instrument that is highly liquid and nearly risk-free but cannot be spent or used as collateral like Treasurys. Past papers have used three measures of the convenience yield, all based on yield spreads:

$$\text{ConYield}_t^{OIS} \equiv \text{OIS}_t^{1m} - \text{TBill}_t \tag{1}$$

$$\text{ConYield}_t^{GCF} \equiv \text{GCF}_t^{1m} - \text{TBill}_t \tag{2}$$

$$\text{ConYield}_t^{AAA} \equiv \text{Aaa Long Maturity}_t - \text{UST Long Maturity}_t \tag{3}$$

Sunderam (2015) measures the convenience yield using Definition 1, which is the spread between similar maturity Tbills and the overnight indexed swap (OIS) rate. The OIS rate is the market-determined rate at which investors can swap the daily fluctuating effective Federal Funds rate over a many months period for a single fixed rate. Duffie and Stein (2015) provide details on the mechanics of the swap. The 1-month OIS rate reflects the market's expectation for the average effective Federal Funds rate over the maturity of the swap, responding both to fluctuations in the Federal Funds markets from reserve scarcity and also fluctuations due to changes in the Federal Reserve monetary policy stance. The OIS is somewhat biased due to risk aversion to changes in interest rates, but this is a small matter for short maturity contracts. Finally, while OIS transactions are collateralized to limit counterparty risk, the underlying reference rate—the effective Federal Funds rate—is itself unsecured.

The appeal of Definition 1 as a measure of the convenience yield is that (1) only one leg moves around as the supply of Treasurys fluctuates, and (2) OIS instruments cannot be spent or easily used as collateral for other transactions or otherwise rehypothecated.

Therefore, fluctuations in the relative appeal of Treasurys—after stripping out the level of interest rates embedded in the OIS rate—drive variations in the spread. The main disadvantage to the measure—other than the small risk aversion bias mentioned above—is that the OIS market is small, standing at about $15 billion notional in dollar terms in 2016. Despite this, I will use Definition 1 as one of the two benchmark measures of the convenience yield.

Definition 2 presents the second benchmark measure of convenience yield used in this analysis. The measure, proposed by Xie (2012), uses the reference rate for general collateral repo which is called the general collateral financing (GCF) repo rate. General collateral is a broad classification of securities that are eligible for use as collateral in general collateral repo transactions. There are two GCF rates, one referencing Treasury collateral and the other agency collateral. I focus on the former in this paper. The eligible collateral in these GCF repos includes Treasurys, and therefore credit risk is negligible; the collateralization by Treasurys, with a haircut, also negates counterparty risk.

GCF is not as useful as money as Tbills. It is difficult, but not impossible, to rehypothecate GCF repo, and only large institutions can do so. Since the rate is for general Treasury collateral, the aggregate supply and demand for Treasurys will affect the GCF rate. Both legs of the spread will fluctuate as the demand and supply of Treasurys varies. Nevertheless, the difference in the yield of the GCF repo rate and the Tbill rate is mostly the difference in moneyness, given the minimal counterparty and credit risk. The measure is an attractive complement to the OIS measure given the long time-series history and size of the market: the gross value of GCF repo stood at $700 billion in Q4 2018 and data is available back to 1991.

For completeness, Definition 3 defines a third measure of the convenience yield used by Krishnamurthy and Vissing-Jorgensen (2012). The measure is useful due to its long time-series. There are myriad differences between long-term U.S. Treasurys and highly-rated corporate bonds, only one of which is the degree of moneyness. Therefore, this paper does not use the spread.

Combined, Definition 1 and Definition 2 measure similar phenomena, albeit in different institutional contexts. Table 7 presents summary statistics for the three spreads. In the post-crisis era, ConYield_t^{GCF} trades four basis points higher than ConYield_t^{OIS}. A brief discussion of how GCF and OIS trade relative to each other is helpful: in general, GCF should trade below OIS because GCF is secured and OIS is a reference rate for an unsecured rate insofar as effective Fed Funds is unsecured. Flight-to-quality and supply or demand factors for new issue Treasurys will affect GCF but not OIS, as the OIS rate is a form of the market's expectation for interest rates over the life of the swap. If $\text{GCF}_t^{1m} > \text{OIS}_t^{1m}$ likely reasons include the oversupply of Treasury securities or the relative constraint of bank balance sheets: for example, the reference repo rate traded above the Fed Funds rate during the Savings and Loan crisis.

Table 8 provides the correlation matrix for the three measures in the post-crisis era. The two benchmark measures are closely correlated with a correlation coefficient of 0.66, and somewhat lower correlations between the two benchmark measures and the AAA measure.

6.2 Seasonally Adjusting the Convenience Yield

The convenience yield has significant seasonality as the demand for safe assets ebbs and flows predictably throughout the year. For example, window-dressing by banks increases the convenience yield at month-ends and quarter-ends. I will seasonally adjust the convenience yield following the procedure set out by Xie (2012). I regress my measures of the convenience yield on day of year dummies to produce the seasonal component of the convenience yield. I then produce the seasonally adjusted convenience yield by subtracting the seasonal component:

$$\text{ConYield}_t^{SA} = \text{ConYield}_t^{NSA} - \text{SeasonalComponent}_t \tag{4}$$

Seasonally adjusting using the count of business day, the count of the week, or using other strategies such as X-13-ARIMA produce highly correlated results.

I perform the seasonal adjustment on the two measures of the convenience yield discussed above, and I create the benchmark seasonal adjustment using a rolling expanding window regression. I separately calculate the seasonal component four periods: pre-crisis, crisis, pre-reform and post-reform. I denote the crisis as beginning in 2007, ending in 2009 whereas the pre-reform period ran from 2010 to July 2014 when the Securities Exchange Commission announced the MMF reforms, and the post-reform is after July 2014. As a check, I find the seasonality of the three non-crisis periods and the rolling adjustment are closely correlated, although the crisis period, unsurprisingly, is less correlated.

6.3 The Convenience Yield as the Price of Safe Assets

Since the convenience yield reflects the price of safe assets, comparative statics around the supply and demand for safe assets generate straightforward predictions about the behavior of the convenience yield. I summarize these predictions in the table, and I check that both benchmark measures of the convenience yield satisfy the a priori predictions.

Curve	Change	*ConYield* Prediction	Empirical Proxy
Supply	Supply of Safe Assets ↑	↓	UST issuance
	Window Dressing ↑	↑	quarter-ends
	Bank-intermediated arbitrage constraints ↑	↑	covered interest parity
	Bank-intermediated arbitrage constraints ↑	↑	reform implementation
Demand	Information production ↑	↑	cross-sectional σ(Equity Returns)
	Information production ↑	↑	cross-sectional $\sigma\left[\Delta(\text{CDS Spreads})\right]$

Table 2: **A priori predictions for convenience yield behavior**

Ceteris paribus, when the supply of safe assets increases the convenience yield should fall; when the supply of safe assets decreases the convenience yield should increase. The logic produces four straightforward predictions for the convenience yield. I now discuss each in turn. First, when Treasurys outstanding increase, the convenience yield should fall. Table 28 presents the result of regressing bill issuance on the two measures of the convenience yield. The table shows that innovations to the detrended Treasury bill issuance over the past five days have a significant negative coefficient sign using the OIS-Tbill measure, and issuance the day before has a significantly negative effect on the subsequent convenience yield using the GCF measure as expected.[8]

Second, window-dressing at financial institutions reduces the amount of private safe assets in the economy—in particular, as banks reduce leverage by paying down liabilities like commercial paper and repo—so the convenience yield should increase. Munyan (2015) shows, for example, that non-U.S. banks with relatively low capital ratios remove an average of $170 billion, or ten percent of the entire market, from the tri-party repo market before quarter-ends to window-dress. I expect the convenience yield measures to spike at quarter-ends. I run the following regressions:

$$\text{OIS}_t^{1m} - \text{TBill}_t = \alpha + \beta_1 \mathbb{I}_{\text{Quarter-End}} + \theta_t + \varepsilon_t \tag{5}$$

$$\text{GCF}_t^{1m} - \text{TBill}_t = \alpha + \beta_1 \mathbb{I}_{\text{Quarter-End}} + \theta_t + \varepsilon_t \tag{6}$$

in which the dummy is equal to one if the date is in the last week of a quarter-end in March, June, September or December and zero otherwise, and θ_t are yearly fixed-effects. I run the regression on the entire time-series available except for the crisis period. The results are reported in Table 9. The results confirm the intuition that the two benchmark measures of the convenience yield are higher at quarter-ends, consistent with my prediction. The magnitudes also show the importance of window-dressing in demand for TBills: Since window-dressing decreases the supply of safe assets, investors bid down the yield of TBills, thereby increasing the spread. The OIS spread increases roughly forty percent, and the GCF spread sixteen percent, at quarter-ends.

Third, banks produce fewer safe assets in periods in which banks are relatively more constrained—as measured by bank-intermediated arbitrages identified by Boyarchenko et al. (2018)—and the convenience yield should increase. When banks are not constrained and can lever up or down as desired the bank-intermediated arbitrage identities should be zero. When the arbitrage identities are large in magnitude, banks are constrained and relatively less able to expand their balance sheet to produce private safe assets. Empirically, I test this by checking the convenience yield measures' correlations with the covered interest parity (CIP) bank-intermediated arbitrages.[9]

[8] I will subsequently use Treasury issuance as an instrument. Importantly, Table 16 and Table 28 show that after Treasury issuance both the unadjusted and the seasonally adjusted convenience yield measures fall.

[9] Another candidate empirical proxy for intermediaries' constraints is the off-the-run/on-the-run basis spread: this spread reflects the liquidity premium of on-the-run Treasurys, which is another form of bank-intermediated arbitrage. However, this arbitrage does not have clear predictions for the convenience yield: when the OFR/OTR spread is high, it could either be that intermediaries are constrained or that increased demand for safe assets has increased the premium for on-the-run Treasurys since these are practically easier to find and purchase. Empirically, the OFR/OTR premium fell in the crisis, suggesting that investors bid up the price of off-the-run Treasuries. I calculate the off-the-run/on-the-run spread by identifying pairs of the on-the-run benchmark issues (6, 12, 24, 36, 60, 84, 120 and 360 months) and also identify off-the-run Treasurys with the closest matching time to maturity. The spread is typically positive as expected, as shown in Figure A5. Pairwise correlations between the convenience yield measures and the different maturity OFR/OTR spreads do not show a clear pattern, suggesting that both forces are at play: the spread reflects

I calculate the covered interest parity violations (relative to the dollar) of G11 currencies at the one-week, one-month, and three-month tenor using both OIS and the respective national IBOR for discounting, as in Du et al. (2018). The calculation results in six buckets of CIP violations: three tenors × two discounting methods for each. I use daily data beginning in 1998.[10] I next take the absolute value of each violation, since the arbitrage identity should be zero and larger deviations from zero indicate frictions in the bank-arbitrageur channel. I then extract the first four principal components from each of the six tenor× discounting groups of CIP violations. I choose the first four principal components as the first four explain between eighty-five and ninety percent of the variation across the six groups. The goal of this aggregation process is to capture the intuition that substantial CIP violations, in absolute terms, across many currencies occur when the intermediary sector is constrained: if the CIP violation is large for a single currency, it may instead capture a specific, idiosyncratic effect.

I check the pairwise correlations of both convenience yield measures with each of these six aggregated CIP measures, shown in Table 10. The correlations are almost uniformly positive and significant. The correlation between the OIS and three-month/IBOR measure is the only insignificant correlation but is still the correct sign. The aggregation process is not sensitive to small changes: using more or less principal components, normalizing each CIP violation to standardized volatilities, or using subsamples of the time-series do not meaningfully change the correlations. Broadly, this confirms my intuition that the convenience yield, a proxy for the price of safe assets, should be higher when banks are constrained, as measured by the magnitude of CIP violations.

The final prediction of the comparative statics exercise is to check that the price of safe assets is, on average, higher in the post-reform time sample than the pre-crisis sample since the combination of regulatory reforms have made it more expensive for intermediaries to expand their balance sheets. I confirm the prediction empirically by comparing the average convenience yield, seasonally adjusted or not, before and after regulators started phasing-in Basel III. My analysis is consistent with the finding of Laarits and Gorton (2018), aptly titled "Collateral Damage." I find that the convenience yield measures are uniformly higher after the phase-in arrangements for Basel III implementation, which ramped up in 2015.[11]

I now discuss predictions based on the demand curve for safe assets. Ceteris paribus, when the demand for safe assets increases the convenience yield should grow; and when the demand for safe assets decreases the convenience yield should decrease. I walk through the three predictions for the convenience yield based on changes in demand for safe assets. First, safe assets are valuable as a transaction medium because they are information-insensitive. Dang et al. (2015) shows that information-insensitive assets are the most

frictions in the bank-intermediated arbitrage channel and that, at times of high demand for safe assets, investors bid down the yield on off-the-run Treasurys.

[10] I show the covered interest parity violations, in basis points in Figure A4.

[11] LCR phase-in started in 2015, while counter-cyclical buffers ramped up beginning in 2016. Additionally, CET1 minimums began increasing in 2013 from 3.5 percent to 4.5 percent by 2015. Broadly, Basel III increased capital requirements ramped up through the entire period from 2013 to 2019, along the dimensions of total capital requirements, redefinitions of risk-weights, and rule-making for the supplementary leverage ratio and net stable funding ratio.

efficient transaction medium because they give people the lowest incentive to acquire private information. Therefore, uninformed people can comfortably trade information-insensitive assets with less concern about adverse selection; namely, that the counterparty has produced private information on the asset and sells lemons to the uninformed agent. Dang et al. (2015) additionally show that financial crises are information events. In this line of thinking, Chousakos et al. (2018) show the amount of information in the economy measured via the cross-sectional variance in equity returns varies over time, and that increased information prediction predicts financial crises.

This logic generates the following empirical prediction: when information production is high the risk of adverse selection is also high, and investors will bid the price of safe assets up because safe assets are a refuge for the uninformed. An example makes this explicit: suppose a money-market fund engages in repo with a bank counterparty, which is collateralized by a basket of asset-backed securities. Suppose now the economy switches to a high-information-production regime. The money-market fund may be fearful that its bank counterparty has produced information on the ABS collateral and is using the money fund to finance its lowest quality collateral. Since the money-market fund does not have the expertise nor time (most repos are less than seven days maturity) to value the ABS (i.e., to produce private information on the ABS), the fund exits the repo agreement and moves the balance to USTs. Hence, as information production in the economy picks up, the convenience yield should increase as well.

I measure information production two ways: first, I use the daily cross-sectional standard deviation in equity returns as proposed by Chousakos et al. (2018). My second measure is the daily cross-sectional standard deviation of changes in five-year credit default swap spreads on senior unsecured debt for AAA to BBB rated debt. I test the prediction by confirming the positive and significant correlation between the two benchmark convenience yield measures, which I show in Table 11.

One final robustness check is to verify Sunderam (2015)'s finding that a higher convenience yield forecasts ABCP issuance, as a higher spread indicates higher money demand which encourages private safe asset producers—including ABCP issuers—to increase issuance. I test that this prediction holds with both benchmark measures of the convenience yield after seasonal adjustment. I run the following regression

$$\log(\text{ABCP Issuance})_{\text{Detrended},t} = \alpha + \beta \text{SeasonalComponent}_t + \mathbb{I}_{\text{Quarter-End}} + \theta_t + \varepsilon_t \quad (7)$$

estimated on data from the post-reform period, using a seasonal component estimated from the pre-reform period, with a dummy for quarter-ends and yearly fixed-effects. Whether or not I lag the seasonal component by one day does not materially change the coefficients or significance, but the main specifications feature this lag, and I report the results with the seasonal component lagged by a day. The dependent variable is the issuance series detrended as described in the following section. I present the results in Table 12, which shows the same relationship in Sunderam (2015): when the convenience yield is higher the day before, ABCP issuer issue more the following date relative to trend. The result is consistent with the idea that ABCP issuers are opportunistically issuing to capture a portion of the convenience yield.

6.4 Issuance

I detrend all issuance series using the same process as Xie (2012). I log each issuance series and then apply a Hodrick-Prescott filter with λ selected to reflect the daily nature of the data. The process allows me to separate the trend from short-run deviations. I then subtract the long-term trend from the total logged issuance number to produce the detrended issuance number:

$$\log(\text{Issuance})_{\text{Detrended},t} = \log(\text{Issuance})_t - \log(\text{Issuance})_{\text{HP-Filter},t} \tag{8}$$

The goal for this process is to measure when an issuer issues more or less than suggested by the recent past. As a check, I also confirm that a piecewise linear regression produces similar detrended issuance series.

7 Empirical Strategy and Results

This paper tests two related questions: first, does safe asset issuance help explain fluctuations in the convenience yield? Second, do safe asset issuers time their issuance in part to earn the convenience yield— that is, do issuers engage in so-called "opportunistic issuance"? I first answer these questions using FHLB issuance. I also analyze whether other agencies and private safe asset producers have a similar impact on the convenience yield and exhibit opportunistic issuance behavior, and how these issuers have changed over time.

It is challenging to analyze the long-term relationship of fluctuations in the convenience yield and private safe asset issuance; instead, I focus on daily fluctuations. Using daily data has two advantages: first, the time-series of FHLB and other agency issuance is only available back to the mid-1990s, so daily data allows for more observations. Second, this paper's focus on short-term deviations in issuance the convenience yield help control for changes in the underlying macroeconomic landscape which is unlikely to change meaningfully from day to day.

7.1 Benchmark Test 1: The Convenience Yield Responds to Agency Issuance *the Day Before*

First, I examine how the convenience yield responds to FHLB issuance the day before, i.e., whether $\text{ConYield}_t^{SA} = f(Issuance_{t-1})$ in the post-reform regime. I use the timing of the independent and dependent variables purposefully; I want to rule out the possibility that convenience yield and FHLB issuance are jointly determined. The benchmark test will use lagged FHLB issuance because the lagged detrended issuance of day $t-1$ is exogenous to the convenience yield on day t. Importantly, the lagged detrended issuance is known at date t.

I run the following regression:

$$\text{ConYield}_t^{SA} = \alpha + \beta \log(\text{Issuance})_{t-1} + \theta_t + \varepsilon_t \tag{9}$$

in which the dependent variable is the seasonally adjusted convenience yield, and the independent variable is the detrended FHLB issuance time-series, and θ_t are fixed-effects. I use data from the post-reform period from July 2014 to December 2018. I show the result in Table 13. Columns (1) through (3) show the results when I measure the convenience yield the OIS-Tbill measure, and columns (4) through (6) show the results with the GCF-Tbill measure of the convenience yield. Across the two measures of convenience yield and different fixed effect specifications, the coefficient on issuance is significantly negative. The result suggests that FHLB debt is a safe asset, as an increase in FHLB debt available on day $t-1$ reduces the price of safe assets the following day, day t.

A one standard deviation increase in the FHLB issuance of $4.84 billion lowers the next day's seasonally adjusted convenience yield by 0.7 to 1.7 basis points using the OIS measure for the smaller estimate and the GCF measure for the larger estimate, using betas shown in columns (2) and (5) of Table 13. The effect is a significant reduction given the post-reform mean for the OIS and GCF convenience yield measures are six basis points and ten basis points, respectively.

7.1.1 Additional Evidence for Benchmark Test 1

I first show there is no common variation between the convenience yield and debt issuance in the prior day more generally. I show the convenience yield is not lower following corporate bonds issuance the day before. The result captures the idea that corporate bonds are risky assets and not private safe assets, so an unusually large issuance of corporate bonds should not affect the convenience yield. Table 14 shows the result from running the benchmark test but changing the independent variable from FHLB issuance to corporate bonds. As expected, the coefficient on corporate bonds' detrended issuance is insignificantly different from zero, confirming the intuition that corporate bonds cannot be driving fluctuations in the subsequent convenience yield.

A second test is to check how FHLB issuance affects the convenience yield compared to other candidate safe assets. That is, I want to rule out the possibility that FHLBs issue debt simultaneously with some other safe asset, which would spuriously make FHLB debt appear to decrease the subsequent convenience yield. I run benchmark test 1 but now as a horserace of FHLB issuance and several other candidates to confirm FHLB issuance is the correct focus. I run the regression on FHLB issuance and also include as controls: financial commercial paper and asset-backed commercial paper issuance with maturities between one and four days; Tbills; Freddie discount notes and term issuance; Fannie term issuance; CDOs; private-label MBS; and, ABS issuance. The standard detrending process described previously is applied to each of these control issuance series. Table 15 presents the results from this regression, using the two measures of the convenience yield. When comparing FHLB issuance against these measures, the relationship between FHLB issuance the day before and the subsequent convenience yield is unchanged, as can be seen by skimming along the top row and noting the always negative and significant relationship between FHLB issuance and the subsequent convenience yield, even after controlling for several other issuers. The only exception is the result using the OIS-Tbill measure of the horserace against private MBS issuance—the coefficient is negative, as expected, but not significantly. There are only ninety-six observations when the FHLBs issue the same day as new MBS, and I expect as times passes and more data becomes available the result will look similar to the other columns.

As a third check, I test whether the benchmark test result holds for Treasurys: when Treasury issues in the previous day the convenience yield should fall since an increase in the supply of safe assets should subsequently drive down the price of safe assets. Table 16 presents the result of regressing bill issuance on the two measures of the convenience yield, showing that innovations to the detrended Treasury bill issuance over the preceding five days have a significant negative coefficient sign using the OIS-Tbill measure, and issuance on the preceding day has a significantly negative effect on the subsequent convenience yield as expected.

Overall, I have shown that the convenience yield responds in ways we expect with regards to private safe production (Tbills), risky asset production (corporate bonds), and in running a horserace of FHLB against other candidates for private safe asset producers (ABCP and financial CP). These tests show the vital role of FHLB issuance in explaining the subsequent convenience yield.

7.1.2 Migration in Convenience-Yield-Determiners

Benchmark test 1 shows that *in the post-MMF-reform period* FHLB issuance helps determine the subsequent convenience yield. I now consider how the convenience-yield-determining power of the FHLBs and similar debt-issuing government agencies have changed from pre-crisis to today. In summary, I find that FHLB issuance has a more significant effect on the convenience yield in the post-reform period, that Fannie's effect has disappeared from pre-crisis to post-reform, and that Freddie's discount notes have a similar impact between pre-crisis and post-reforms.

First, I run benchmark test 1 on the FHLB issuance over four regimes: pre-crisis, crisis, pre-reform, and post-reform. I show the results in Table 17. In the pre-crisis period, FHLB issuance does not have the negative relationship between issuance the day before and the subsequent convenience yield, whereas the post-reform period—and at least in the sign for the pre-reform period—FHLB issuance has a significantly negative effect on the convenience yield. This result shows the new position of FHLBs as a result of the changing post-crisis regulatory regime, which has made FHLBs large suppliers of safe assets to money-market funds; something that was not the case pre-crisis.

It is possible to run benchmark test 1 using interactions in a combined model rather than as a split-sample regression corresponding to the four regimes. To perform this test, I use the following specification:

$$\text{ConYield}_t^{SA} = \alpha + \beta_1 \log(\text{Issuance})_{t-1} + \sum_{i=1}^{3} \beta_i \log(\text{Issuance})_{t-1} \times \mathbb{I}_{\text{Regime}^i} + \mathbb{I}_{\text{Regime}^i} + \theta_t + \varepsilon_t \tag{10}$$

in which $i = 1, 2, 3$ corresponds to indicator variables for the crisis, pre-reform, and post-reform samples, θ_t are fixed-effects and the regression is run relative to the pre-crisis baseline with the detrended issuance series. The results from this specification are shown in Table 18. The basic result is the coefficient on $Issuance_{t-1} \times \mathbb{I}_{PostReform}$ in column (1) of both panels, which shows the convenience yield falls in the day after issuance of 4-week to 26-week maturity debt from FHLBs in the post-reform period.

Next, I use the interaction specification above to test what other agency issuers affect the convenience yield, and in what regime they did so. A priori, it is possible that any of the debt-issuing government agencies' issuance may affect the convenience yield. I expect the largest debt issuers—Fannie and Freddie—will have the largest effects in driving the convenience yield pre-crisis, and they will have less effect after the crisis due to their diminished role in agency debt production. I report the results in Table 18. The interpretation is the same as the previous specification: if the issuer affects the convenience yield as a safe asset producer, then the coefficient will be significant and decrease the subsequent convenience yield. The first row shows the marginal effect of issuance in the pre-crisis period: Fannie Mae and Freddie Mac are the only issuers with at least one significant and negative effect across the two convenience yield measures. The next row shows the crisis period, which shows no issuer exhibits the convenience yield driving effect. In the pre-reform and post-reform period, Freddie Mac broadly displays the negative and significant relationship, but the marginal effect is smaller for longer-maturity debt.

Table 18 summarizes the fact that safe asset production has migrated to FHLBs away from Fannie while the Freddie issuance continues to impact the convenience yield. Fannie appears to have lost the relationship between its issuance and the subsequent convenience yield: unsurprising given the volume of borrowing shown previously in Table 6. Pre-crisis Fannie and Freddie's debt outstanding was \$1.5 trillion, of which roughly twenty percent was short-dated, compared with the FHLBs at \$1 trillion with eighteen percent short-dated. In 2017, however, Fannie/Freddie had \$632 billion outstanding with twelve percent short-maturity, whereas FHLBs have \$1 trillion with more than forty percent having a maturity less than one year in maturity. Combined, this table shows three factors: (1) FHLB issuance plays a new role in the convenience yield in the post-reform world, (2) Freddie issuance, and particularly non-overnight disco issuance, affects the subsequent convenience yield the same both pre- and post-crisis, and (3) Fannie issuance no longer has an effect on the convenience yield.[12]

I now return to the original split sample version of the benchmark test and run the

[12] Due to lack of data availability, I have not tested Fannie discos. It is possible Fannie discos have the same behavior as Freddie behavior.

specification separately on each of the agency issuers to test if they display an effect on the convenience yield. I present the results of these individual split sample regressions in Table 21, with Panel A showing the results when using the OIS-Tbill measure and Panel B with the GCF-Tbill measure. The expectation for a safe asset producer is a significantly negative coefficient on the lagged issuance variable, and migration occurs when the coefficient flips sign (or loses significance). Figure 8 plots the coefficients of interest. Here, we again see the basic result that FHLB issuance only lowers the subsequent convenience yield post-crisis. As with the previous test, we against see that Freddie Mac issuance had a significant convenience-yield-driving effect across shorter-term reference notes and longer maturity issuance, and that effect is somewhat smaller post-reforms. In this test, Fannie has a significantly negative coefficient only with the GCF measure.

As a final check to confirm that both Fannie and Freddie displayed the convenience-yield-determining effects pre-crisis, I run the Fannie and Freddie detrended issuance series in benchmark test 1 but include other private safe assets in a horserace. The test helps determine whether Fannie and Freddie contributed to the convenience yield or instead coincide with the issuance of other safe asset issuance which exhibits the actual effect. Table 22, Table 23 and Table 24 show the results from running this horserace of, respectively, Freddie term discos, Freddie overnight discos, and Fannie issuance compared against ABCP and financial commercial paper issuance. The results show that both Fannie and Freddie played an essential role in determining the convenience yield pre-crisis, but post-crisis only Freddie continues to affect the convenience yield.

Combined, I show FHLBs have a convenience-yield-driving effect only in the post-reform period, while Fannie had convenience-yield-driving effects pre-crisis that have become both smaller in magnitude and also—depending on the exact specification and measure of the convenience yield—are occasionally insignificant from zero. The relationship between Freddie disco issuance and the convenience yield has not changed from pre-crisis and post-crisis. I argue this shows that FHLBs have become the most critical agency safe asset producer post-crisis, taking the reins from Fannie, and that Freddie remains a relevant safe asset issuer.

7.1.3 Benchmark Test 1: Vector Autoregression

I now present a vector autoregression (VAR) to analyze the impulse response function of the convenience yield in response to shock to issuance. I run the model on three separate overnight issuers: FHLBs, asset-backed commercial paper, and financial commercial paper. I estimate the model on the same data as in the previous tests, with the exception that out of window-dressing related idiosyncrasies I drop month-ends and quarter-ends. The VAR is run separately for each of the three issuers on the data in the pre- and post-reform periods separately. The regression is in log levels. Lag selection is determined by the Schwarz information criterion. The system is summarized by

$$\begin{bmatrix} Issuance_t \\ \text{ConYield}_t^{SA} \end{bmatrix} = \boldsymbol{A} \begin{bmatrix} Issuance_{t-1} & \dots & Issuance_{t-n} & \text{ConYield}_{t-1} & \dots & ConYield_{t-n} \end{bmatrix}^{\intercal} + \begin{bmatrix} \varepsilon_{Issuance,t} \\ \varepsilon_{ConYield,t} \end{bmatrix}$$

in which $\varepsilon \equiv [\varepsilon_{1t}\varepsilon_{2t}]'$, $\mathbb{E}_t[\varepsilon_t\varepsilon_t'] = \Sigma$, and by assumption $E[\varepsilon_t] = 0$. I impose D is the upper triangular decomposition of Σ: $DD' \equiv \Sigma$ and $\varepsilon_t = Du_t$.The impulse response sets $u_{1t} = 1$: a one standard deviation shock to issuance. The structure of the shocks uses the logic that a shock to issuance affects convenience yield immediately, but the shock to convenience yield takes a period for an issuer to adjust since they cannot simultaneously adjust issuance. The structure of the shocks is realistic since issuers issue debt at discrete points, and the market does not know the convenience yield until the close of business, whereas the market does know issuance since issuance decisions for the day typically occur in the morning or early afternoon.

The impulse response function for all three issuers is shown in Figure 9 along with 95 percent confidence intervals. A priori, one would expect a positive shock to safe asset issuance will drive the convenience yield down. The relative importance of FHLB debt is confirmed in this analysis: FHLBs and financial commercial paper issuance drives down the convenience yield, although it is only significant for the FHLBs. ABCP exhibits a counterintuitive effect: a positive shock to ABCP overnight issuance modestly increases the convenience yield, however this effect is only marginally significant.

Figure 10 compares the impulse response function for the threes issuers but shows the results from estimating the model before and after money-market mutual fund reforms. This comparison makes clear that in the post-reform period the relative sensitivity of the convenience yield to FHLB issuance is a magnitude larger than pre-crisis, and also that the sensitivity is larger than other overnight issuers. The VAR evidence links FHLB debt issuance to the convenience yield.

7.2 Benchmark Test 2: FHLB Issuance Responds to the Convenience Yield *the Day Before*

The second benchmark test examines whether the FHLBs issue opportunistically in response to variations in the convenience yield, i.e., whether $FHLBIssuance_t = f(\text{ConYield}_{t-1})$. I use the timing of the independent and dependent variables carefully to ensure the explanatory variable—the convenience yield—is not determined simultaneously with the issuance decision. To help identify the effect, I use Xie (2012)'s methodology of using the seasonal component of the convenience yield as an instrument. Seasonality is a useful instrument because it is exogenous to issuers (i.e., it would be impossible for the issuance at date t to affect the seasonal component estimated for date t from the existing data) and seasonality is predictable to issuers. Issuers can time the convenience yield in two ways: first, by anticipating fluctuations in the convenience yield due to seasonality (e.g., window dressing) or second, by noticing that the seasonally adjusted convenience yield has been high in the past days due to other reasons.

In this setup, I test the following specification:

$$\log(\text{Issuance})_t = \alpha + \beta_1 \text{SeasonalComponent}_t + \beta_2 \text{ConYield}^{SA}_{t-1} + \theta_t + \varepsilon_t \qquad (11)$$

in which I predict the $\text{SeasonalComponent}_t$ out-of-sample, I detrend issuance as described above, and θ_t are fixed-effects. I report the results in Table 25. I measure the convenience yield via the two definitions, and the dependent variable is three flavors of FHLB debt: overnight FHLB discount notes, FHLB discount notes with 4-weeks to 26-weeks in maturity, and FHLB bonds with a maturity greater than one year. I report the main result in the first row: across both measures of the convenience yield and all tenors of FHLB debt, FHLBs issue more debt when the previous day's convenience yield is higher. The empirical evidence does not support FHLBs timing the seasonal predictability of the convenience yield, but rather time issuance based on the seasonally adjusted convenience yield.

The magnitude is important. A one standard deviation increase in the seasonally adjusted convenience yield of 9.7 basis points implies an increase is FHLB issuance of \$196 million (\$113 million) for overnight debt, \$549 million (\$323 million) for 4 week to 26 week maturity debt, and \$55 million (\$38 million) for greater than 1 year maturity debt using the OIS-Tbill (GCF-Tbill) convenience yield measure betas shown in Table 25.

7.2.1 Alternative Benchmark Test 2: When-Issued Market

Using "tails" and "throughs" from Treasury auctions as a second shock allows me to test FHLB opportunistic issuance without relying on the benchmark definitions of the convenience yield. When the Treasury announces an auction, dealers start trading that specific security on the same day in the when-issued (WI) market. WI transactions settle on the issue date of the auctioned security. For example, if the Treasury announces a bill auction on Thursday morning, then the auction results are announced Monday afternoon, with settlement later that week. The purpose of the WI market is to allow trading of the security before the security is physically available. When the stop-out yield in the Treasury auction exceeds the yield on the WI security the auction is termed a "tail," which indicates weak demand for the Treasury. Likewise, when the stop-out yield in the auction falls below the yield on the WI security the auction is termed a "through," which indicates strong demand for the Treasury. Mercer et al. (2013) provides additional details on the WI market.

Traders in the WI market can speculate and therefore have profit motives to forecast tails and throughs correctly. For example, an investor who thinks the WI yield is too low—meaning Treasury demand will be weaker than is priced in the WI security—can "play for a tail" by selling the WI short while covering the short by placing a competitive bid at a yield higher than on the WI security. The covering leg must carry a yield sufficiently low—below the stop-out yield—since covering with a too-high yield bid will leave the investor with a naked short position in the WI (Treasurys are not allocated to investors submitting bids which are too high). Similar, but reversed, logic applies for speculating on a "through" auction.

Tails and throughs provide a discrete method to measure unexpected Treasury demand. Tails and throughs proxy the unexpected demand for safe assets because speculators have incentives to forecast Treasury demand correctly and because Treasury typically fixes the size of the offering. If the demand for safe assets is higher than expectations, we would expect a through in the auction; if the demand is low, then we should expect a tail.

I test FHLB issuance around tails and throughs. I measure the tail as the difference between the yield in the WI market 1 minute before the Treasury announces the results at 1:00 P.M. and the subsequent yield on the actual Treasury at 1:30 P.M.:

$$\text{Tail}_t = Yield_{1:30pm} - Yield_{12:59pm}$$

Thus if $\text{Tail}_t > 0$ then the auction is a tail, and a $\text{Tail}_t < 0$ indicates a through.

I test FHLB opportunistic issuance by running the following regression:

$$\log(\text{Issuance})_t = \alpha + \beta_1 \text{Tail}_{t-1} + \theta_t + \varepsilon_t \tag{12}$$

in which θ_t are fixed-effects. I expect demand for safe assets is lower and FHLBs will issue less when the Treasury auction tailed the previous day. The test examines opportunistic issuance based on the demand for safe assets but measured via Treasury tails rather than the convenience yield measures. I report the results of running the regression in Table 26. I report the main result in the first two columns, which shows that β_1 in the above specification is negative and significant, matching intuition. Columns (3) and (4) provide additional controls for the seasonality of the convenience yield, showing that tails are indeed particularly important in FHLB issuance in the following day.

7.2.2 Additional Evidence for Benchmark Test 2

It is important to show there is no typical common variation in debt market issuance and money markets to confirm the specification of benchmark test 2. In addition to exploiting the timing differences (the day before vs. the day after) in the main specifications, I now perform three checks.

First, I test whether corporate bond issuers opportunistically time the convenience yield. Since FHLBs produce private safe assets, I have argued that they will want to issue these assets when the price of safe assets is higher. However, corporate bonds are risky and not useful as safe assets. Therefore, I expect there is no timing of the convenience yield by corporate bond issuers. Table 27 reruns benchmark test 2 but replaces FHLB issuance with corporate bond issuance. Columns (3) and (4) show corporate bond issuance does not exhibit opportunistic issuance behavior—there is no evidence of corporate issuers timing the seasonally adjusted convenience yield, and if anything corporate bond issuer issue more when the seasonal component is lower. The result is inconsistent with the characteristics of safe asset production.

A second test is to check whether the Treasury issues opportunistically. The Treasury is not a profit-maximizing institution and has no obligation to do so. For this reason, I run the benchmark test 2 specification with Treasury issuance as the dependent variable and expect that β_1 and β_2 are not significantly different from zero. Columns (5) and (6) in Table 27 report the results. There is no evidence that Treasury times issue based on the previous day's convenience yield for either measure of the convenience yield, however, there is evidence that Treasury issues more when the seasonal component is higher as measured by GCF-Tbill. The significance of the seasonal component coefficient is likely due to the year-to-year pattern of Treasury's issuance schedule. Overall, the results confirm the prior that the Treasury, unlike FHLBs, does not opportunistically issue debt to time the convenience yield.

A third check is to use Treasury issuance as a shock. As discussed in Xie (2012), the convenience yield likely fluctuates as the Treasury issues and redeems Treasury debt. A large issue of Treasurys will crowd out other safe assets like FHLBs, and the FHLBs will issue less. I now perform the following two-step regression: first, I show an increase in Treasury issuance affects the convenience yield via:

$$\text{ConYield}_t^{NSA} = \alpha + \sum_{i=1}^{5} \beta_i (\text{TBill Issuance})_{t-i} + \varepsilon_t \tag{13}$$

This is reported in Table 28. Next, I use Treasury issuance as an instrument to predict the convenience yield as shown in the above specification and then show the FHLBs are indeed crowded out by Treasury issuance, which I present in Table 29.

$$FHLB\ Issuance_t = \alpha + \widehat{\text{ConYield}}_{t-1}^{NSA} + \varepsilon_t \tag{14}$$

in which $\widehat{\text{ConYield}}_{t-1}^{NSA}$ is the first stage estimate of the convenience yield from Treasury issuance. I show the main result from this test in columns (1)-(6) in Table 29: when the convenience yield is higher, as estimated via Treasury issuance, then FHLBs issue more. The result is robust to using both measures of the convenience yield and controlling for year fixed-effects as well as with a month-end dummy.

Importantly, FHLBs exhibit "gap-filling" behavior with issuance in that FHLB issuance is lower when bill issuance the day before is larger: I present the result in columns (7) to (9) of Table 29.

To summarize, I have present five pieces of additional evidence for opportunistic issuance. First, FHLBs issue less when demand for Treasury debt is low as measured via auction tails in the WI market. Second, issuers of risky assets do not time the convenience yield. Third, Treasury issuance does not time the convenience yield. Fourth, FHLBs issue more when using Treasury issuance as a shock to estimate a first stage convenience yield. Finally, FHLBs exhibit "gap-filling" behavior. Each of these tests matches intuition and confirm the behavior of FHLBs as safe asset producers who time the seasonally adjusted convenience yield.

7.2.3 Who Else Opportunistically Issuances?

Benchmark test 2 shows that the FHLBs opportunistically time issuance based on the convenience yield in the previous day, which has been the case for the entire sample and not only after the money market reforms. Who else opportunistically times the convenience yield? I now run benchmark test 2 on other agency and commercial paper issuers to examine their opportunistic issuance behavior, and report the results in Table 30 and Figure 11 plots the beta coefficient on $\text{ConYield}_{t-1}^{SA}$. The issuance series include Freddie discos (excluding overnight), Fannie bond issuance greater than one year, Federal Farm Credit Bank issuance greater than one year, as well as one to four-day maturity highly-rated ABCP, financial CP, and non-financial CP. As discussed before, there are two possible ways to time the convenience yield: either based on $\text{SeasonalComponent}_t$ or $\text{ConYield}_{t-1}^{SA}$.

The test shows the following facts: first, that Freddie discount notes time both the seasonal component and $\text{ConYield}_{t-1}^{SA}$, although the effect is marginal when using the OIS measure of the convenience yield. Second, it does not appear Fannie debt issuance with a maturity longer than one year opportunistically times either of the convenience yield components. Third, the Federal Farm Credit Banks time $\text{ConYield}_{t-1}^{SA}$ and the seasonal component, but the latter coefficient is statistically marginal. ABCP issuance times the $\text{SeasonalComponent}_t$, which is consistent with Sunderam (2015). Non-financial commercial paper also exhibits opportunistic issuance, whereas financial commercial paper does not. The latter is unsurprising since window-dressing constraints financials precisely when the convenience yield is high (e.g., at quarter-ends during window-dressing), and so financials cannot opportunistically issue.

8 Conclusion

This paper aims to show three related facts: first, that various financial reforms in the wake of the financial crisis have made the FHLBs major issuers of safe assets. Second, that fluctuations in FHLB issuance post-reform—as well as Freddie issuance—can help explain variation in the subsequent convenience yield on a day-to-day basis. While Freddie exhibits the same effect on the convenience yield post-crisis as pre-crisis, Fannie's effect has disappeared. Third, the FHLBs issue debt opportunistically to time fluctuations convenience yield, allowing them to earn the convenience yield; Freddie also issues opportunistically. The results suggest that safe asset production has migrated toward the FHLBs.

Policymakers and regulators should raise their eyebrows when thinking about FHLBs' contribution to systemic risk given (1) how today's safe asset production characteristics of the FHLBs match Fannie and Freddie's characteristics pre-crisis, (2) the large money-market holdings of FHLB debt and use of FHLB debt as repo collateral, (3) the magnitude of maturity transformation performed by the FHLB system, and (4) the FHLBs' implicit government guarantee.

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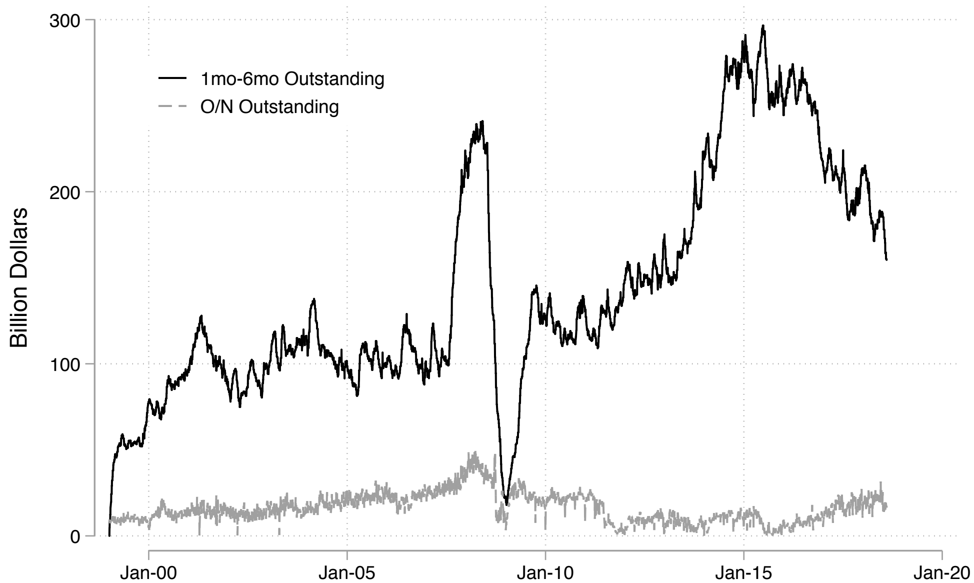
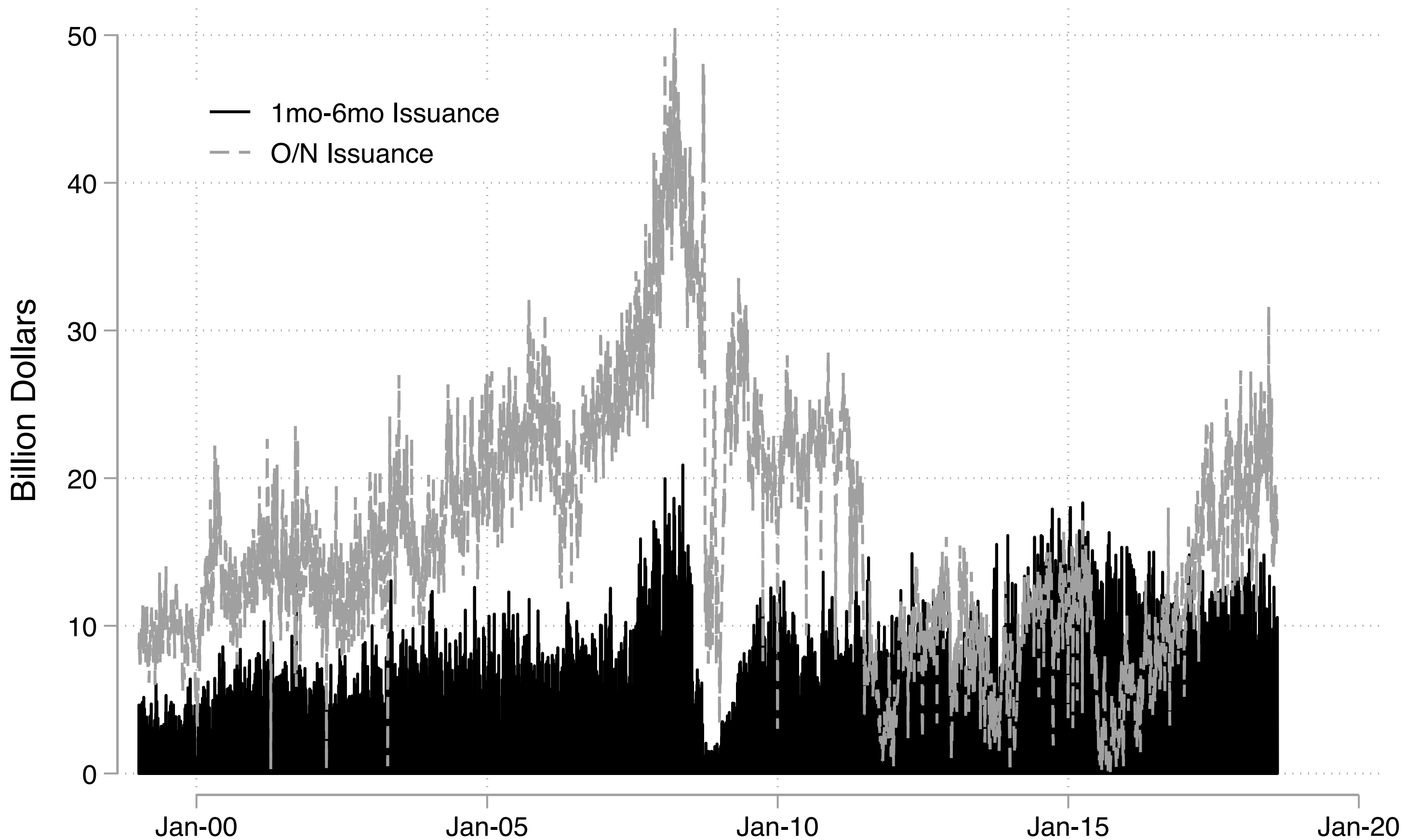
9 Figures

Figure 1: FHLB Discount Notes Outstanding



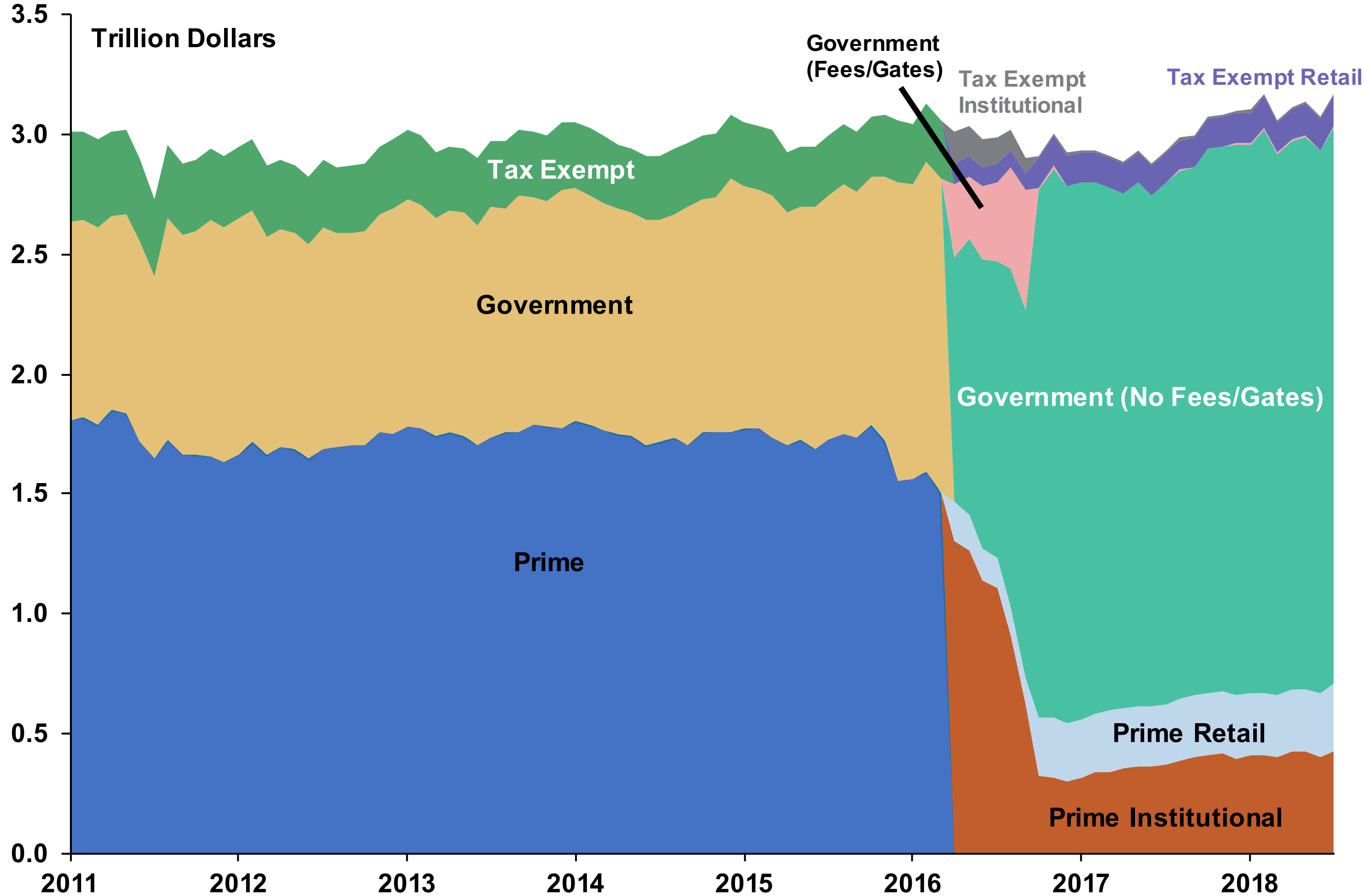
Source: FHLB Office of Finance

Figure 2: FHLB Discount Notes Issuance



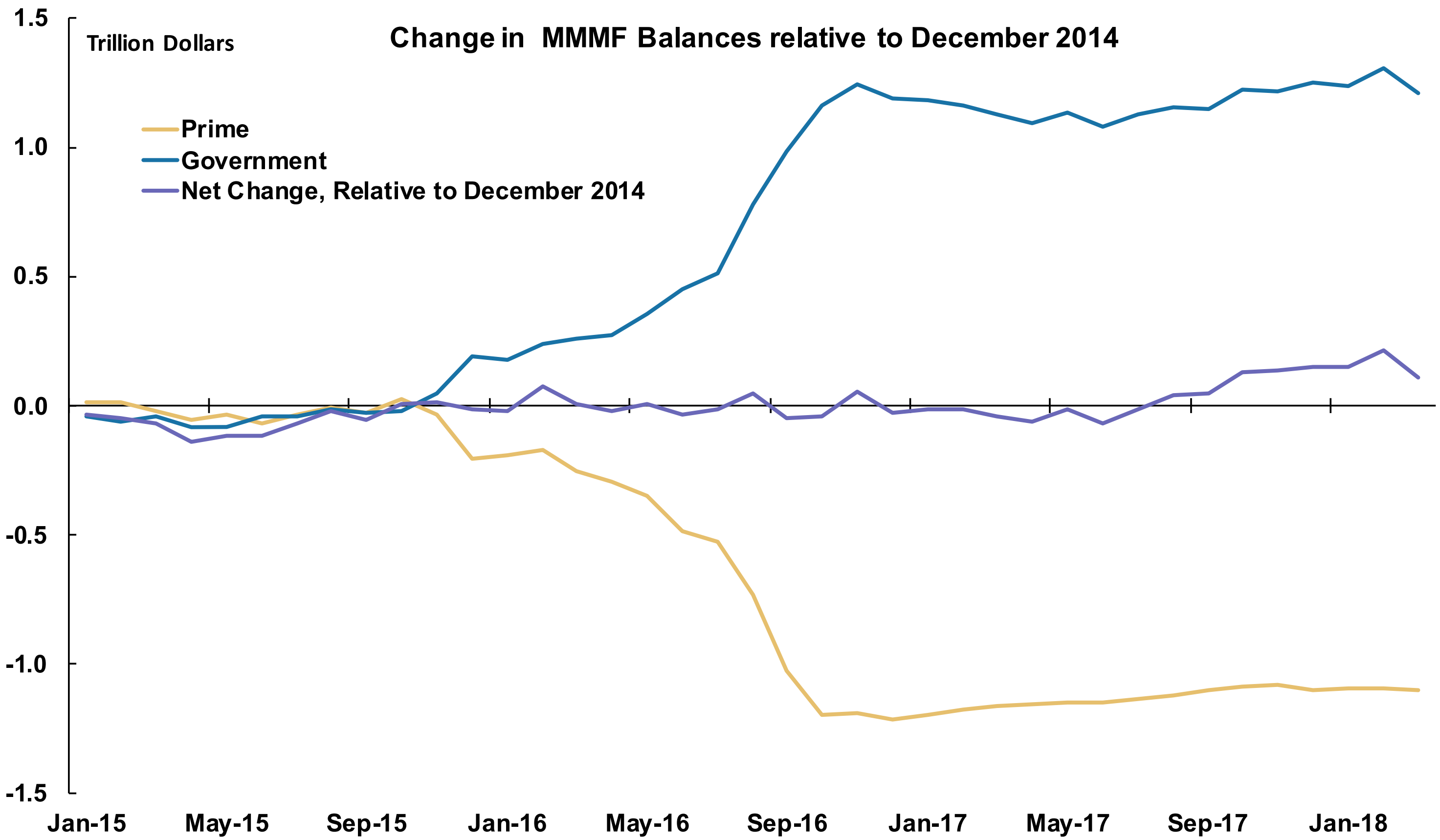
Source: FHLB Office of Finance

Figure 3: Money-market fund Landscape



Source: Office of Financial Research U.S. money-market fund Monitor

Figure 4: Reform Moved Assets from Prime to Government Funds

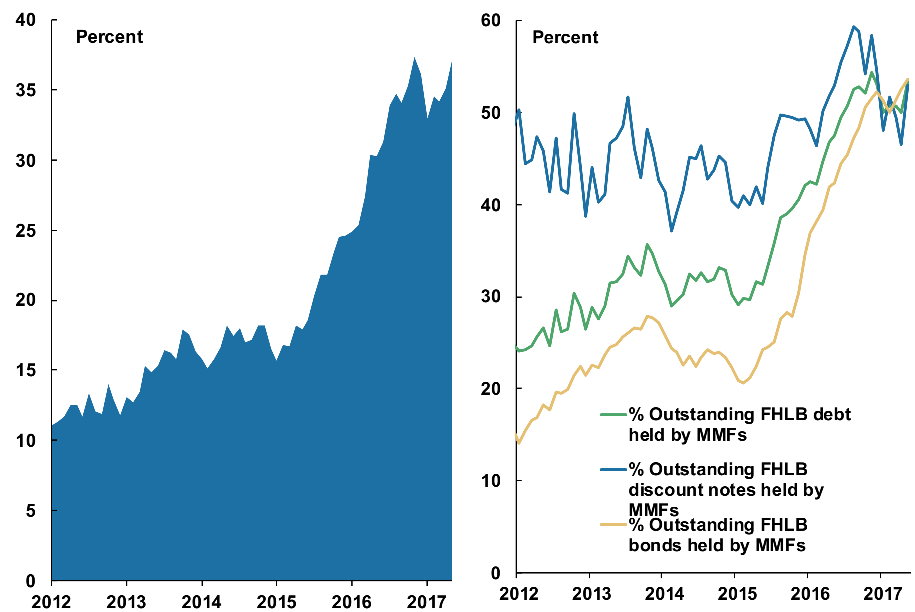


Source: Office of Financial Research U.S. money-market fund Monitor

Figure 5: FHLB Debt and money-market funds

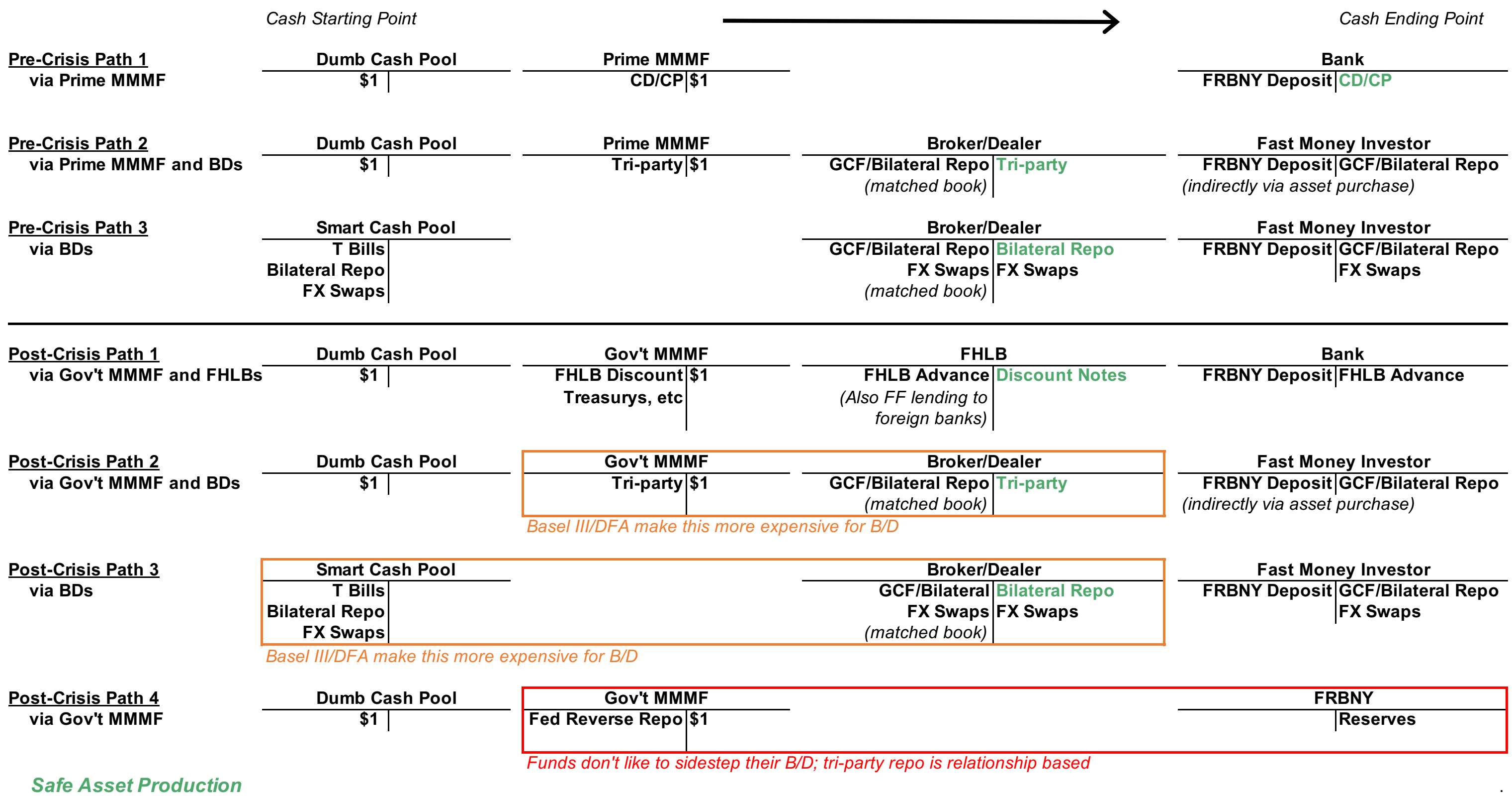
(a) Share of MMF Assets in FHLB Debt

(b) Share of FHLB Debt Held by MMFs



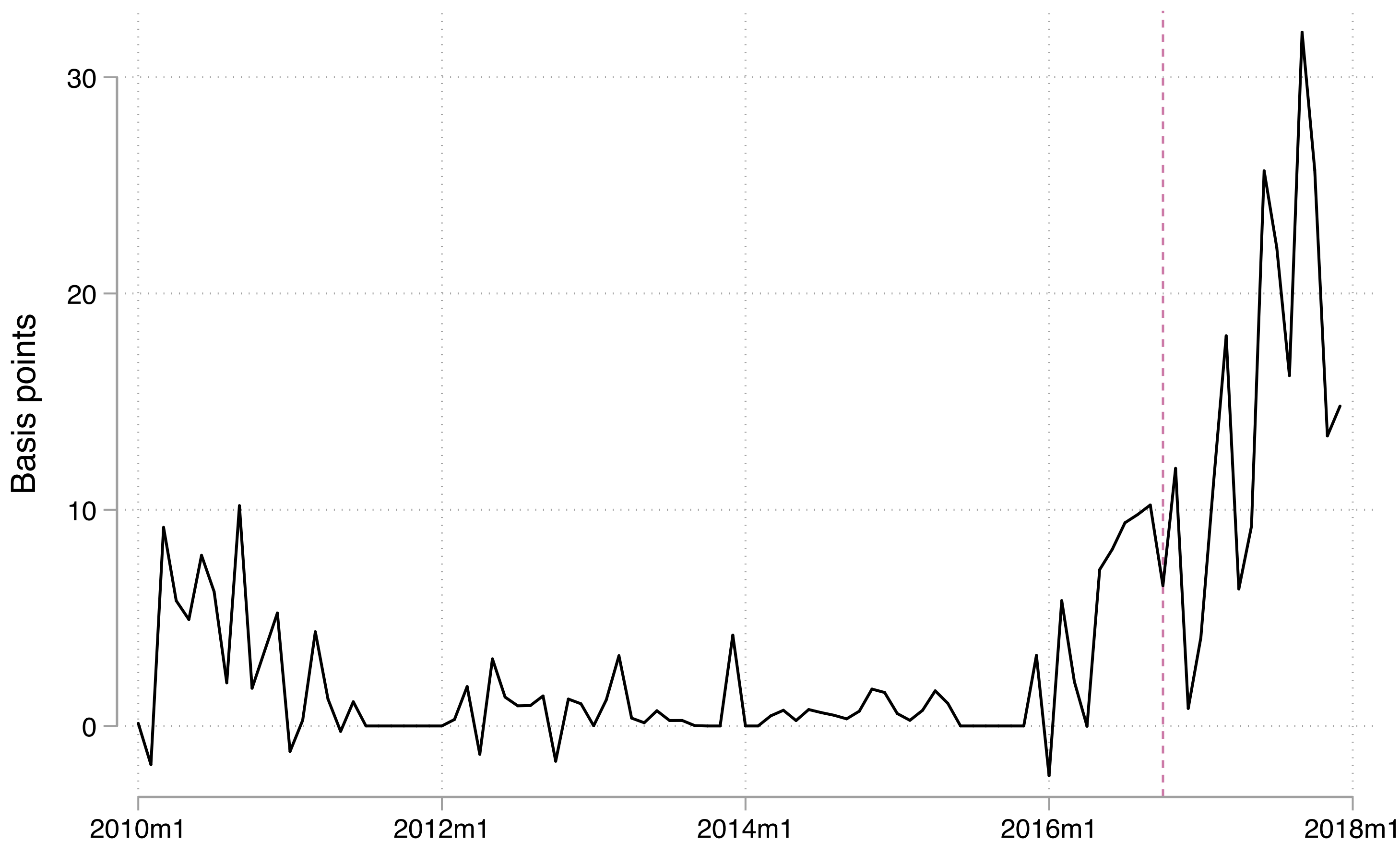
Source: Gissler and Narajabad (2017b)

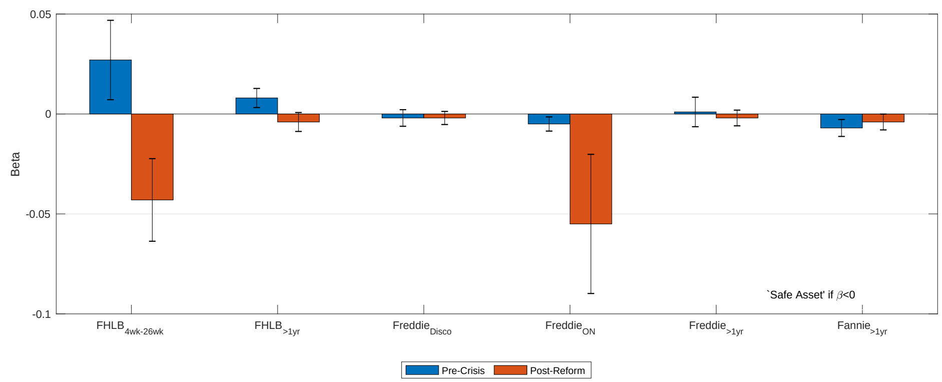
Figure 6: Changing Sources of Safe Assets



Source: Modified from Pozsar (2017).

Figure 7: Money Market Reforms Pushed Month-End Flows to FHLBs: Difference between intra-month and month-end rate for O/N FHLB discos





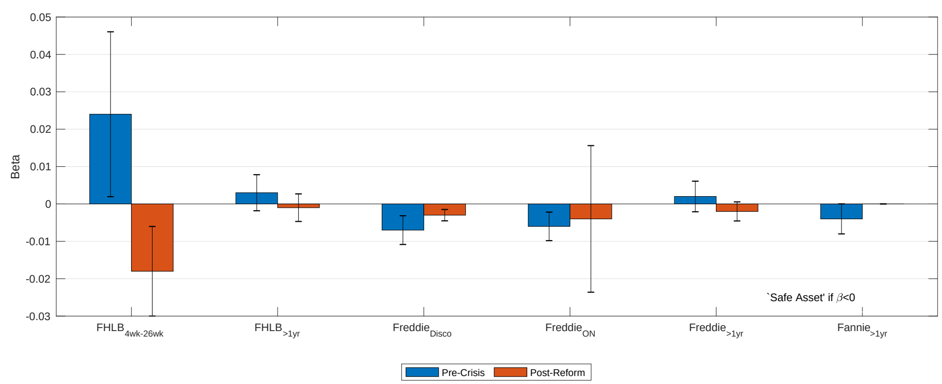


Figure 8: **Issuance Impact on Convenience Yield** Top: GCF-Tbill measure; Bottom: OIS-Tbill measure. Bar graphs plot the beta calculated in the following regression: $\text{ConYield}_t^{SA} = \alpha + \beta \log(\text{Issuance})_{t-1} + \theta_t + \varepsilon_t$. The results for this regression are reported in Table 21. Error bars represent 2 times the robust standard errors. θ_t are yearly fixed-effects. Regression run at the daily level. Dependent variable is seasonally adjusted convenience yield, measured either via the OIS-TBill or the GCF-TBill measure shown in Panels A and B respectively, which correspond to definitions 1 and 2. Issuance is calculated from the detrended series issuer i as described above. Freddie discos are discount notes that are not overnight, Freddie ON are overnight discos. Freddie and Fannie $> 1yr$ are issuances with greater than 1 year in maturity. Notice the timing: issuance from the day $t-1$ and the convenience yield as measured on day t.

Figure 9: Impulse Response Function: Effect of Impulse to Issuance on Convenience Yield (Post Money-Market Reforms)

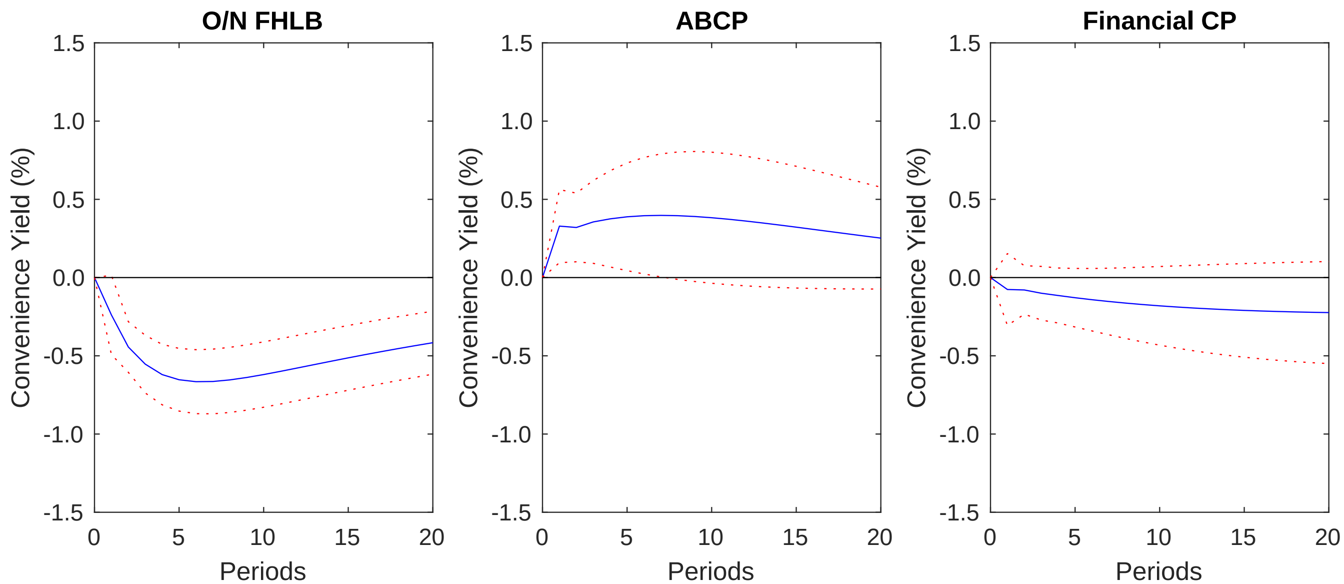
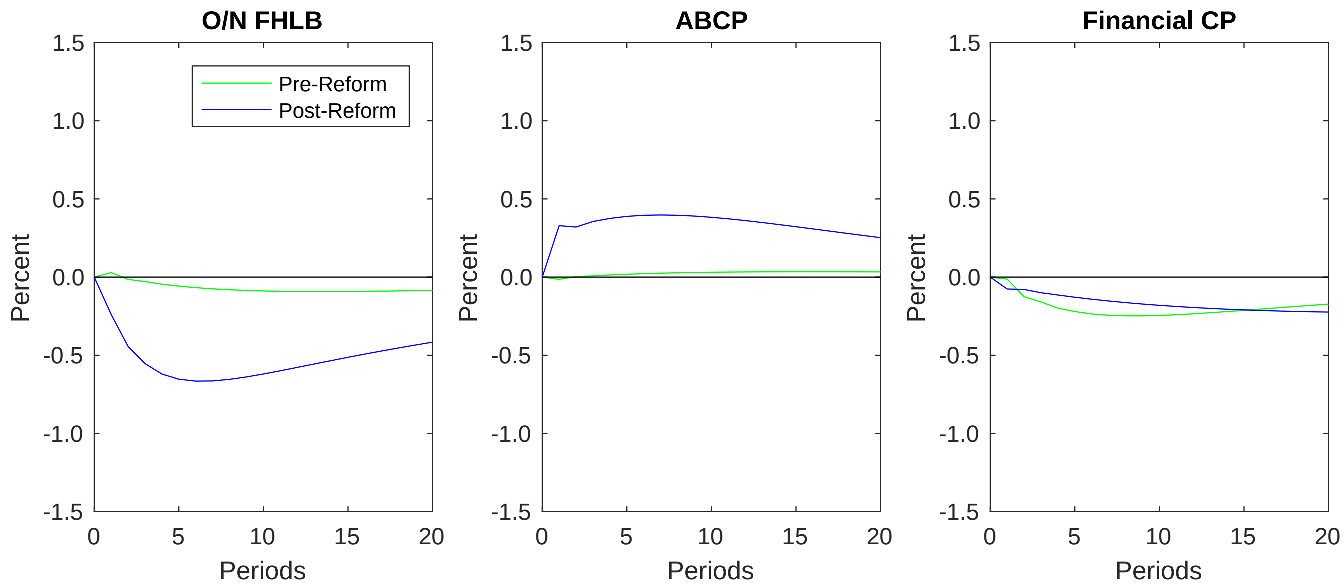


Figure 10: Impulse Response Function: Effect of Impulse to Issuance on Convenience Yield, Pre and Post-Reforms



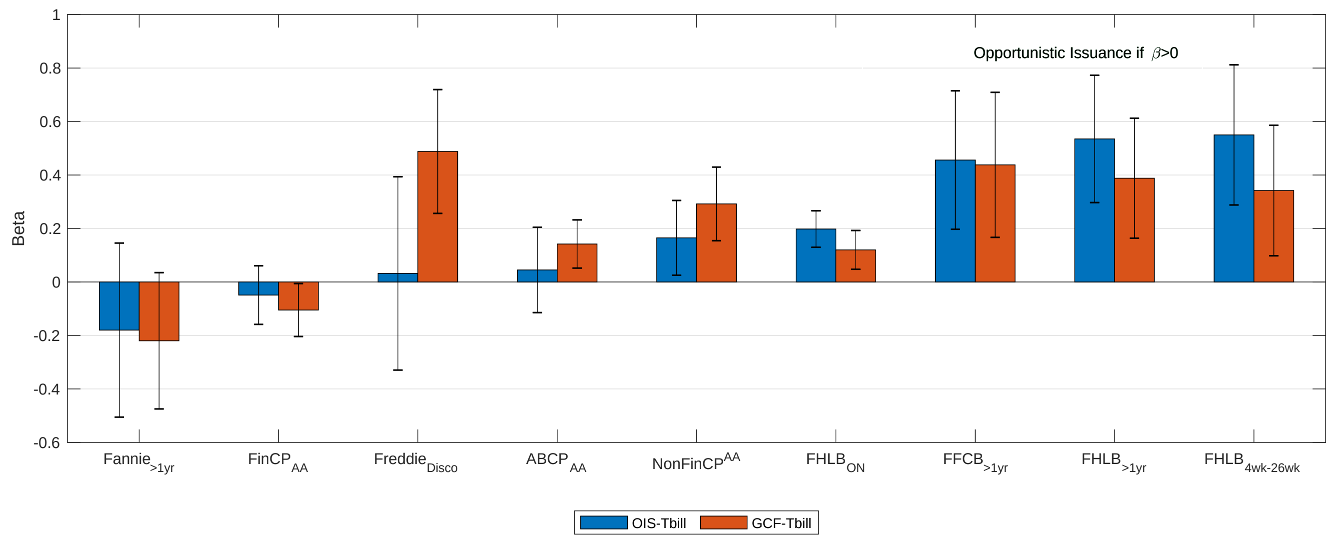


Figure 11: **Who Times Issuance? Beta of Issuance on Lagged Convenience Yield Measures.** Plots show beta coefficient shown in Table 30 from running benchmark test 2 regression: $\log(\text{Issuance})_t = \alpha + \beta_1 \text{SeasonalComponent}_t + \beta_2 \text{ConYield}^{SA}_{t-1} + \theta_t + \varepsilon_t$. Regression run at the daily level. Dependent variable is seasonally adjusted convenience yield, measured either via the OIS-TBill measure, which correspond to definitions 1. Independent variable is the issuance of the indicated series which is calculated from the detrended log of the issuance series. Notice the timing: issuance from the day $t-1$ and the convenience yield as measured on day t. $Freddie_{Disco}$ refers to Freddie discount notes, *Fannie* to bond issues with maturity greater than 1 year, and *FFCB* to Federal Farm Credit Banks bond issues with greater than 1 year maturity. ABCP, financial, and nonfinancial refers to commercial paper issuance with maturities 1 day to 4 days. Error bars reflect robust standard errors.

10 Tables

Table 3: Short-Term Sovereign Safe Debt Outstanding ($ Billions)

Year	FHLBs	Freddie	Fannie	Farm Cred.	Farmer Mac	TVA	Treasury Bills
2006	158.1	167.4	168.6	17.8	3.3	2.6	940.8
2007	378.4	197.6	234.2	19.7	0.7	1.6	999.5
2008	441.1	330.9	332.5	16.1	0.9	2.4	1,861.2
2009	198.6	238.3	200.6	11.6	1.9	1.1	1,793.5
2010	194.5	197.2	152.0	19.2	3.4	0.2	1,772.5
2011	190.2	161.4	146.8	13.6	4.1	0.8	1,520.5
2012	216.3	117.9	105.3	14.6	5.0	1.0	1,629.0
2013	293.3	141.8	72.3	18.6	5.0	1.8	1,592.0
2014	362.4	134.7	105.0	27.0	5.5	1.1	1,457.9
2015	494.3	113.6	71.1	32.3	5.0	1.5	1,514.0
2016	410.1	71.5	35.0	29.6	3.8	2.0	1,818.0
2017	392.0	73.2	33.4	25.6	1.7	2.7	1,955.9
2018	425.1	68.7	28.3	19.2	1.2	1.2	2,340.0

Note: Agency numbers include all maturities ≤1 year. 2018 value is 2018Q3.
Source: Sifma, U.S. Treasury.

Table 4: Consolidated FHLB Balance Sheet, Year End 2007

Assets (billions)		**Liabilities (billions)**	
Advances	875.1	Consolidated Bonds	802.6
Held-to-maturity securities	151.2	Consolidated Discos	376.3
Mortgages loans held in portfolio	91.6	Deposits	22.1
Fed funds sold	85.8	Derivative Liabilities	5.3
Interest bearing securities	48.2	Repo	1.5
Trading securities	6.8	Mandatorily redeemable capital stock	1.1
Available-for-sale securities	5.8	Total	1,220.9
Reverse repo	0.8		
Cash	0.3		
Total	1,274.5	Loss absorbing capital	50.3
Memo:			
GSE MBS	55.1	Leverage	25.4×
Private-Label MBS	88.0	Capital Ratio	3.94%
Total Investments	298.7		

Table 5: Consolidated FHLB Balance Sheet, 2018 Q3

Assets (billions)		**Liabilities (billions)**	
Advances	706.0	Consolidated Bonds	613.5
Held-to-maturity securities	80.3	Consolidated Discos	402.8
Mortgages loans held in portfolio	60.1	Deposits	8.2
Fed funds sold	72.7	Derivative Liabilities	0.4
Interest bearing securities	13.6	Other	5.7
Trading securities	13.4	Mandatorily redeemable capital stock	1.1
Available-for-sale securities	80.3	Total	1,220.9
Reverse repo/Securities Lending	45.3		
Cash/Deposits	14.4		
Total	1,098.3	Capital + Retained Earnings	57.6
Memo:			
GSE Obligations	19.6	Leverage	19.1×
Private-Label MBS	7.0	Capital Ratio	5.24%
GSE MBS	135.3		
Total Investments	318.3		

Table 6: Agency Debt Outstanding: 2007 vs. 2017

Billion Dollars		2007	2017	Percent Change
Freddie Mac	Overnight		1.0	
	Short-term excl. o/n	159.5	44.7	-71.3
	Long-term	362.8	162.3	-55.3
	Other	254.6	98.7	-61.2
	Total	776.9	306.7	-60.5
Fannie Mae	Short-term	161.7	33.3	-79.4
	Long-term	605.1	291.4	-51.8
	Total	766.9	324.7	-57.7
FHLB	Overnight	28.2	17.1	-39.4
	Short-term, excl. o/n	188.6	386.8	105.1
	Long-term	806.0	615.2	-23.7
	Total	1,022.8	1,019.1	-0.4

Table 7: Summary Statistics: Convenience Yield Measures (Post-Crisis)

	N	μ(%)	σ	Min	Max
Aaa Long Maturity$_t$ – UST Long Maturity$_t$	2,206	0.22	0.39	-0.65	0.89
OIS_t^{1mo} – TBill$_t$	2,165	0.06	0.05	-0.22	0.22
GCF$_t$ – TBill$_t$	2,165	0.10	0.08	-0.16	0.48

Table 8: Correlation: Convenience Yield Measures (Post-Crisis)

	AAA-UST	OIS-TBill	GCF-TBill
Aaa Long Maturity$_t$ – UST Long Maturity$_t$	1.00		
OIS_t^{1mo} – TBill$_t$	0.21	1.00	
GCF$_t$ – TBill$_t$	0.48	0.66	1.00

	OIS-TBill (1)	GCF - TBill (2)
Quarter End	0.022***	0.053***
	(5.60)	(9.01)
Constant	0.058***	0.326***
	(8.51)	(33.53)
N	3,432	6,052
Year FE	Yes	Yes

Table 9: **Convenience Yield Robustness Test: Quarter-End Dummy Regression**. Regression specification: $\text{OIS}_t^{1m} - \text{TBill}_t = \alpha + \beta_1 \mathbb{I}_{\text{Quarter-End}} + \theta_t + \varepsilon_t$ and $\text{GCF}_t^{1m} - \text{TBill}_t = \alpha + \beta_1 \mathbb{I}_{\text{Quarter-End}} + \theta_t + \varepsilon_t$. T-statistics are reported in parentheses using robust standard errors. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

	$ConYield^{SA}_{OIS}$	$ConYield^{SA}_{GCF}$	1W/OIS	1W/IBOR	1M/OIS	1M/IBOR	3M/OIS	3M/IBOR
$ConYield^{SA}_{OIS}$	1.000							
$ConYield^{SA}_{GCF}$	0.837***	1.000						
1 Week/OIS	0.149***	0.131***	1.000					
1 Week/IBOR	0.0886***	0.110***	0.433***	1.000				
1 Month/OIS	0.150***	0.136***	0.949***	0.203***	1.000			
1 Month/IBOR	0.0435**	0.0662***	0.306***	0.587***	0.292***	1.000		
3 Month/OIS	0.208***	0.176***	0.928***	0.157***	0.973***	0.229***	1.000	
3 Month/IBOR	-0.0159	0.0654***	0.113***	0.377***	0.0888***	0.721***	0.105***	1.000

Table 10: **Pairwise Correlation Between Benchmark Convenience Yield Measures and Covered Interest Parity Violations**. The convenience yield measures are seasonally adjusted using the pre-crisis regime sample. Each covered interest parity series is the first four principal components of the absolute value of the basis parity violation relative to the dollar from 1998 to 2018, measured at a daily level, and discounted either at OIS or the respective country's interbank offered rate. Series include the G11 currencies: Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), Danish krone (DKK), euro (EUR), British pound (GBP), Japanese yen (JPY), Norwegian krone (NOK), New Zealand dollar (NZD), and Swedish krona (SEK). 1 Week/XIBOR series does not include CAD or NZD, as the data is not available. Covered interest parity violations are calculated as in Du et al. (2018). *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

	$ConYield^{SA}_{OIS}$	$ConYield^{SA}_{GCF}$	*EquityVol*	*CDSVol*
$ConYield^{SA}_{OIS}$	1.000			
$ConYield^{SA}_{GCF}$	0.837***	1.000		
EquityVol	0.154***	0.392***	1.000	
CDSVol	0.222***	0.236***	0.577***	1.000

Table 11: **Pairwise Correlations between Benchmark Convenience Yield Measures and Information Production Measures Cross-Sectional Standard Deviation of Equities and CDS.** Cross-sectional volatility for stocks, *EquityVol* is proposed in Chousakos et al. (2018) and is calculated from cross sectional volatility of daily CRSP returns following sample selection of Asness et al. (2013). In particular, sample excludes: financials, real estate, insurance companies; stocks with share codes that are not ordinary common stocks; stocks with a price less than $1 at the beginning of a month; stocks without at least 12 months of return history; and stocks that are not in the top 90% of market value when ranked by market value. The purpose of this selection is produce a sample of stocks that are the most liquid and easily tradable. Additional details provided in Asness et al. (2013). The credit default swap measure, *CDSVol*, is the cross-sectional standard deviation in the daily change in 5 year swap spreads across specific contracts. Daily data is provided by Markit and the sample includes contracts with the following attributes: USD-denominated; North American reference entity, senior unsecured tier, ratings between AAA and BBB.

Dep. Var.: ABCP Issuance	(1)	(2)
$SeasonalComponent_{t-1}^{OIS-TBill}$	1.200**	
	(2.98)	
$SeasonalComponent_{t-1}^{GCF-TBill}$		1.698***
		(6.99)
Quarter End	-0.107***	-0.117***
	(-3.78)	(-4.06)
Constant	-0.080**	-0.159***
	(-2.96)	(-6.11)
N	993	993
Year FE	Yes	Yes

Table 12: **Convenience Yield Robustness Test: ABCP Issuance and Measures of the Convenience Yield.** Regression specification: $\log(\text{ABCP Issuance})_{\text{Detrended},t} = \alpha + \beta \text{SeasonalComponent}_{t-1} + \mathbb{I}_{\text{Quarter-End}} + \theta_t + \varepsilon_t$. T-statistics are reported in parentheses using robust standard errors. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Con. Yield Measure:		OIS-TBill			GCF-TBll	
$Issuance_{t-1}$	-0.018*	-0.015**	-0.012**	-0.041**	-0.036***	-0.011
	(-2.04)	(-2.89)	(-3.17)	(-3.02)	(-4.01)	(-1.91)
Constant	0.024**	0.027***	0.011***	0.070***	0.040**	0.023
	(2.66)	(8.47)	(2.68)	(6.24)	(5.60)	(1.81)
N	422	422	422	422	422	422
Adj. R^2	0.01	0.57	0.84	0.03	0.44	0.83
fixed-effects	None	Year	Year-Month	None	Year	Year-Month

Table 13: **Benchmark Test 1 Main Result: FHLB Issuance Drives the Subsequent Convenience Yield.** $\text{ConYield}_t^{SA} = \alpha + \beta \log(\text{FHLB Issuance})_{t-1} + \theta_t + \varepsilon_t$. Regression run at the daily level. Dependent variable is seasonally adjusted convenience yield, measured either via the OIS-TBill or the GCF-TBill measure, which correspond to definitions 1 and 2, respectively. Issuance is calculated from the detrended series for FHLB issuance of maturities 4 weeks to 26 weeks. Notice the timing: issuance from the day $t-1$ and the convenience yield as measured on day t. Time frame is July 2014 to December 2018, reflecting the period after which the money market reforms had been announced. T-statistics are reported in parentheses using robust standard errors except for the specifications without fixed-effects which instead report Newey-West standard errors with a maximum of 20 lags. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Con. Yield Measure:		OIS-TBill			GCF-TBll	
$Issuance_{t-1}$	0.003	0.000	0.002	-0.001	-0.002	0.000
	(0.52)	(0.05)	(1.57)	(-0.21)	(-0.98)	(0.35)
Constant	0.092***	0.015**	0.017**	0.060***	-0.036**	-0.035**
	(6.14)	(2.60)	(2.98)	(5.24)	(-3.17)	(-3.02)
N	4123	4123	4123	4109	4109	4109
Adj. R^2	0.00	0.65	0.91	-0.00	0.61	0.84
FE	None	Year	Year-Month	None	Year	Year-Month

Table 14: **Benchmark Test 1 Robustness Test: Corporate Bond Issuance Does Not Drive the Convenience Yield.** $\text{ConYield}_t^{SA} = \alpha + \beta \log(\text{Corporate Bond Issuance})_{t-1} + \theta_t + \varepsilon_t$. Regression run at the daily level. Dependent variable is seasonally adjusted convenience yield, measured either via the OIS-TBill or the GCF-TBill measure, which correspond to definitions 1 and 2, respectively. Issuance is calculated from the detrended series for corporate bond issuance. Notice the timing: issuance from the day $t-1$ and the convenience yield as measured on day t. T-statistics are reported in parentheses using robust standard errors except for the specifications without fixed-effects which instead report Newey-West standard errors with a maximum of 20 lags. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

Panel A: OIS-Tbill Measure of Convenience Yield	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
$FHLB_{t-1}$	-0.013*	-0.015**	-0.015**	-0.017*	-0.014**	-0.015**	-0.013*	-0.014*	-0.020**	-0.011	-0.019*
	(-2.57)	(-2.78)	(-2.85)	(-2.39)	(-3.04)	(-2.85)	(-2.57)	(-2.53)	(-2.70)	(-1.10)	(-2.12)
$ABCP_{t-1}$		0.002									
		(0.21)									
$FinCP_{t-1}$		0.004									
		(1.45)									
$Tbill_{t-1}$			-0.157*								
			(-2.04)								
$Freddie^{ON}_{t-1}$				0.003							
				(0.23)							
$Freddie^{Disco}_{t-1}$					-0.002						
					(-1.94)						
$Freddie^{>1yr}_{t-1}$						-0.004*					
						(-2.06)					
$Fannie^{>1yr}_{t-1}$							0.002				
							(0.95)				
$FFCB^{>1yr}_{t-1}$								0.001			
								(0.53)			
CDO_{t-1}									0.001		
									(0.13)		
MBS_{t-1}										-0.007	
										(-1.15)	
ABS^{US}_{t-1}											0.002
											(0.62)
Constant	0.026***	0.025***	0.026***	-0.011	0.026***	0.025***	0.026***	0.026***	0.029***	0.027***	0.028***
	(9.36)	(8.21)	(9.09)	(-0.52)	(8.69)	(8.59)	(8.10)	(9.07)	(7.44)	(5.12)	(7.40)
N	422	416	400	341	416	338	190	387	237	96	272
Adj. R^2	0.58	0.56	0.53	0.60	0.59	0.51	0.41	0.55	0.63	0.55	0.59
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: GCF-Tbill Measure of Convenience Yield	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
$FHLB_{t-1}$	-0.028**	-0.040***	-0.025**	-0.033**	-0.030***	-0.031**	-0.028**	-0.033***	-0.038**	-0.029	-0.042**
	(-3.24)	(-4.35)	(-2.89)	(-3.14)	(-3.41)	(-3.32)	(-2.71)	(-3.45)	(-2.87)	(-1.66)	(-3.09)
$ABCP_{t-1}$		0.092***									
		(6.20)									
$FinCP_{t-1}$		0.003									
		(0.77)									
$Tbill_{t-1}$			0.201								
			(1.69)								
$Freddie^{ON}_{t-1}$				-0.044							
				(-1.89)							
$Freddie^{Disco}_{t-1}$					0.001						
					(0.33)						
$Freddie^{>1yr}_{t-1}$						-0.006*					
						(-2.08)					
$Fannie^{>1yr}_{t-1}$							0.002				
							(0.75)				
$FFCB^{>1yr}_{t-1}$								-0.001			
								(-0.37)			
CDO_{t-1}									0.011		
									(1.22)		
MBS_{t-1}										-0.006	
										(-0.72)	
ABS^{US}_{t-1}											0.001
											(0.26)
Constant	0.034***	0.038***	0.034***	0.024	0.034***	0.034***	0.029***	0.035***	0.043***	0.041*	0.033***
	(4.99)	(6.40)	(5.12)	(0.75)	(4.96)	(4.99)	(3.37)	(5.10)	(4.91)	(2.59)	(3.67)
N	422	416	400	341	416	338	190	387	237	96	272
Adj. R^2	0.45	0.47	0.46	0.49	0.45	0.41	0.37	0.46	0.48	0.45	0.45
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 15: **Benchmark Test 1 Robustness Test: FHLB Horseraces.** $\text{ConYield}_t^{SA} = \alpha + \beta_1 \log(\text{FHLB Issuance})_{t-1} + \beta_2 \log(\text{Control Issuance})_{t-1} + \theta_t + \varepsilon_t$. Regression run at the daily level. Dependent variable is seasonally adjusted convenience yield, measured either via the OIS-TBill measure or GCF-Tbill measure, which correspond to definitions 1 and 2. Independent variable is the issuance of the indicated series which is calculated from the detrended log of the issuance series. Notice the timing: issuance from the day $t-1$ and the convenience yield as measured on day t. Time frame is post-reform period fro July 2014 to December 2018. *FHLB* is 4 week to 26 week maturity disco issuance; *FinCP* and *ABCP* refer to commercial paper issuance with maturities 1 day to 4 days. *CDO*, *MBS*, and *ABS* refer to USD denominated securitized issuance after detrending. T-statistics are reported in parentheses using robust standard errors. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Con. Yield Measure:			GCF-Tbill					OIS-Tbill		
$TBill_{t-1}$	-0.795*	-0.787*	-0.772*	-0.749*	-0.734*	-0.750**	-0.739**	-0.722*	-0.710*	-0.690*
	(-2.17)	(-2.14)	(-2.11)	(-2.05)	(-2.02)	(-2.66)	(-2.63)	(-2.56)	(-2.51)	(-2.44)
$TBill_{t-2}$		-0.274	-0.261	-0.237	-0.218		-0.512	-0.503	-0.486	-0.475
		(-0.70)	(-0.67)	(-0.61)	(-0.56)		(-1.84)	(-1.81)	(-1.74)	(-1.70)
$TBill_{t-3}$			-0.427	-0.409	-0.391			-0.564*	-0.556*	-0.542
			(-1.20)	(-1.14)	(-1.09)			(-2.00)	(-1.97)	(-1.92)
$TBill_{t-4}$				-0.599	-0.584				-0.531	-0.524
				(-1.62)	(-1.58)				(-1.75)	(-1.73)
$TBill_{t-5}$					-0.543					-0.434
					(-1.56)					(-1.43)
Constant	0.112***	0.112***	0.112***	0.112***	0.112***	0.036***	0.036***	0.036***	0.036***	0.036***
	(46.24)	(46.23)	(46.24)	(46.25)	(46.25)	(23.44)	(23.43)	(23.45)	(23.46)	(23.47)
N	5,985	5,985	5,985	5,985	5,985	3,365	3,365	3,365	3,365	3,365
Adj. R^2	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01

Table 16: **Additional Evidence for Benchmark Test 1: Convenience Yield Falls After Treasury Bill Issuance.** $\text{ConYield}_t^{SA} = \alpha + \sum_{j=1}^{5} \beta_j \log(\text{TBills})_{t-j} + \theta_t + \varepsilon_t$. Regression run at the daily level. Dependent variable is seasonally adjusted convenience yield, measured either via the OIS-TBill or the GCF-TBill measure, which correspond to definitions 1 and 2, respectively. Issuance is calculated from the detrended series for Treasury bill issuance. Notice the timing: issuance from the day $t-1$ and the convenience yield as measured on day t. Sample excludes the crisis period. T-statistics are reported in parentheses using robust standard errors. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Pre-Crisis		Crisis		Pre-Reform		Post-Reform	
Con. Yield Measure:	OIS-Tbill	GCF-Tbill	OIS-Tbill	GCF-Tbill	OIS-Tbill	GCF-Tbill	OIS-Tbill	GCF-Tbill
$Issuance_{t-1}$	0.023*	0.036***	0.130***	0.021	-0.002	-0.010**	-0.015**	-0.036***
	(2.30)	(3.50)	(3.93)	(0.72)	(-0.78)	(-3.98)	(-3.06)	(-3.98)
Constant	-0.009	-0.416***	0.483***	0.273***	-0.003	-0.009***	0.027***	0.040***
	(-0.41)	(-10.50)	(17.02)	(10.78)	(-1.84)	(5.60)	(-4.21)	(5.60)
N	425	527	311	307	475	475	422	422
Adj. R^2	0.53	0.52	0.51	0.48	0.06	0.47	0.57	0.44
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 17: **Migration in Benchmark Test 1: FHLB Issuance Drives Convenience Yield Post Crisis, Not Pre-Crisis**. $\text{ConYield}_t^{SA} = \alpha + \beta \log(\text{FHLB Issuance})_{t-1} + \theta_t + \varepsilon_t$. Pre-crisis regime is through 2007, crisis is through 2009, pre-reform is through July 2014, and post-reform is after July 2014. Regression run at the daily level. Dependent variable is seasonally adjusted convenience yield, measured either via the OIS-TBill or the GCF-TBill measure, which correspond to definitions 1 and 2, respectively. Issuance is calculated from the detrended series for FHLB issuance of maturities 4 weeks to 26 weeks. Notice the timing: issuance from the day $t-1$ and the convenience yield as measured on day t. T-statistics are reported in parentheses using robust standard errors. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

Panel A: OIS-Tbill Measure of Convenience Yield

	(1) $FHLB_{4wk-26wk}$	(2) $FHLB_{>1yr}$	(3) $Freddie_{ON}$	(4) $Freddie_{Disco}$	(5) $Freddie_{>1yr}$	(6) $Fannie_{>1yr}$	(7) $FFCB_{>1yr}$
$Issuance_{t-1}$	0.043***	0.003	-0.006**	-0.006***	0.000	-0.004*	0.005
	(3.99)	(1.11)	(-3.30)	(-3.41)	(0.19)	(-2.03)	(1.85)
$Issuance_{t-1} \times \mathbb{I}_{Crisis}$	0.085**	0.050***	0.023	0.013	-0.001	0.004	0.030**
	(2.81)	(5.01)	(0.74)	(1.53)	(-0.08)	(0.46)	(2.78)
$Issuance_{t-1} \times \mathbb{I}_{PreReform}$	-0.031	-0.001		0.004	-0.003	0.006	-0.010**
	(-1.91)	(-0.28)		(1.32)	(-0.83)	(1.88)	(-2.63)
$Issuance_{t-1} \times \mathbb{I}_{PostReform}$	-0.050***	0.000	0.063***	0.001	0.003	0.006	-0.002
	(-3.72)	(0.13)	(3.64)	(0.36)	(0.89)	(1.86)	(-0.40)
$\mathbb{I}_{Crisis}$	-0.163***	-0.186***	0.522***	-0.179***	-0.175***	-0.176***	-0.181***
	(-9.59)	(-16.06)	(4.75)	(-17.00)	(-16.22)	(-15.12)	(-13.77)
$\mathbb{I}_{PreReform}$	-0.222***	-0.199***		-0.195***	-0.201***	-0.191***	-0.199***
	(-10.95)	(-14.03)		(-14.28)	(-13.08)	(-7.17)	(-12.67)
$\mathbb{I}_{PostReform}$	-0.217***	-0.206***	-0.216***	-0.205***	-0.216***	-0.211***	-0.211***
	(-14.42)	(-18.91)	(-18.17)	(-20.53)	(-19.29)	(-9.84)	(-16.81)
Constant	-0.002	-0.010	-0.010	-0.010	-0.010	-0.010	-0.009
	(-0.16)	(-1.09)	(-0.97)	(-1.17)	(-1.18)	(-1.01)	(-0.80)
N	1633	3768	1270	3891	3260	2919	3442
Adj. R^2	0.65	0.64	0.64	0.62	0.62	0.63	0.63
Year FE	Yes	Yes		Yes	Yes	Yes	Yes

Panel B: GCF-Tbill Measure of Convenience Yield

	(1) $FHLB_{4wk-26wk}$	(2) $FHLB_{>1yr}$	(3) $Freddie_{ON}$	(4) $Freddie_{Disco}$	(5) $Freddie_{>1yr}$	(6) $Fannie_{>1yr}$	(7) $FFCB_{>1yr}$
$Issuance_{t-1}$	0.054***	0.002	-0.006**	0.006**	-0.005*	-0.004*	0.002
	(4.34)	(0.88)	(-2.67)	(2.62)	(-2.10)	(-1.97)	(0.96)
$Issuance_{t-1} \times \mathbb{I}_{Crisis}$	-0.021	0.026***	0.036	-0.003	-0.005	-0.000	0.013
	(-0.81)	(3.45)	(1.56)	(-0.54)	(-0.79)	(-0.01)	(1.70)
$Issuance_{t-1} \times \mathbb{I}_{PreReform}$	-0.060***	0.000		-0.007**	0.005	0.009***	-0.003
	(-4.02)	(0.14)		(-2.84)	(1.91)	(3.40)	(-1.11)
$Issuance_{t-1} \times \mathbb{I}_{PostReform}$	-0.061***	-0.005	-0.006	-0.007**	0.005	0.003	-0.001
	(-4.04)	(-1.52)	(-0.36)	(-2.90)	(1.72)	(1.05)	(-0.22)
$\mathbb{I}_{Crisis}$	-0.292***	-0.057***	0.119	-0.451***	-0.053*	-0.046*	-0.031
	(-19.30)	(-3.83)	(1.59)	(-32.54)	(-2.33)	(-2.18)	(-1.22)
$\mathbb{I}_{PreReform}$	-0.282***	-0.040*		-0.433***	-0.043	-0.043	-0.022
	(-14.43)	(-2.31)		(-27.31)	(-1.69)	(-1.63)	(-0.82)
$\mathbb{I}_{PostReform}$	-0.250***	-0.015	-0.240***	-0.409***	-0.020	-0.024	-0.002
	(-16.16)	(-0.97)	(-21.14)	(-29.09)	(-0.82)	(-1.00)	(-0.09)
Constant	0.096***	-0.146***	0.079***	0.252***	-0.141***	-0.150***	-0.168***
	(7.59)	(-10.45)	(8.43)	(19.48)	(-6.41)	(-7.34)	(-6.70)
N	2035	6241	2591	5717	5238	4924	4849
Adj. R^2	0.56	0.61	0.63	0.62	0.61	0.62	0.62
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 18: **Migration in Benchmark Test 1: Pre-Crisis to Post-Reforms Migration between Freddie, Fannie, and FHLBs**

Regime	(1) Pre	(2) Reform	(3) Pre	(4) Reform	(5) Pre	(6) Reform	(7) Pre	(8) Reform	(9) Pre	(10) Reform	(11) Pre	(12) Reform	(13) Pre	(14) Reform	(15) Pre	(16) Reform	(17) Pre	(18) Reform
$FHLB_{t-1}$	0.023*	-0.015**	0.023*	-0.018***	0.027*	-0.017**	0.022*	-0.016**	0.022*	-0.015**	0.022	-0.021**	0.024*	-0.016***	0.016	-0.016**	0.021	-0.013*
	(2.30)	(-3.03)	(2.32)	(-3.32)	(2.48)	(-2.77)	(2.24)	(-3.19)	(2.22)	(-2.98)	(1.53)	(-2.92)	(2.37)	(-3.58)	(1.68)	(-3.09)	(1.92)	(-2.55)
$ABCP_{t-1}$			-0.003	0.009														
			(-0.16)	(0.82)														
$FinCP_{t-1}$			-0.055**	0.005														
			(-2.71)	(1.87)														
ABS_{t-1}					0.009*	-0.006*												
					(2.06)	(-2.37)												
$Tbill_{t-1}$							-0.144	-0.199*										
							(-1.34)	(-2.49)										
$Treasurys_{t-1}$									-0.686	-0.689								
									(-1.42)	(-1.17)								
$Freddie^{ON}_{t-1}$											-0.006*	-0.005						
											(-2.57)	(-0.42)						
$Freddie^{Disco}_{t-1}$													-0.002	-0.003*				
													(-0.96)	(-2.44)				
$Freddie^{>1yr}_{t-1}$															0.003	-0.004*		
															(0.76)	(-2.06)		
$Fannie^{>1yr}_{t-1}$																	-0.002	0.001
																	(-0.70)	(0.76)
Constant	-0.009	0.027***	-0.014	0.026***	-0.009	0.027***	-0.007	0.027***	-0.004	0.027***	-0.018	-0.014	-0.009	0.027***	-0.009	0.028***	-0.009	0.023***
	(-0.41)	(8.47)	(-0.65)	(7.49)	(-0.40)	(7.99)	(-0.35)	(8.34)	(-0.19)	(8.37)	(-0.81)	(-0.66)	(-0.42)	(7.67)	(-0.45)	(8.00)	(-0.42)	(6.70)
N	425	422	424	415	418	386	425	399	425	399	294	342	425	416	394	337	390	190
Adj. R^2	0.53	0.57	0.53	0.55	0.53	0.58	0.53	0.52	0.53	0.51	0.44	0.59	0.52	0.59	0.54	0.51	0.53	0.35
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 19: **Migration in Benchmark Test 1: OIS-Tbill measure.** $\text{ConYield}_t^{SA} = \alpha + \beta_1 \log(\text{FHLB Issuance})_{t-1} + \beta_2 \log(\text{Control Issuance})_{t-1} + \theta_t + \varepsilon_t$. Regression run at the daily level. Dependent variable is seasonally adjusted convenience yield, measured via the OIS-TBill measure, which corresponds to definition 1. Independent variable is the issuance of the indicated series which is calculated from the detrended log of the issuance series. *Treasurys* includes bills, notes and bonds. Notice the timing: issuance from the day $t-1$ and the convenience yield as measured on day t. Pre-crisis regime refers to pre-2008, whereas reform period refers to July 2014 to December 2018, reflecting the period after which the money market reforms had been announced. T-statistics are reported in parentheses using robust standard errors except for the specifications without fixed-effects which instead report Newey-West standard errors with a maximum of 20 lags. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

Regime	(17) Pre	(18) Reform	(19) Pre	(20) Reform	(21) Pre	(22) Reform	(23) Pre	(24) Reform	(25) Pre	(26) Reform	(27) Pre	(28) Reform	(29) Pre	(30) Reform	(31) Pre	(32) Reform	(33) Pre	(34) Reform
$FHLB_{t-1}$	0.062***	-0.036***	0.062***	-0.051***	0.056***	-0.040***	0.062***	-0.033***	0.063***	-0.032***	0.060***	-0.040***	0.062***	-0.038***	0.058***	-0.039***	0.055***	-0.030**
	(5.08)	(-3.98)	(3.92)	(-5.49)	(4.59)	(-3.48)	(4.95)	(-3.62)	(4.94)	(-3.45)	(4.30)	(-3.68)	(5.13)	(-4.14)	(4.69)	(-4.03)	(4.21)	(-2.90)
$ABCP_{t-1}$			-0.028	0.106***														
			(-0.69)	(7.07)														
$FinCP_{t-1}$			-0.029	0.006														
			(-1.15)	(1.64)														
ABS_{t-1}					-0.007	-0.008*												
					(-1.17)	(-2.14)												
$Tbill_{t-1}$							0.053	0.150										
							(0.37)	(1.16)										
$Treasurys_{t-1}$									0.300	1.845*								
									(0.44)	(2.07)								
$Freddie^{ON}_{t-1}$											-0.008**	-0.058*						
											(-3.01)	(-2.50)						
$Freddie^{Disco}_{t-1}$													-0.004	-0.001				
													(-1.43)	(-0.35)				
$Freddie^{>1yr}_{t-1}$															0.003	-0.006*		
															(0.64)	(-2.32)		
$Fannie^{>1yr}_{t-1}$																	-0.007	0.000
																	(-1.45)	(0.11)
Constant	0.077***	0.040***	0.045	0.043***	0.077***	0.040***	0.077***	0.039***	0.077***	0.039***	0.076***	0.017	0.076***	0.039***	0.074***	0.039***	0.072***	0.033***
	(6.50)	(5.60)	(1.61)	(7.04)	(6.45)	(5.40)	(6.53)	(5.68)	(6.53)	(5.69)	(6.56)	(0.50)	(6.35)	(5.41)	(5.84)	(5.19)	(6.09)	(4.55)
N	829	422	622	415	801	386	829	399	829	399	680	342	827	416	765	337	747	190
Adj. R^2	0.53	0.44	0.44	0.48	0.53	0.44	0.53	0.45	0.53	0.45	0.53	0.48	0.53	0.44	0.53	0.40	0.53	0.34
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 20: **Migration in Benchmark Test 1: GCF-Tbill measure.** $\text{ConYield}^{SA}_t = \alpha + \beta_1 \log(\text{FHLB Issuance})_{t-1} + \beta_2 \log(\text{Control Issuance})_{t-1} + \theta_t + \varepsilon_t$. Regression run at the daily level. Dependent variable is seasonally adjusted convenience yield, measured via the GCF-TBill measure, which corresponds to definition 2. Independent variable is the issuance of the indicated series which is calculated from the detrended log of the issuance series. *Treasurys* includes bills, notes and bonds. Notice the timing: issuance from the day $t-1$ and the convenience yield as measured on day t. Pre-crisis regime refers to pre-2008, whereas reform period refers to July 2014 to December 2018, reflecting the period after which the money market reforms had been announced. T-statistics are reported in parentheses using robust standard errors. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

Panel A: OIS-Tbill Measure of Convenience Yield

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
i =	$FHLB_{4wk-26wk}$		$FHLB_{>1yr}$		$Freddie_{ON}$		$Freddie_{Disco}$		$Freddie_{>1yr}$		$Fannie_{>1yr}$	
Regime	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
$Issuance^{i}_{t-1}$	0.024*	-0.018**	0.003	-0.001	-0.007***	-0.003***	-0.006**	-0.004	0.002	-0.002	-0.004*	-0.000
	(2.18)	(-3.00)	(1.24)	(-0.54)	(-3.65)	(-3.95)	(-3.14)	(-0.41)	(0.98)	(-1.57)	(-1.99)	(-0.19)
Constant	-0.020	0.026***	-0.014	0.023***	-0.014	0.023***	-0.016	0.036***	-0.015	0.023***	-0.014	0.021***
	(-0.97)	(7.73)	(-1.72)	(12.36)	(-1.76)	(11.33)	(-1.39)	(5.31)	(-1.82)	(11.55)	(-1.58)	(10.73)
N	405	405	949	911	970	967	544	678	858	745	909	411
Adj. R^2	0.52	0.59	0.54	0.57	0.55	0.62	0.43	0.61	0.56	0.52	0.55	0.36
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: GCF-Tbill Measure of Convenience Yield

	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
i =	$FHLB_{4wk-26wk}$		$FHLB_{>1yr}$		$Freddie_{ON}$		$Freddie_{Disco}$		$Freddie_{>1yr}$		$Fannie_{>1yr}$	
Regime	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
$Issuance^{i}_{t-1}$	0.027**	-0.043***	0.008***	-0.004	-0.002	-0.002	-0.005**	-0.055**	0.001	-0.002	-0.007***	-0.004*
	(2.72)	(-4.16)	(3.35)	(-1.69)	(-0.96)	(-1.22)	(-2.82)	(-3.16)	(0.27)	(-1.02)	(-3.31)	(-2.02)
Constant	-0.253***	0.039***	-0.255***	0.033***	-0.254***	0.032***	-0.252***	0.111***	-0.256***	0.033***	-0.257***	0.032***
	(-27.93)	(5.22)	(-47.18)	(7.08)	(-47.27)	(6.81)	(-39.63)	(8.52)	(-47.24)	(6.16)	(-47.50)	(6.08)
N	497	405	1163	911	1188	967	713	678	1074	745	1117	411
Adj. R^2	0.50	0.47	0.49	0.43	0.49	0.45	0.38	0.48	0.49	0.41	0.49	0.37
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 21: **Migration in Benchmark Test 1: From Fannie to FHLBs, Freddie Unchanged.** $\text{ConYield}^{SA}_{t} = \alpha + \beta \log(\text{Issuance})_{t-1} + \theta_t + \varepsilon_t$. Regression run at the daily level. Dependent variable is seasonally adjusted convenience yield, measured either via the OIS-TBill or the GCF-TBill measure shown in Panels A and B respectively, which correspond to definitions 1 and 2. Issuance is calculated from the detrended series issuer i as described above. Notice the timing: issuance from the day $t-1$ and the convenience yield as measured on day t. T-statistics are reported in parentheses using robust standard errors. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Con. Yield Measure:	OIS-Tbill				GCF-Tbill			
Regime	PreCrisis	Reform	PreCrisis	Reform	PreCrisis	Reform	PreCrisis	Reform
$Freddie^{Disco}_{t-1}$	-0.004*	-0.003**	-0.004*	-0.002**	0.004	-0.001	0.003	-0.001
	(-2.17)	(-2.99)	(-2.21)	(-2.79)	(1.96)	(-0.39)	(1.36)	(-0.58)
$ABCP_{t-1}$			0.019	-0.010			-0.035	0.078***
			(1.55)	(-1.24)			(-1.58)	(6.51)
$FinCP_{t-1}$			-0.033**	0.003			0.008	0.001
			(-3.23)	(1.56)			(0.24)	(0.32)
Constant	-0.106***	0.023***	-0.118***	0.022***	-0.139***	0.033***	0.095***	0.034***
	(-7.20)	(11.69)	(-7.94)	(9.83)	(-99.47)	(6.94)	(5.78)	(7.65)
N	1013	1009	1011	981	2847	1009	1484	981
Adj. R^2	0.59	0.61	0.59	0.57	0.65	0.44	0.45	0.44
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 22: **Additional Evidence for Benchmark Test 1: Freddie Disco Horseraces.** $\text{ConYield}^{SA}_t = \alpha + \beta_1 \log(\text{Freddie Disco Issuance})_{t-1} + \beta_2 \log(\text{Control Issuance})_{t-1} + \theta_t + \varepsilon_t$. Regression run at the daily level. Dependent variable is seasonally adjusted convenience yield, measured either via the OIS-TBill or GCF-TBill measure, which correspond to definitions 1 and 2, respectively. Independent variable is the issuance of the indicated series which is calculated from the detrended log of the issuance series. Notice the timing: issuance from the day $t-1$ and the convenience yield as measured on day t. Pre-crisis regime refers to pre-2008, whereas reform period refers to July 2014 to December 2018, reflecting the period after which the money market reforms had been announced. T-statistics are reported in parentheses using robust standard errors. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Con. Yield Measure:	OIS-Tbill				GCF-Tbill			
Regime	PreCrisis	Reform	PreCrisis	Reform	PreCrisis	Reform	PreCrisis	Reform
$Freddie^{ON}_{t-1}$	-0.003	-0.001	-0.002	-0.019	-0.005*	-0.051**	-0.006**	-0.047*
	(-1.84)	(-0.15)	(-1.56)	(-1.88)	(-2.53)	(-2.85)	(-2.59)	(-2.44)
$ABCP_{t-1}$			-0.006	-0.039**		-0.095**	0.044*	
			(-0.31)	(-3.08)		(-3.14)	(2.12)	
$FinCP_{t-1}$			-0.038**	0.006**		0.005	0.008*	
			(-3.01)	(2.59)		(0.10)	(2.11)	
Constant	-0.105***	0.034***	-0.116***	0.047***	-0.136***	0.108***	0.100***	0.129***
	(-5.13)	(4.91)	(-5.43)	(5.67)	(-9.54)	(8.08)	(5.28)	(9.22)
N	544	677	543	655	1867	677	902	655
Adj. R^2	0.48	0.61	0.49	0.58	0.63	0.47	0.45	0.45
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 23: **Additional Evidence for Benchmark Test 1: Freddie Overnight Horseraces.** $\text{ConYield}_t^{SA} = \alpha + \beta_1 \log(\text{Freddie Overnight Issuance})_{t-1} + \beta_2 \log(\text{Control Issuance})_{t-1} + \theta_t + \varepsilon_t$. Regression run at the daily level. Dependent variable is seasonally adjusted convenience yield, measured either via the OIS-TBill or GCF-TBill measure, which correspond to definitions 1 and 2, respectively. Independent variable is the issuance of the indicated series which is calculated from the detrended log of the issuance series. Notice the timing: issuance from the day $t-1$ and the convenience yield as measured on day t. Pre-crisis regime refers to pre-2008, whereas reform period refers to July 2014 to December 2018, reflecting the period after which the money market reforms had been announced. T-statistics are reported in parentheses using robust standard errors. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Con. Yield Measure:	OIS-Tbill				GCF-Tbill			
Regime	PreCrisis	Reform	PreCrisis	Reform	PreCrisis	Reform	PreCrisis	Reform
$Fannie_{t-1}^{>1yr}$	0.002	-0.001	0.002	-0.001	-0.003	-0.005*	-0.004	-0.005*
	(0.87)	(-0.58)	(1.02)	(-0.44)	(-1.74)	(-2.42)	(-1.42)	(-2.36)
$ABCP_{t-1}$			-0.008	0.004			-0.033	0.081***
			(-0.59)	(0.48)			(-1.52)	(5.20)
$FinCP_{t-1}$			-0.036***	0.005*			0.016	0.007
			(-3.56)	(2.33)			(0.50)	(1.76)
Constant	-0.106***	0.022***	-0.110***	0.022***	-0.086***	0.033***	0.092***	0.037***
	(-7.60)	(9.98)	(-7.61)	(8.21)	(-7.12)	(5.90)	(5.36)	(6.29)
N	945	433	944	432	2,957	433	1391	432
Adj. R^2	0.58	0.35	0.59	0.36	0.65	0.36	0.44	0.40
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 24: **Additional Evidence for Benchmark Test 1: Fannie Horseraces.** $\text{ConYield}_t^{SA} = \alpha + \beta_1 \log(\text{Fannie Issuance})_{t-1} + \beta_2 \log(\text{Control Issuance})_{t-1} + \theta_t + \varepsilon_t$. Regression run at the daily level. Dependent variable is seasonally adjusted convenience yield, measured either via the OIS-TBill or GCF-TBill measure, which correspond to definitions 1 and 2, respectively. Independent variable is the issuance of the indicated series which is calculated from the detrended log of the issuance series. Notice the timing: issuance from the day $t-1$ and the convenience yield as measured on day t. Pre-crisis regime refers to pre-2008, whereas reform period refers to July 2014 to December 2018, reflecting the period after which the money market reforms had been announced. T-statistics are reported in parentheses using robust standard errors. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	$FHLB_{Overnight}$		$FHLB_{4wk-26wk}$		$FHLB_{>1yr}$	
	OIS-TBill	GCF-TBill	OIS-TBill	GCF-TBill	OIS-TBill	GCF-TBill
$ConYield^{SA}_{t-1}$	0.198***	0.120***	0.550***	0.342**	0.535***	0.388***
	(5.80)	(3.31)	(4.20)	(2.80)	(4.50)	(3.46)
$\text{SeasonalComponent}_t$	-0.173*	-0.399***	-0.102	-0.619**	-0.811**	-0.028
	(-2.23)	(-5.67)	(-0.43)	(-2.83)	(-3.25)	(-0.14)
Constant	0.085	0.087***	-0.183	0.076	0.120	0.240
	(1.76)	(3.94)	(-0.78)	(0.97)	(0.53)	(1.11)
N	3,735	4,660	1,526	1,903	3,612	5,983
Adj. R^2	0.02	0.02	0.04	0.03	0.01	0.00
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes

Table 25: **Benchmark Test 2 Main Result: FHLB Issuance Responds to Convenience Yield the Day Before.** $\log(\text{Issuance})_t = \alpha + \beta_1 \text{SeasonalComponent}_t + \beta_2 \text{ConYield}^{SA}_{t-1} + \theta_t + \varepsilon_t$. Regression run at the daily level. Dependent variable is the issuance which is calculated from the detrended series for FHLB issuance of three maturity buckets: overnight, 4 weeks to 26 weeks, and greater than one year. The independent variable is the seasonally adjusted convenience yield, measured either via the OIS-TBill or the GCF-TBill measure, which correspond to definitions 1 and 2. Seasonal adjustments are rolling through the period to reflect the information available on each day. The GCF measure begins in 1991 and the OIS measure begins in 2003. T-statistics are reported in parentheses using robust standard errors. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

	(1)	(2)	(3)	(4)
Con. Yield Measure			GCF-Tbill	OIS-Tbill
Tail_{t-1}	-0.085*	-0.087**	-0.076**	-0.060*
	(-2.50)	(-3.00)	(-2.70)	(-2.09)
$ConYield^{SA}_{t-1}$			0.279	0.489*
			(1.42)	(2.28)
$\text{SeasonalComponent}_t$			-1.350**	-2.756**
			(-2.66)	(-2.71)
Constant	-0.020	-0.120	0.206	0.083
	(-0.56)	(-1.19)	(1.26)	(1.37)
N	520	520	514	333
Adj. R^2		0.04	0.08	0.15
fixed-effects	None	Year	Year	Year

Table 26: **Benchmark Test 2 Alternative Specification: FHLB Issuance Responds to Treasury Demand the Day Before as Measured by Tails.** $\log(\text{Issuance})_t = \alpha + \beta_1 \text{Tail}_{t-1} + \theta_t + \varepsilon_t$. Regression run at the daily level. Dependent variable is the issuance which is calculated from the detrended series for FHLB issuance of 4 weeks to 26 weeks maturity debt. The independent variable *Tail*, which is the percent change between yields implied 1 minute before auction and yields realized 30 minutes after the auction. A positive value for *Tail* means yields increased after auction indicating lower Treasury demand than anticipated in the when-issued market. $ConYield^{SA}_{t-1}$ is the seasonally adjusted convenience yield, measured either via the OIS-TBill or the GCF-TBill measure, which correspond to definitions 1 and 2. Seasonal adjustments are rolling through the period to reflect the information available to investors. The GCF measure begins in 1991 and the OIS measure begins in 2003. Tails are calculated from 1991 to 2008 due to data constraints. T-statistics are reported in parentheses using robust standard errors except for the specifications without fixed-effects which instead report Newey-West standard errors with a maximum of 20 lags. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	$FHLB_{4wk-26wk}$		$CorpBond$		$Tbill$	
	OIS-Tbill	GCF-Tbill	OIS-Tbill	GCF-Tbill	OIS-Tbill	GCF-Tbill
$ConYield^{SA}_{t-1}$	0.550***	0.342**	-0.153	-0.178	-0.002	-0.009
	(4.20)	(2.80)	(-0.91)	(-1.63)	(-0.31)	(-1.69)
$\text{SeasonalComponent}_t$	-0.102	-0.619**	-0.781**	-1.880***	0.008	0.033***
	(-0.43)	(-2.83)	(-2.65)	(-8.61)	(0.72)	(4.99)
Constant	-0.183	0.076	-0.709	0.518***	0.008*	-0.012***
	(-0.78)	(-0.97)	(-1.33)	-4.23	(2.01)	(-5.56)
N	1,526	1,903	3,761	6,305	3865	6479
Adj. R^2	0.04	0.03	0.01	0.02	0.00	0.01
fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Sample	Full	Full	Full	Full	Full	Full

Table 27: **Additional Evidence for Benchmark Test 2: Corporate Bonds and Treasuries.** $\log(\text{Issuance})_t = \alpha + \beta_1 \text{SeasonalComponent}_t + \beta_2 \text{ConYield}^{SA}_{t-1} + \theta_t + \varepsilon_t$. Regression run at the daily level. Dependent variable is the issuance which is calculated from the detrended series for FHLB issuance and similarly the detrended series for corporate bond issuance. The independent variable is the seasonally adjusted convenience yield, measured either via the OIS-TBill or the GCF-TBill measure, which correspond to definitions 1 and 2. Seasonal adjustments are rolling through the period to reflect the information available on each day. The GCF measure begins in 1991 and the OIS measure begins in 2003. T-statistics are reported in parentheses using robust standard errors. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Con. Yield Measure	GCF-Tbill				OIS-Tbill			
$TBill_{t-1}$	-0.872*	-0.846*	-0.822*	-0.806*	-0.962***	-0.925***	-0.907**	-0.879**
	(-2.37)	(-2.30)	(-2.24)	(-2.20)	(-3.44)	(-3.30)	(-3.23)	(-3.12)
$TBill_{t-2}$		-0.331	-0.307	-0.285		-0.703*	-0.679*	-0.664*
		(-0.85)	(-0.79)	(-0.73)		(-2.53)	(-2.43)	(-2.37)
$TBill_{t-3}$		-0.476	-0.458	-0.439		-0.750**	-0.739**	-0.719*
		(-1.33)	(-1.28)	(-1.23)		(-2.66)	(-2.63)	(-2.55)
$TBill_{t-4}$			-0.611	-0.594			-0.728*	-0.718*
			(-1.64)	(-1.59)			(-2.41)	(-2.38)
$TBill_{t-5}$				-0.596				-0.626*
				(-1.69)				(-2.05)
Constant	0.182***	0.182***	0.182***	0.182***	0.087***	0.087***	0.087***	0.087***
	(74.66)	(74.67)	(74.69)	(74.70)	(55.01)	(55.16)	(55.25)	(55.30)
N	5,986	5,986	5,986	5,986	3,366	3,366	3,366	3,366
Adj. R^2	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02
Sample	NotCrisis	NotCrisis	NotCrisis	NotCrisis	NotCrisis	NotCrisis	NotCrisis	NotCrisis

Table 28: **Additional Evidence for Benchmark Test 2: Treasury Issuance Shock, First Stage.** Regression is $\text{ConYield}_t^{NSA} = \alpha + \sum_{i=1}^{5} \beta_i (TBill\ Issuance)_{t-i} + \varepsilon_t$. Regression run at the daily level. Dependent variable is the issuance which is calculated from the detrended series for FHLB issuance and similarly the detrended series for corporate bond issuance. The independent variable is the non-seasonally adjusted convenience yield, measured either via the OIS-TBill or the GCF-TBill measure. T-statistics are reported in parentheses using robust standard errors. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
First Stage GCF-Tbill	3.607***	3.567***	3.633***						
	(4.00)	(4.02)	(4.11)						
First Stage OIS-Tbill				2.636***	2.612***	2.676***			
				(3.76)	(3.78)	(3.90)			
$TBill_{t-1}$							-5.228**	-5.444**	-5.460**
							(-2.91)	(-3.09)	(-3.09)
Month End			-0.384***			-0.384***			-0.380***
			(-4.86)			(-4.86)			(-4.86)
Constant	-0.656***	-0.710***	-0.711***	-0.228***	-0.287***	-0.281***	-0.002	-0.058	-0.047
	(-3.97)	(-4.06)	(-4.07)	(-3.65)	(-3.48)	(-3.40)	(-0.19)	(-1.13)	(-0.91)
N	2,017	2,017	2,017	2,017	2,017	2,017	2,017	2,017	2,017
Adj. R^2	0.01	0.02	0.04	0.01	0.02	0.04	0.01	0.02	0.04
Year FE	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Regime	FullSample	FullSample	FullSample	FullSample	FullSample	FullSample	FullSample	FullSample	FullSample

Table 29: **Additional Evidence for Benchmark Test 2: Treasury Issuance Shock, Second Stage.** Regression is $FHLB\ Issuance_t = \alpha + \widehat{\text{ConYield}}^{NSA}_{t-1} + \varepsilon_t$, using estimated $\widehat{\text{ConYield}}^{NSA}_{t-1}$ from the first stage. T-statistics are reported in parentheses using robust standard errors. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

Panel A: Agencies	(1)	(2)	(3)	(4)	(5)	(6)
	Freddie^{Disco}		*Fannie*		*FFCB*	
	OIS-Tbill	GCF-Tbill	OIS-Tbill	GCF-Tbill	OIS-Tbill	GCF-Tbill
SeasonalComponent$_t$	0.055	0.637**	-1.310***	-0.686**	0.506	0.398
	(0.17)	(2.65)	(-3.45)	(-2.73)	(1.92)	(1.52)
$ConYield^{SA}_{t-1}$	0.032	0.488***	-0.180	-0.220	0.456***	0.438**
	(0.18)	(4.22)	(-1.11)	(-1.73)	(3.52)	(3.23)
Constant	0.110	-0.421***	0.380	0.450**	0.423	-0.273
	(0.40)	(-3.37)	(1.28)	(2.97)	(1.93)	(-1.07)
N	3,727	5,478	2,790	4,710	3,292	4636
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

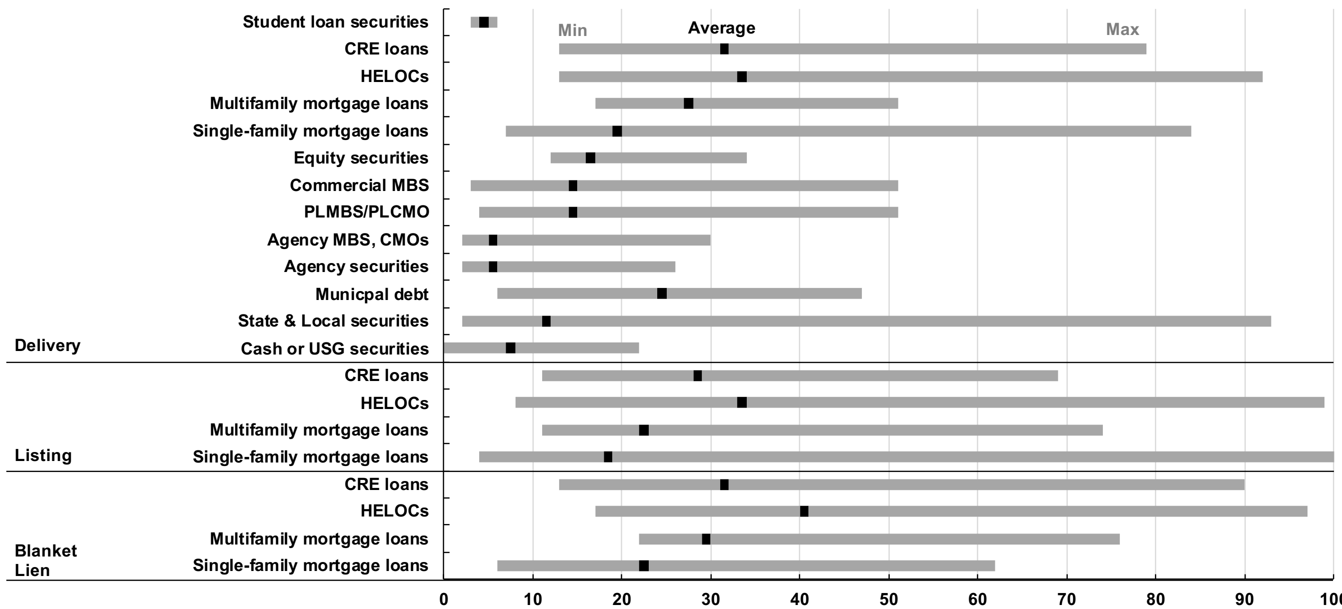
Panel B: Private Safe Assets	(7)	(8)	(9)	(10)	(11)	(12)
	ABCP		*FinCP*		*NonFinCP*	
	OIS-Tbill	GCF-Tbill	OIS-Tbill	GCF-Tbill	OIS-Tbill	GCF-Tbill
SeasonalComponent$_t$	0.328***	0.355***	0.021	-0.207	0.431**	0.236
	(5.16)	(4.19)	(0.15)	(-1.37)	(2.91)	(1.48)
$ConYield^{SA}_{t-1}$	0.045	0.142**	-0.049	-0.105*	0.165*	0.292***
	(0.56)	(3.15)	(-0.89)	(-2.12)	(2.36)	(4.24)
Constant	0.109***	-0.093**	-0.124**	0.075	0.231**	-0.090
	(4.26)	(-3.20)	(-2.67)	(1.52)	(2.60)	(-1.72)
N	3,740	4,189	3,699	4,148	3,736	4185
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 30: **Who Times Issuance: Non-FHLB Agencies and Commercial Paper Issuers.** $\log(\text{Issuance})_t = \alpha + \beta_1 \text{SeasonalComponent}_t + \beta_2 \text{ConYield}^{SA}_{t-1} + \theta_t + \varepsilon_t$. Regression run at the daily level. Dependent variable is seasonally adjusted convenience yield, measured either via the OIS-TBill measure, which correspond to definitions 1. Independent variable is the issuance of the indicated series which is calculated from the detrended log of the issuance series. Notice the timing: issuance from the day $t-1$ and the convenience yield as measured on day t. *Freddie* refers to Freddie discount notes (excluding overnight), *Fannie* to bond issues with maturity greater than 1 year, and *FFCB* to Federal Farm Credit Banks bond issues with greater than 1 year maturity. ABCP, financial, and nonfiannci al refers to commercial paper issuance with maturities 1 day to 4 days. T-statistics are reported in parentheses using robust standard errors. *, **, and *** denote significance at the 5%, 1%, and 0.1% levels respectively.

11 Appendix

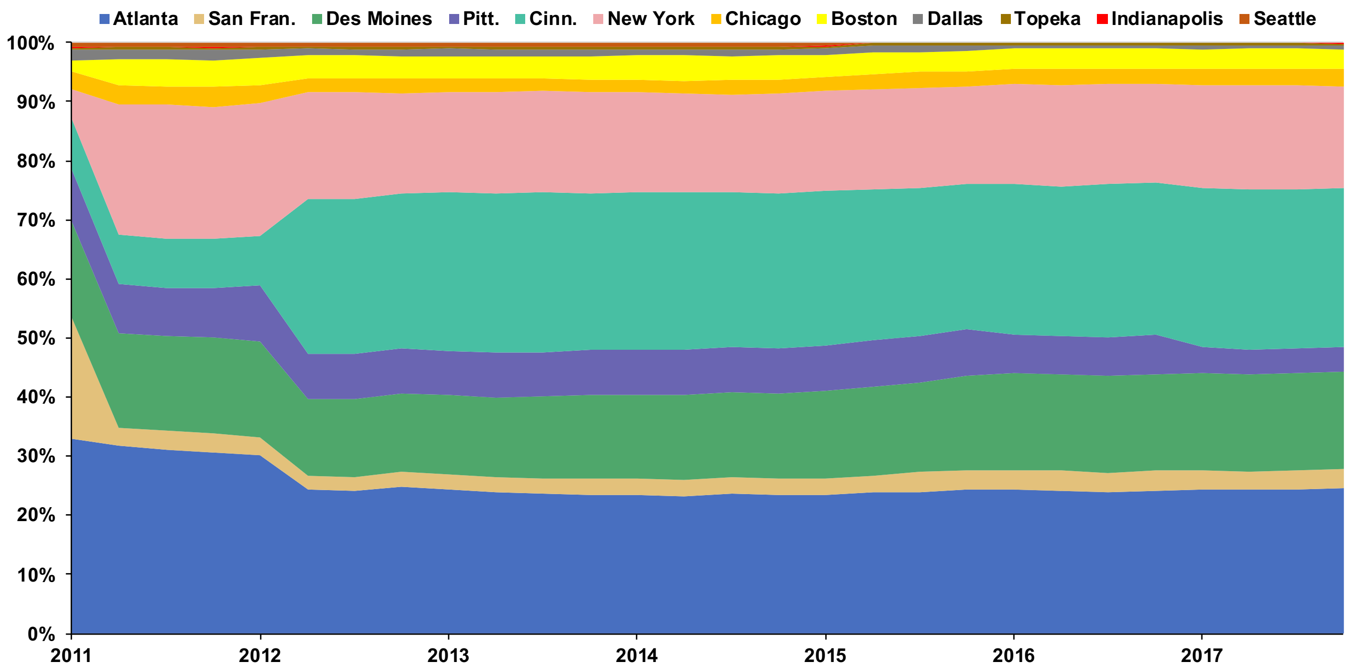
11.1 Appendix Tables and Figures

Figure A1: Advance Haircuts, Q4 2017



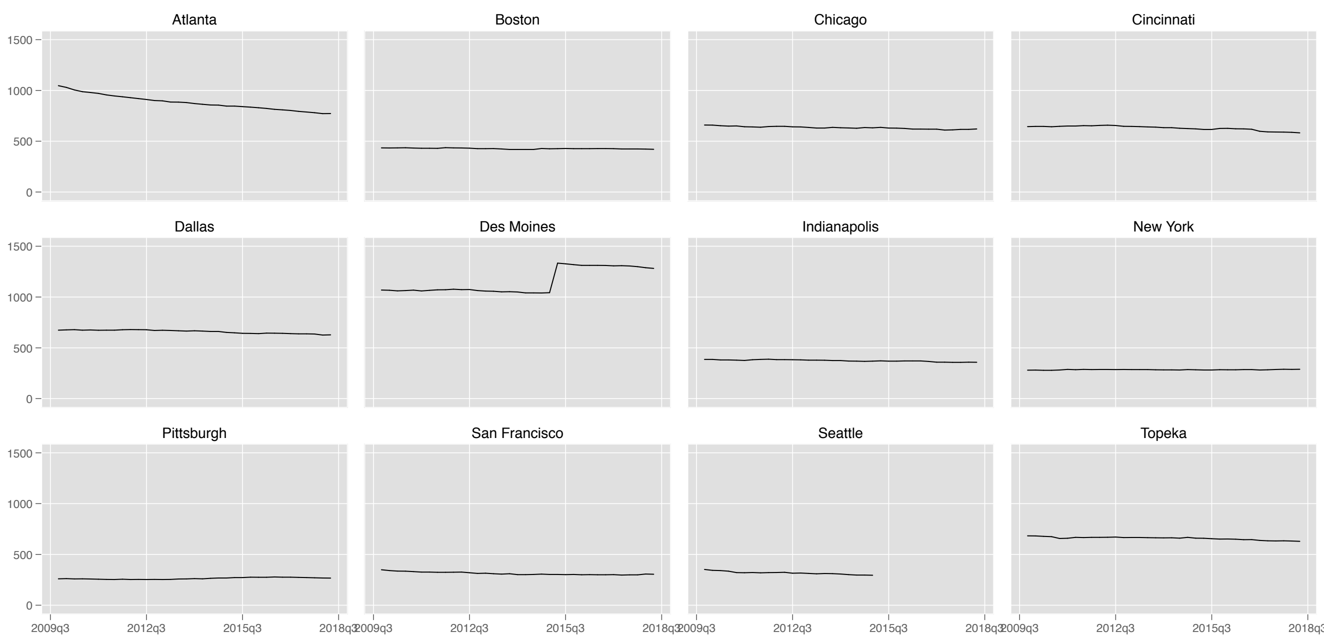
Source: 2017 FHLB Office of Finance Collateral Q&A.

Figure A2: Share of Total Commercial Bank Assets by District



Source: FHLB and Federal Reserve. Only includes commercial banks matched in WRDS and does not include non-commercial-bank members.

Figure A3: Member Institutions by District, Total Number of Institutions



Source: FHFA

Figure A4: Covered Interest Parity Violations

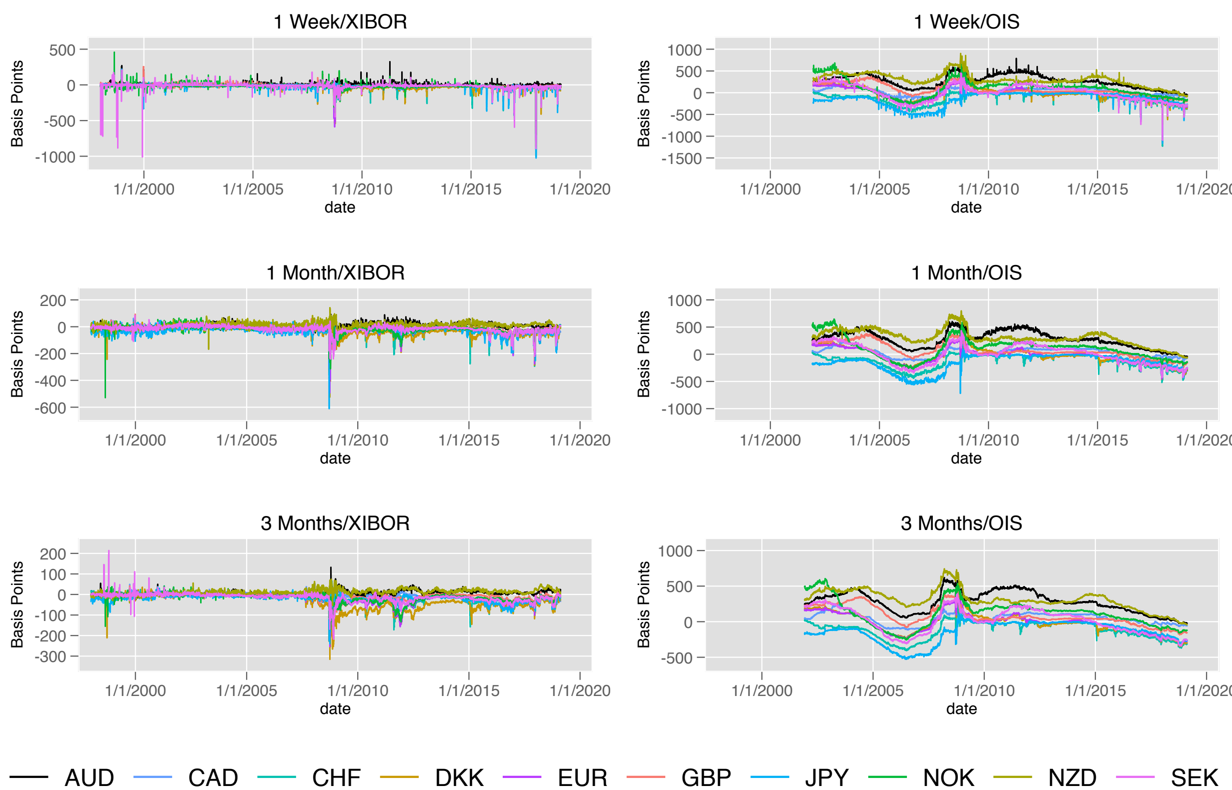
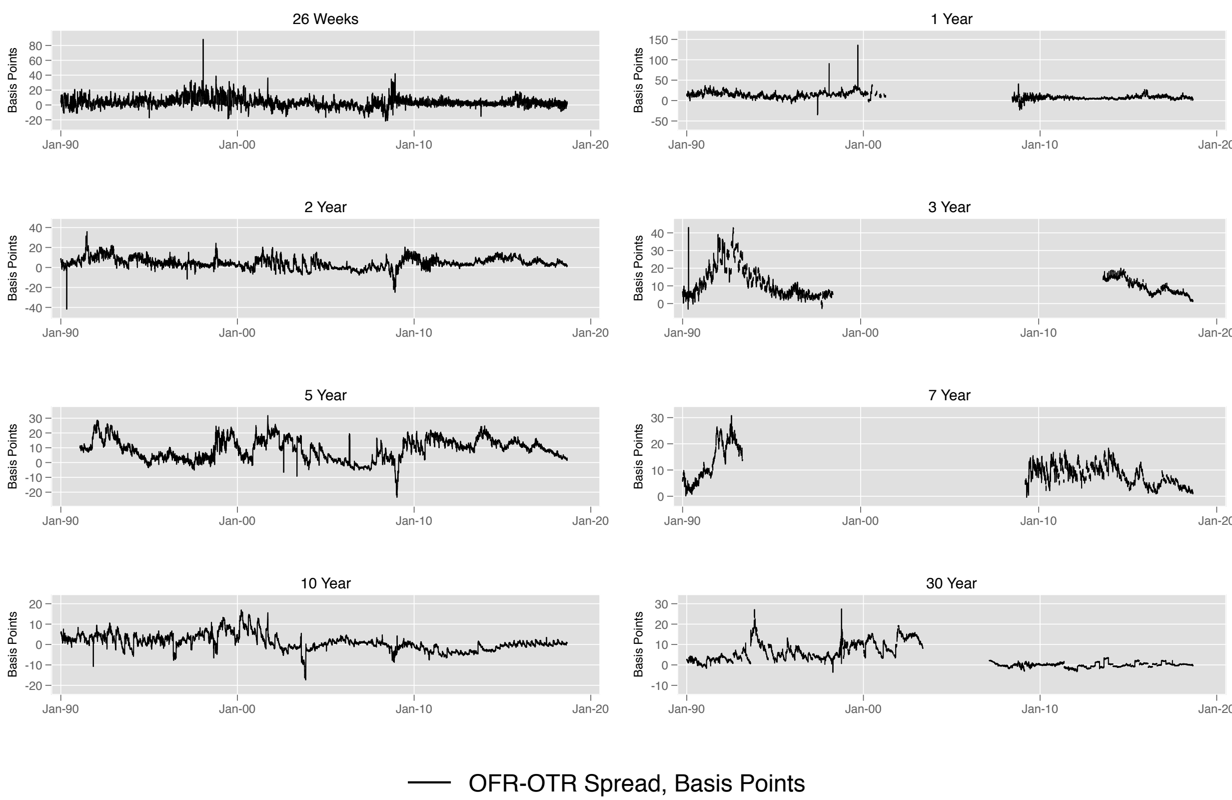


Figure A5: Off-the-run/On-the-run Treasury Spread



Collateral Type	Blanket %	Listing %	Delivery %	Total %	Blanket $ bil	Listing $ bil	Delivery $ bil	Total $ bil
Single family mortgage	43.5	68.4	2.2	51.6	484	885	6	1,375
CRE loans	33.7	11.3	12.4	20.8	376	146	32	554
Multifamily loans	6.4	12.2	4.9	9.1	71	158	12	241
HELOCs	7.9	7.1	0.0	6.8	88	92	0	180
Agency MBS, CMOs			48.0	4.6			122	122
Agency Securities			7.5	0.7			19	19
U.S. obligations			6.5	0.6			16	16
CMBS			6.3	0.6			16	16
PLMBS/PLCMO			2.2	0.2			6	6
Other	8.5	1.0	9.9	5.0	95	13	25	133
Total	100	100	100	100	1,114	1,294	254	2,662

Table A1: Advance Collateral

$ billion	**Large Borrowers**	**All Others**	**Large Share**
Advances Outstanding (principal)	527	209	72%
Other Credit Products	79	69	54%
Collateral Outstanding	1,583	1,080	59%
Average Haircut	33%	19%	

Table A2: **Concentration of Advances.** Note: Large borrowers defined as borrowers with ≥ $1 billion of advances outstanding.

Table A4: Off-the-Run/On-the-Run Yield Spread, Basis Points

	26 Week	1 Year	2 Year	3 Year	5 Year	7 Year	10 Year	30 Year
Full Sample								
Mean	3.365	11.113	4.757	11.092	8.995	9.419	1.011	3.663
Stan. Dev.	6.447	7.437	5.397	7.585	7.158	5.579	3.825	4.830
Precrisis								
Mean	4.063	14.852	4.666	11.981	8.327	13.250	2.562	6.838
Stan. Dev.	7.090	7.729	5.633	8.891	7.378	7.555	3.962	4.560
Crisis								
Mean	1.742	5.834	1.873		3.311	8.989	-0.242	0.025
Stan. Dev.	8.591	7.726	7.173		7.801	3.731	1.885	0.975
Pre-Reform								
Mean	2.308	6.236	5.360	14.847	14.220	10.556	-3.125	-0.275
Stan. Dev.	2.629	2.500	3.242	1.212	4.187	2.917	1.592	1.302
Post-Reform								
Mean	2.815	8.714	6.625	8.414	9.931	5.104	0.117	0.282
Stan. Dev.	3.940	4.115	3.529	3.755	3.594	2.463	0.962	0.784

Member Type	Charter	Q4 2009	Q2 2018
Commercial Bank	State	4,496	3,504
Credit Union	Federal	516	735
	State	488	734
Insurance Company	N/A	207	419
Savings Bank	Federal	437	0
	State	395	331
Savings Association	Federal	0	316
	State	0	52
Savings and Loan	Federal	227	0
	State	73	0
CDFI	N/A	0	52

Table A3: Total Number of FHLB Members by Institution Type