De-Limiting Arbitrage:

Evidence from the Term Asset-Backed Securities Loan Facility[1]

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Abstract

We use the Term Asset-Backed Securities Loan Facility (TALF) crisis liquidity program in which all borrowers, including a broad set of nonbanks, faced the same counterparty and program terms as a laboratory to test the predictions of limits to arbitrage models and their dynamics. Using detailed loan-level data and variation in the risk of assets and constraints of investors, we show that arbitrageurs invest in lower-risk assets than long-term investors during financial crises. As their leverage constraints ease, arbitrageurs gradually increase risk-taking. Spreads widen on assets when arbitrageurs face an exogeneous increase in their leverage constraints.

Keywords: Limits to Arbitrage, Non-Bank Financial Institutions, Lender of Last Resort, Term Asset-Backed Securities Loan Facility, TALF, Securitization

JEL Codes: E52, E53, G01, G12, G23

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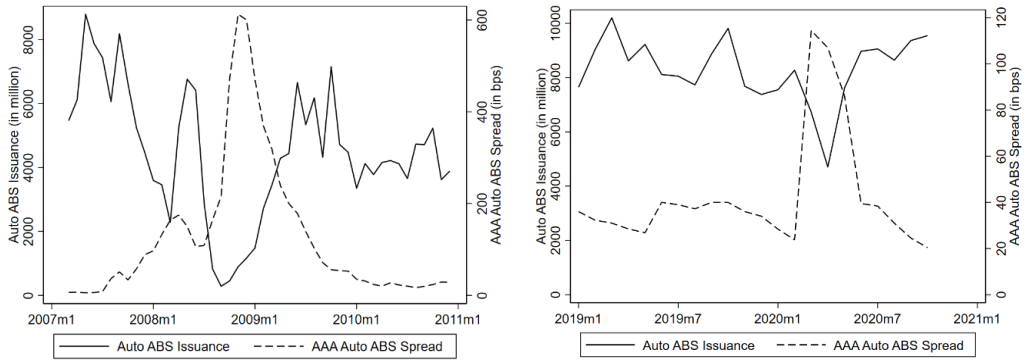
1. Introduction

The "limits to arbitrage" literature starting with Shleifer and Vishny (1997) has observed that pricing anomalies can persist over time, even when arbitraging these anomalies would appear to be profitable. One explanation for the persistence of these anomalies, especially in times of stress, is that the firms that would typically arbitrage these price differentials are unable to do so because they experience hits to their own funding and capital (Xiong, 2001; Brunnermeier and Pederson, 2009; Gromb and Vayanos, 2002, 2010a, 2010b, 2018). Persistent price differentials can inflict damage on the real economy by raising the price of credit. Designing policy responses that will limit this harm requires an understanding of the causes and mechanisms of limits to arbitrage. Despite the intuitive appeal of limits-to-arbitrage models, though, real-world laboratories in which economists can convincingly test their implications and mechanisms are rare.

We suggest such the Term Asset-Backed Securities Loan Facility (TALF) provides such a laboratory in the contexts of the Global Financial Crisis (GFC) and the Covid crisis. We derive testable hypotheses from the dynamic limits to arbitrage theory and test them with unique loan-level data from the TALF program that identifies whether the TALF borrower is an arbitrageur or a long-term investor. We show that prices and spreads reacted to TALF announcements in a manner consistent with limits to arbitrage affecting market dynamics. We then demonstrate the microfoundations of limits to arbitrage models by showing that when constraints were most binding, arbitrageurs took much less risk in their investment decisions than long-term investors.

Figure 1. Auto ABS Issuance and Spreads 2007-10 and 2019-20



Source. Courtesy J.P. Morgan Chase & Co., Copyright 2021, and Bloomberg.
Note: Spreads shown are for three-year triple-A rated auto ABS over comparable-maturity swaps and are monthly averages. In weekly data, the spread spikes at 200 basis points the week of March 19, 2020. Auto ABS issuance is a three-month moving average.

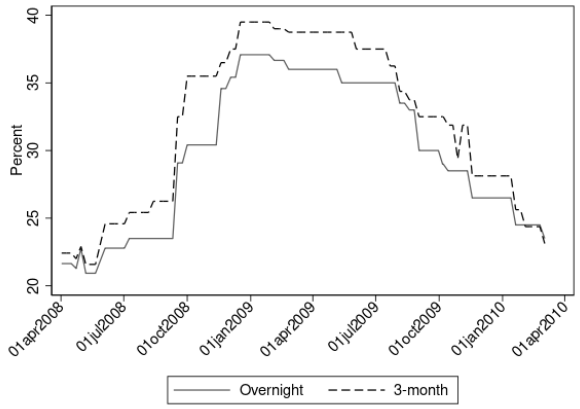
In both the GFC and the Covid crisis, there were significant dislocations in the prices of the asset-backed securities (ABS) that firms issue to finance receivables such as auto, credit card, and student loans. In both episodes, ABS issuance plummeted as spreads soared (Figure 1), resulting in a credit crunch for households and businesses that threatened the real economy (Benmelech et al., 2017). ABS spreads widened so dramatically, to use the terminology of Gromb and Vayanos (2018, henceforth GV), because of both fundamental risk (credit risk) and nonfundamental shocks to demand (the sudden withdrawal of

some ABS investors from the market). The Federal Reserve and U.S. Treasury launched TALF in both crises to address the price dislocations in the ABS markets and thus limit the effects of a credit crunch on the economy.

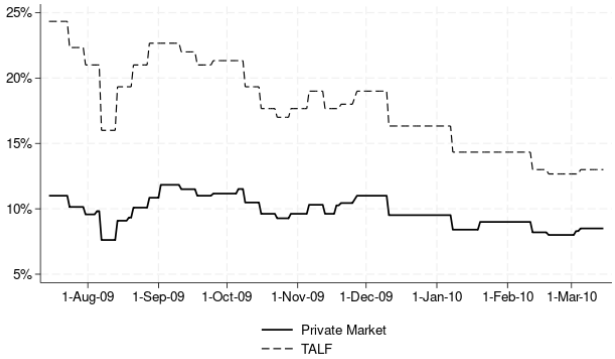
TALF is a useful setting for testing the implications of limits to arbitrage models, such as the GV model, that emphasize the role of leverage constraints (see also Fostel and Geanakoplos, 2008, Geanakoplos, 2010, Gârleanu and Pedersen, 2011). Any U.S. company—both arbitrageurs and long-term investors—could borrow from TALF to purchase qualifying ABS. However, arbitrageurs were subject to more severe constraints during this period. Arbitrageurs typically finance ABS with short-term repo funding. In the GFC period, haircuts in the bilateral repo market for ABS skyrocketed to such an extent (Copeland et al., 2014; Gorton and Metrick, 2012) that arbitrageurs were unable to enter the market and stabilize prices. The haircut dislocations for ABS were significantly more severe than for other types of securities. At the time of the GFC-era TALF program (TALF 1.0), for example, the median quoted dealer haircut for CMBS collateral in bilateral repo transactions rose from around 20 percent in April 2008 to more than 35 percent in early 2009 (Figure 2, panel a). Likewise, at the time of the Covid-era TALF program (TALF 2.0), nearly 90 percent of dealers reported on the June 2020 Senior Credit Officer Opinion Survey that they had tightened haircuts on repo loans collateralized by CMBS in the previous three months, compared with around half for corporate bonds.

Figure 2

Panel (a) Median Haircuts on Repo Transactions Collateralized by CMBS



Panel (b) Return on Equity for a CMBS Investment Financed by Repo or a TALF Loan



Source. Repo haircuts, FR 2004 and related reports. Return on equity, staff calculations based on repo haircuts from FR 2004 and CMBS spreads Courtesy J.P. Morgan Chase & Co., Copyright 2021
Notes. Haircuts are the median response from a survey conducted by the Federal Reserve Bank of New York of primary dealers in which dealers were asked what haircuts they charge their clients.

TALF was an attractive arbitrage opportunity for leveraged-constrained arbitrageurs for three reasons—albeit a risky one since arbitrageurs could lose the haircuts associated with loans. First, at the peak of the crisis, the TALF haircuts were lower than those on private-market repo. The Federal Reserve set haircuts to protect itself from credit risk, whereas dealer haircuts were designed for protection against liquidity and other market risks in addition to credit risk. Second, the loan collateral was not marked-to-market during the TALF loan duration of 3 or 5 years, and so the arbitrageur did not face the prospect of

capital-depleting margin calls. Third, the TALF loans were non-recourse, so the borrower did not face the possibility of losing capital beyond that allocated to the haircut.

To illustrate the attractiveness of the arbitrage opportunity, Figure 2 panel (b) shows an estimate of the return on equity (ROE) during the time when the TALF 1.0 program was operational from investing in a CMBS with a five-year weighted average life using either TALF financing or private-market repo financing. The ROE moves with the CMBS spread (which was volatile over this period, but on net decreasing) and with the haircuts (which are constant over time for CMBS financed with TALF and decreasing for CMBS financed with private repo). The ROE calculation only includes the levered carry and ignores any capital gains or losses that investors might have anticipated from changes in the price of the security. We use the TALF interest rate for both calculations because data on private-market repo rates for CMBS are not available for this period.

The estimated ROE from using a TALF loan to finance a CMBS purchase at the first CMBS subscription in July 2009 was 24 percent (dashed line), whereas the estimated ROE using private-label overnight repo was 11 percent. Our TALF ROE estimates are consistent with those reported in news articles for the TALF 1.0 program (Chan and Protess, 2010; Williamson 2020a, 2020b), while ROEs were reportedly much lower for TALF 2.0 (Williamson, 2020b). The 11 percent ROE estimate with private funding is likely an upper bound, as some investors were reportedly unable to obtain private repo financing for CMBS at any price during this period (Krishnamurthy et al., 2014). By the end of the program, as TALF successfully stabilized the ABS market and CMBS spreads contracted, the estimated ROEs declined and converged (13 percent, TALF haircuts; 9 percent, private-label repo).

Beyond being conceptually similar to the GV set up, the TALF program also provides sufficient empirical variation to test the predictions of the model. The TALF 1.0 program was large, extending nearly 2,000 loans totaling $72 billion to 167 borrowers. We hand-code the borrower type using internal documents collected by the Federal Reserve Bank of New York (FRBNY), which allows us to demonstrate that both arbitrageurs and long-term investors were well represented within the borrower base. All borrowers faced the same terms, which us control for the typical confounding factor that some investors receive funding on more favorable terms than others.

The Gromb-Vayamos model predicts that measures that alleviate the leverage constraints associated with investing in an asset should decrease that asset's spreads. We test this proposition using a surprise announcement by the Federal Reserve in April 2020 that only conduit CMBS, and not single-asset, single-borrower (SABS) CMBS, were eligible collateral for the TALF 2.0 program, even though SASB were eligible in TALF 1.0. We find that SASB prices fell by 1 percentage point relative to conduit CMBS after this announcement, consistent with TALF eligibility alleviating leverage constraints for investments in conduit CMBS but not SASB. Although the TALF program was not yet operational at the time of the announcement, this finding suggests that investors bid up prices immediately in anticipation that TALF funding would alleviate arbitrageurs' leverage constraints in the future. However, we also find that within 2 weeks the prices differences dissipated, suggesting significant liquidity spillovers of the TALF program across asset classes.[2] The Gromb-Vayamos model also predicts that measures that alleviate leverage constraints should be more valuable for assets with more volatile fundamentals. The most

[2] Spillovers of central bank interventions have been documented in other contexts (e.g., Krishnamurthy and Vissing-Jorgensen (2011)).

natural analog in our setting is CMBS with long weighted average lives (WAL). Since CMBS are fixed-rate securities, the prices of longer-WAL securities fluctuate more with interest rates than short-WAL securities. In the context of TALF 1.0, long-WAL securities also had more credit risk because they were underwritten in the extremely lax years before the GFC. One of the key features of TALF loans--that collateral was not marked-to-market and so investors were not subject to capital-depleting margin calls--would be more valuable for securities, such as long-WAL CMBS, that were subject to more price volatility. Consistent with this hypothesis, we find large, persistent TALF announcement effects for above-median WAL CMBS securities relative to below-median WAL CMBS securities.

We next use our unique loan-level microdata to establish the microfoundations of the GV model: that the leverage constraints faced by arbitrageurs during this period were a major factor in their investment decisions. We have data from all loan requests (both accepted and rejected) submitted to FRBNY. Data on accepted loan requests are publicly available, but data on rejected requests are not.[3] We supplement these data with our hand-coding of borrower investor types. We classify hedge funds and mortgage REITs as arbitrageurs, since these firms are heavily dependent on short-term repo to finance securities purchases.

We take advantage of three sources of variation: leverage constraints affected arbitrageurs more than long-term investors; leverage constraints eased over time as the private repo market recovered; and haircuts for CMBS—and thus arbitrageurs' leverage constraints—varied in a quasi-exogeneous way. CMBS haircuts varied because the FRBNY had the option to reject loan requests collateralized by CMBS after investors had already purchased the collateral, in which case investors faced the much-higher haircuts of private repo funding. Although it became clear which types of CMBS were more likely to be rejected, investors could never fully predict FRBNY's rejection algorithm.

We find that arbitrageurs' investment choices were much more sensitive than those of long-term investors to the possibility of loan rejection. Especially in the early months of the program, arbitrageurs purchased CMBS that were less likely to be rejected by FRBNY. When FRBNY surprised the market with some unexpected CMBS rejections in October 2009, arbitrageurs pulled back from the TALF CMBS program more than long-term investors did. However, as external financing became more available, arbitrageurs became less risk-averse and offered up CMBS with riskier characteristics as loan collateral, and the share of CMBS loan requests submitted by arbitrageurs that were rejected increased.

Finally, we hypothesize that spreads on CMBS that were rejected as TALF collateral should increase after the rejection announcement, as arbitrageurs demand higher compensation to invest given the tighter leverage constraints for the assets. We also hypothesize, consistent with the GV model, that this spread reaction should diminish over time as private-market funding becomes more available and arbitrageurs' leverage constraints ease. In line with this prediction, we find that a strong increase in spreads after rejection in the first few subscriptions but not in the latter ones.

[3] Data on TALF loans and borrowers are available on the Federal Reserve website at http://www.federalreserve.gov/newsevents/reform_talf.htm for the 2008-10 TALF program and https://www.federalreserve.gov/monetarypolicy/talf.htm for the 2020 TALF program.

We contribute to the literature on financially constrained arbitrage (see Gromb and Vayanos, 2010, for a survey). The empirical literature testing the mechanism of these theories is scarce.[4] Gabaix, Krishnamurthy and Vigneron (2007) provide evidence from the MBS market consistent with specialized arbitrageurs. Aragon and Strahan (2012) provide evidence on the importance of arbitrageurs for stock pricing using the Lehman collapse as an experiment. Du et al (2018) and Avdjiev et al (2019) document deviations from covered interest rate parity. Siriwardane et al (2022) use arbitrage trades to document frictions and constraints of intermediaries. We expand this literature by providing comprehensive evidence for the mechanisms in financially constrained arbitrage models using cross-section variation in the risk of assets and the constraints of borrowers, as well as changes over time as financial conditions improved.

Our paper also relates to the broader literature on liquidity provision and lender of last resort programs by the Federal Reserve during the Global Financial Crisis (see, e.g., Campbell et al., 2011; Covitz et al., 2013; Fleming, 2012; Duygan-Bump et al., 2013). There are a number of studies that focus on different programs, for example, broker-dealers (Acharya et al., 2017; Carlson and Macchiavelli, 2020) and money market mutual funds (Duygan-Bump et al., 2013). Numerous papers also assess the facilities in the COVID-19 crisis in the U.S. and Europe (Boyarchenko, et al., 2022; Breckenfelder and Hoerova, 2023). Within the literature on emergency facilities only a few papers focus on TALF (Campbell et al., 2011; Ashcraft et al., 2011; Wilson,2011; Caviness et al., 2021). In contrast to these TALF studies, our focus is not the effects of the program itself but using the specific setup to test the implications of limits to arbitrage.

In the remainder of the paper, we describe the TALF design and the testable hypotheses that we derive from the GV model. We then test these hypotheses using first data on broad CMBS prices and spreads and then data from the investment choices of different types of investors and the changes in spreads on CMBS that were rejected as TALF collateral. The last section provides closing thoughts.

2. TALF Design

In this section, we lay out the key features of the TALF program that we link to the GV model in our hypothesis development section below.

TALF was designed to restore liquidity to the ABS market and credit to households and businesses by inducing investors to return to the ABS market.[5] Eligible collateral for TALF loans included the triple-A rated tranches of several types of newly issued ABS ("consumer" ABS such as auto, credit card, and student loan ABS, as well as small business and other types) as well as "legacy" CMBS that were trading in the secondary market. The eligible asset classes were large and economically significant: in 2007, $306 billion of consumer and small-business ABS and $241 billion in non-agency CMBS was issued.[6]

The interest rates on TALF loans were not particularly cheap. They were set above the rate earned by equivalent ABS in normal market conditions, and below the rate in stressed conditions, so that

[4] Recently, Chu, Hirschleifer, and Ma (2020) provide evidence for the causal effect of limits to arbitrage on asset pricing anomalities. They also provide a comprehensive overview of the literature on the proxies commonly used to measure limits to arbitrage.

[5] The program term sheets are available at https://www.newyorkfed.org/markets/talf_terms.html (2009-10) and https://www.federalreserve.gov/newsevents/pressreleases/files/monetary20200728a6.pdf (2020). Five-year loans were offered only in the 2009-10 TALF program and only for certain types of securities.

[6] Data are from U.S. Asset Backed Securities Statistics, SIFMA.

borrowers would prepay their loans when market conditions normalized. However, the loans had other features that were attractive to leverage-constrained investors in a crisis. First, the haircuts offered on the TALF loans were well below those on private-market repo funding during the crisis. Second, the TALF loans provided long-term (3- or 5-year) financing at a time when many private lenders were shortening maturity. Third, the loans were not subject to margin calls and thus guarded investors against the risk of having to post more collateral if ABS spreads spiraled upward. Finally, the TALF program only had recourse to the collateral and not the borrower and so borrowers' loss was limited to their loan haircut.

The Federal Reserve Bank of New York put multiple other measures in place, in addition to the haircuts, to ensure that taxpayers were protected from losses. Most crucially, the Federal Reserve Bank of New York performed a credit review on the ABS submitted for TALF loans. For new-issue ABS, this review was conducted before the ABS was issued, and the issuer could adjust the ABS structure to insure that it was in compliance with FRBNY's requirements. The ABS was issued in coordination with the TALF loan disbursement so that investors only had to come up with funds for the collateral haircut.

In contrast, in the legacy CMBS program, the borrower was required to purchase the CMBS in an arms-length transition before the loan subscription and thus had to come up with funds for the entire CMBS purchase. After the borrower requested a TALF loan, FRBNY performed the credit review, and posted accepted and rejected CUSIPs publicly. (The borrower who submitted the CUSIP was not identified.) If the FRBNY rejected the CMBS, borrowers had to line up alternative funding or sell the CMBS, often at a loss.

3. Hypothesis development

We derive testable hypotheses about how investors' collateral choices in the TALF program are affected by their funding constraints through the lens of the GV model. This model closely resembles the environment in which the TALF programs operated: 1) arbitrageurs' capital was hit by a large negative shock (a sharp increase in private repo haircuts) that left the arbitrageurs financially constrained, 2) those leverage constraints were more binding for some assets than others (CMBS that were more likely to be rejected as TALF loan collateral), 3) arbitrageurs traded across several risky assets, and 4) arbitrageurs' leverage constraints eased over time, as haircuts on private-label repo returned to more-normal levels. In addition, TALF borrowers included both arbitrageurs and long-term investors.

In the GV model, an increase in haircuts leads to higher spreads on that asset and decreased arbitrageur positions. The key mechanism is that financially constrained arbitrageurs will demand higher compensation for trades that require more of their scarce capital.[7] In our setting, arbitrageurs without TALF funding were reliant on private repo funding, which was punitive during crisis conditions because haircuts were very high, margin calls were possible, and the funding was recourse. By alleviating arbitrageurs' funding constraints, TALF should decrease spreads on securities. Hence, our first hypothesis is:

Hypothesis 1: Spreads on securities that were TALF-eligible should be lower.

The GV model predicts that leverage-constrained investors will require more compensation for investing in assets with more volatile fundamentals. Within CMBS that were eligible for TALF, CMBS with longer

[7] This insight is not unique to GV, see, for instance, Brunnermeier and Pedersen (2009).

WALs had more volatile fundamentals. CMBS are fixed-rate instruments, so the prices of long-WAL CMBS move more with interest rates than the prices of short-WAL CMBS. The protection that TALF provides against margin calls should be more valuable for these securities.

> **Hypothesis 2**: Spreads on longer WAL CMBS securities that were TALF-eligible should tighten more than spreads on shorter WAL CMBS securities that were TALF-eligible.

The GV model also has implications for how investors should react to the rejection risk in the CMBS program. Since losing TALF funding is akin to a sharp increase in haircuts for leverage-constrained arbitrageurs, arbitrageurs should weigh the costs of rejection more heavily in their investment decisions than long-term investors.

> **Hypothesis 3:** Since CMBS with longer WALs and higher yields were more likely to be rejected as TALF loan collateral, arbitrageurs should submit loan requests collateralized by CMBS with shorter WALs and lower yields relative to long-term investors.

> **Hypothesis 4:** Arbitrageurs should react to an increase in the perceived risk of loan rejection by
>
> - **a.** reducing their TALF participation more than long-term investors
> - **b.** submitting less risky collateral than long-term investors

> **Hypothesis 5**: As arbitrageurs' external financing constraints ease over time
>
> - **a.** arbitrageurs should become more willing to submit CMBS that are more likely to be rejected as loan collateral.
> - **b.** arbitrageurs should have more loan requests rejected

Since arbitrageurs will demand more compensation to hold securities with an increased risk of rejection, spreads on CMBS should increase after a rejection announcement. However, as external funding becomes more available and arbitrageurs' leverage constraints ease, we expect the reaction of spreads to rejection to diminish.

> **Hypothesis 6**: After rejection announcements
>
> - **a.** spreads on rejected CMBS will increase
> - **b.** spreads on high-WAL CMBS will increase more than on low-WAL CMBS
> - **c.** spreads will increase more at the beginning of the program than the end

We test these hypotheses in the next sections, first looking at changes in broad CMBS prices in TALF-eligibility announcements, then contrasting the behavior of arbitrageurs and long-term investors within the TALF program, and finally examining the response of spreads to rejection decisions.

4. Evidence from CMBS Prices around TALF Announcements

In the GV model, financially constrained arbitrageurs will demand higher compensation for trades that require more of their scarce capital. In our setting, arbitrageurs need less capital for TALF-eligible assets, and so arbitrageurs should increase their positions in these assets and thereby drive down spreads.

We test this proposition (and our first hypothesis) using the April 9, 2020, announcement that added CMBS to the list of TALF-eligible collateral.8 To the surprise of market participants, only AAA-tranches of conduit CMBS, and not of single-asset single-borrower (SASB) CMBS, were eligible. SASB CMBS were close to half of the CMBS market in 2019 and were eligible collateral in TALF 1.0.9 Since the initial announcement of TALF 2.0 on March 23, 2020, hewed closely to the TALF 1.0 design, market participants likely anticipated that SABS CMBS would be eligible collateral in TALF 2.0 as well. Exploiting the change in SASB spreads relative to conduct spreads as our identifying variation lets us control for the fact that the Federal Reserve announced a host of measures on April 9 that might also affect ABS spreads.

We obtain daily price data from Bloomberg on 1,911 AAA-rated tranches of conduit and SASB CMBS sponsored by 61 issuers. The SASB and conduit indicators were obtained from Intex.[10] We interact an indicator variable that is equal to 1 if the CMBS is a SASB with the trading day for 5 days before and 10 days after the announcement. We cannot extend the pre-period window due to prior Federal Reserve announcements that impacted the pre-period. To absorb CUSIP and trading day-specific effects, we saturate the model with trading day α_t and CUSIP μ_i fixed effects:

$$CMBS\ Prices_{it} = \beta_t\ SASB_i \times Trading\ day_t + \alpha_t + \mu_i + \varepsilon_{it}$$

Before the April 9 announcement, the spreads on AAA-tranches of conduit and SASB CMBS were closely aligned with each other (Figure 3). After the announcement, SASB CMBS traded at price discount of slightly over 100 bps, on average, relative to conduit CMBS.[11] In other words, spreads of TALF-eligible conduit CMBS decreased relative to TALF-ineligible SABS CMBS. This discrepancy in the spreads suggests that investors immediately priced in the future option to obtain a TALF loan collateralized with conduit CMBS with a limit on the downside risk of the CMBS purchase—and is consistent with the first hypothesis.

The price differences between TALF-eligible and TALF-ineligible securities dissipated after about 1 week after the announcement and became insignificant after two weeks. The finding is consistent with liquidity spillovers of central bank interventions (see, e.g., Krishnamurthy and Vissing-Jorgensen (2011)).[12]

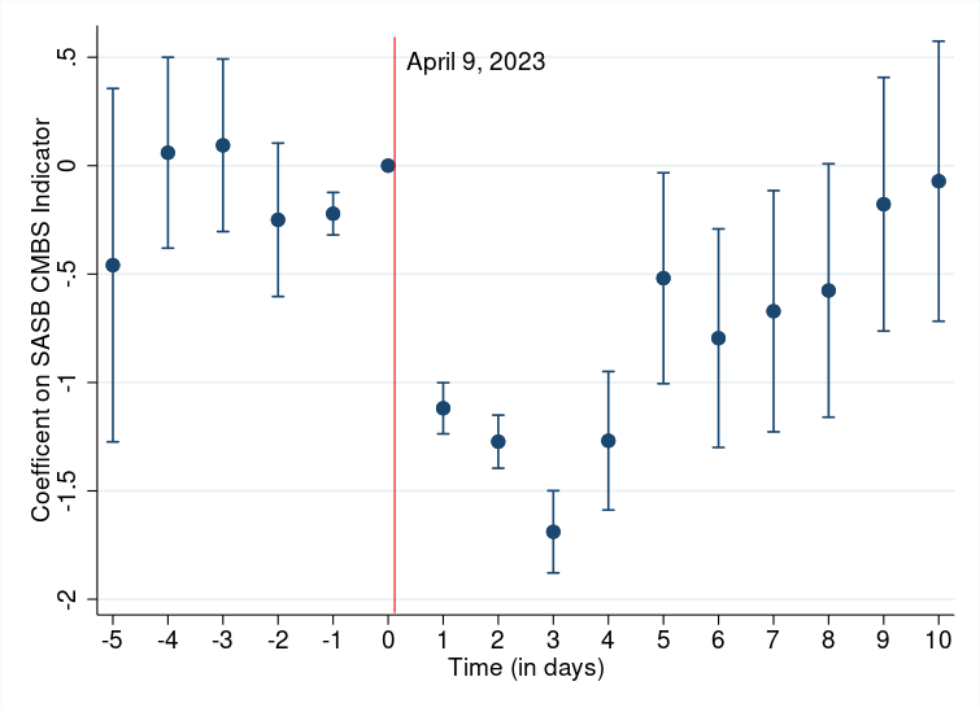
[8] In related analyses, Campbell et al. (2011) show that spreads on TALF-eligible asset classes narrowed relative to the CDX and to equivalent European ABS classes in TALF 1.0. Caviness et al. (2021) show that spreads on TALF-eligible securities narrowed relative to ineligible securities (AAA-rated government guaranteed student loans and BBB-rated credit card and auto ABS) in TALF 2.0.

[9] See Commercial Real Estate Finance Council (2020) for this statistic and a discussion of SASB and conduit CMBS structures. We had multiple conversations with market participants, who confirmed that they were surprised by the fact that TALF 2.0 did not accept SASB CMBS AAA-tranches as collateral.

[10] We thank Jeremy Brizzi of the Federal Reserve Bank of Philadelphia for creating these data and providing technical advice.

[11] The average AAA-tranche CMBS price in our sample is 102.78.

Figure 3. Event Study: TALF Announcement of CMBS eligibility on April 9, 2020



Source. Bloomberg Finance LP, Global CMO/CMBS/Whole Loans Back Office; Intex Solutions, a leading provider of information and valuation software on structured finance securities, and authors' calculation.
Note. This graph shows the event study coefficients from regressing CMBS prices on a SABS indicator variable interacted with the respective trading days and 95% confidence intervals. The regression includes trading day and CUSIP fixed effect. Standard errors are clustered at the CMBS issuer level.

Next, we assess whether the effects of TALF on spreads for larger for CMBS with longer WALs (hypothesis 2). Since CMBS are fixed-rate securities, the sensitivity of CMBS prices to interest rates movements increases with WAL. Large price movements expose arbitrageurs to margin calls, which are very costly at a time when leverage constraints are binding. TALF funding—which offers predictable haircuts and no margin calls—should be particularly attractive for these securities.

We test this hypothesis by estimating the equation above with an indicator for above-median WAL instead of a SASB indicator. We look at variation only within TALF-eligible CMBS securities, that is, conduit CMBS securities.

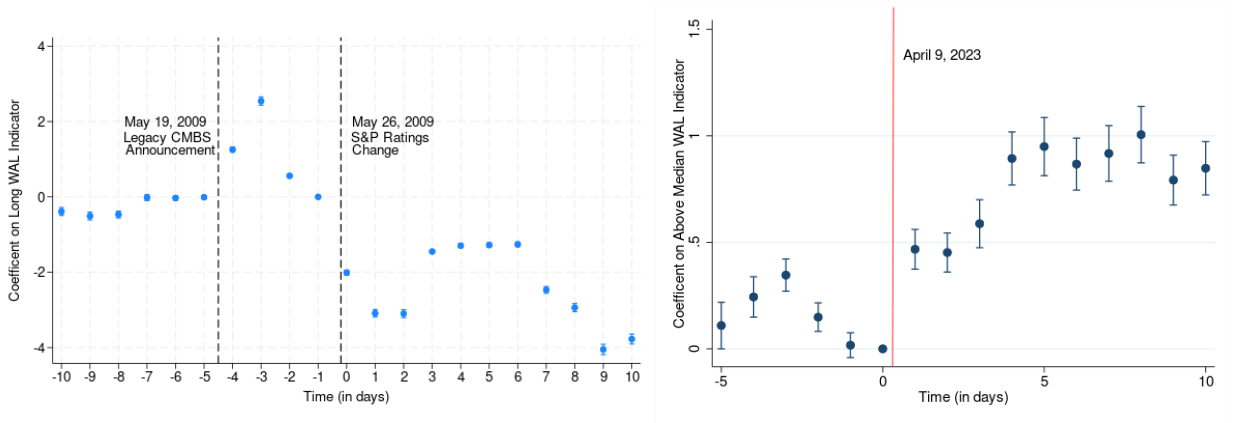
$$CMBS\ Prices_{it} = \beta_t\ Above\ Median\ WAL_i \times Trading\ day_t + \alpha_t + \mu_i + \varepsilon_{it}$$

Figure 4, left panel shows that results for TALF 1.0 in May 2009 around legacy CMBS program announcement and the May 26 S&P announcement regarding rating changes. Consistent with theory, longer term WAL securities gained relatively more after legacy CMBS became eligible for TALF. These gains reversed and turned negative once S&P announced a change to the ratings that halved the share of legacy CMBS that were potentially TALF-eligible. Longer term WAL securities lost about 300 bps after the S&P announcement, suggesting large effects of TALF-eligibility.

As shown in Figure 4, right panel after the April 9th announcement, prices on conduit CMBS with WALs above the median increased by about 100 bps more than the prices on conduit CMBS with WALs below the median. Unlike our comparison between SASB and conduit CMBS, this difference does not dissipate over our estimation horizon. This finding is consistent with TALF eligibility being more valuable for CMBS with volatile fundamentals, consistent with the GV model predictions.

The fact that we find large spread responses to the TALF 2.0 announcement and the subsequent liquidity spillovers to non-TALF eligible securities—well in advance of the actual opening of the program—suggests that market participants were confident that TALF 2.0 would be successful in restoring liquidity to the ABS market. The mostly likely explanation for the credibility of this announcement is that the Federal Reserve's announcement was seen as credible because investors had a positive experience with TALF 1.0. More broadly, our findings suggest that a credible central bank commitment to provide liquidity in the near future can immediately improve liquidity conditions.

Figure 4. Event Studies: Price Effect on Longer WAL CMBS Conduit Securities



Source. Bloomberg Finance LP, Global CMO/CMBS/Whole Loans Back Office; Intex Solutions, a leading provider of information and valuation software on structured finance securities, and authors' calculation. Note. This graph shows the event study coefficients from regressing CMBS prices on an above median WAL indicator variable interacted with the respective trading days and 95% confidence intervals. The regression includes trading day and CUSIP fixed effect. Standard errors are clustered at the CMBS issuer level.

5. Evidence from Borrower Behavior

Our classification of TALF borrowers is one of the major contributions of our paper. Although the name of the borrower, its parent, and its material investors are released publicly, most of the TALF borrowers are private capital funds or their subsidiaries and very little information on these borrowers is available in public data sources. To classify borrowers into the types described in the next section, we consulted the materials collected by FRBNY as part of its "Know Your Customer" process, such as the funds' confidential private placement memoradums (PPMs) and other data sources documented in the Data Appendix. As other researchers have noted (e.g., Begenau and Siriwardane, forthcoming), PPMs and other governing documents of private capital funds are almost never observed by outside scholars.

Our analysis is based on loan-level data on 1,919 loan requests submitted to FRBNY in the 2009-10 TALF program and 220 requests submitted in the 2020 TALF program.[13] Most of these data are available on the Board's website (data on rejected loan requests are not released publicly). We augment these data with information from Trepp and Bloomberg on the weighted average life and the yield on the securities collateralizing the loan request.

TALF Borrowers

We divide TALF borrowers into two groups: *Arbitrageurs,* who typically fund securities purchases with short-term repo, and *Long-Term Investors*, who typically use relatively more stable sources of funding. Within the category of Long-Term Investors, we highlight "TALF-only funds," which were private capital funds with committed capital that were created solely to profit from the TALF program. We highlight these funds to demonstrate that the private market can innovate in response to arbitrage opportunities in unexpected ways.

Arbitrageurs

Hedge funds are the classic arbitrageurs: they take advantage of price dislocations using short-term leverage, generally repo funding. However, their ability to obtain repo funding was severely curtailed during after the GFC.[14] In addition to suffering hits to their capital from higher haircuts on their repo funding, during the GFC some hedge funds experienced hits to their capital from redemption requests from investors. Forty-one hedge funds requested more than $20 billion in loans from TALF 1.0 – almost 30 percent of the total. Five hedge funds requested $153 million from TALF 2.0, only 3 percent of the total.

Mortgage REITs (mREITs) can resemble hedge funds in that they fund investments in MBS, whole loans, or other mortgage-related assets with short-term repo and gravitate toward the assets with the greatest price dislocations. The commercial mREIT sector collapsed in the GFC; half of the 14 commercial mREITs that were listed in *REIT Watch*, the primary statistical source on REITs, in September 2007 were no longer listed in September 2009.[15] In addition to suffering capital hits from higher haircuts, some mREITs faced difficulty in raising fresh capital from stock issuance. In 2009, some new publicly traded mREITs were launched, in part because TALF funding made CMBS seem like a more viable investment.[16]

[13] The number of loans in our data differs from that in the publicly available data for two reasons. First, our data include rejected loan requests. Second, as described in the Data Appendix, in some instances a loan appears as multiple records in the public data, either because the loan was refinanced or because one loan was split into multiple requests. We consolidate these records to one loan.

[14] Aragon and Strahan (2012) show that hedge funds depending on Lehman Brothers lacked funding liquidity after the investment bank's collapse. Acharya et al (2017) provide evidence that dealers were financial constrained during this period.

[15] A news article in 2008 opened, "In the world of mortgage REITs, the game being played is no longer *Who Wants to be a Millionaire?* Instead, it's turned into a vicious and bloody game of *Survivor."* Harden (2008).

[16] Commercial Mortgage Alert, August 7, 2009, "Ex Goldman Exec Huang Lands at Starwood."

Table 1. TALF Participation by Investor Type

TALF Borrowers	Number of Borrowers	Percent	Requested Number of Loans	Percent	Loan Amount (in millions)	Percent
TALF 1.0						
Arbitrageurs						
Hedge funds	41	25	536	28	20,628	29
REITs	9	5	125	7	2,401	3
Total	50	30	661	35	23,029	32
Long-Term Investors						
Insurance companies	10	6	119	6	5,068	7
Pension funds	6	4	49	3	6,114	8
Banks	3	2	8	0	606	1
Mutual funds	25	15	136	7	2,926	4
Individuals	21					
Fixed life partnerships	8	5	62	3	3488	5
TALF-only funds	44	27	761	40	28,391	40
Total	117	70	1,258	65	48,992	68
Total	167	100	1,919	100	72,021	100
TALF 2.0						
Arbitrageurs						
Hedge funds	5	25	8	4	153	3
Long-Term Investors						
Fixed-life partnerships	4	20	20	9	231	5
TALF-only funds	11	55	192	88	4,065	92
Total	15	75	212	97	4,296	97
Total	20	100	220	100	4,449	100

Note. The TALF 1.0 loan request numbers include about $1 billion in loans denied by FRBNY because the CMBS collateral was determined too risky.
Source. Authors' calculations, public data disclosures on Federal Reserve website, and internal FRBNY data.

Nine mREITs borrowed from TALF 1.0, including four of the five largest publicly traded REITs that focused on commercial mortgages in 2009.[17] No mREITs borrowed from TALF 2.0.

We can gain insight into the tight financing financing conditions for mREITs from their public filings. At year-end 2009, one mREIT that borrowed from TALF noted in its 10-K that "Currently, we have no repurchase agreements or bank credit facilities in place, and there can be no assurance that we will be able to obtain one or more such facilities on favorable terms" and three noted that "Under current market conditions, structured financing arrangements are generally unavailable," and that without this

[17] Data are from December 31, 2009, as reported in NAREIT (2010). We use data from that date because some REITs that participated in TALF came into existence in fall 2009. We count hybrid REITs as commercial mortgage REITs for this purpose.

longer-term take-out financing in place, lenders were hesitant about extending short-term credit. The tone of the filings changed by their March 2010 10-Q, when two REITs reported having obtained repo facilities with money-center banks. The sustained recovery in REIT stock prices by early 2010 likely also contributed to their ability to raise external capital.[18]

Long-term investors

Insurance companies, *pension funds*, and *banks* invest in ABS and other fixed-income securities to fund their liabilities. Ten insurance companies borrowed from TALF, including four of the six largest insurance companies as measured by net assets in 2009.[19] Only six pension funds borrowed from TALF 1.0—two large state funds and four small local funds—although many other pension funds participated through investments in private capital funds that we describe next.[20] Bank participation was quite limited--one regional bank and two US affiliates of foreign banks borrowed from TALF 1.0—and we exclude banks from much of the analysis. None of these investors borrowed from TALF 2.0.

Mutual funds, *individual investors,* and *fixed-life partnerships* borrowed from TALF for the benefit of their underlying investors. Twenty-five mutual funds—both open-end and closed-end--from six large fund families borrowed from TALF 1.0, and 21 individuals borrowed from TALF 1.0 through either pre-existing or newly created investment vehicles. These individuals, or their families, family trusts, or family foundations were the sole beneficiaries of these vehicles. We drop these borrowers from our analysis.

Fixed-life partnerships, like hedge funds, are private-capital funds open only to sophisticated "accredited" investors, such as pension funds or other institutional investors. Unlike hedge funds, though, fixed-life partnerships are funded with committed capital from investors. Investors cannot redeem their capital for the life of the partnership (typically five to ten years).

Many asset managers created new fixed-life partnerships specifically tailored for the TALF program. These "TALF-only" funds were limited by investment guidelines to hold only TALF-eligible ABS. These funds became the main TALF borrowers: 44 such funds borrowed in TALF 1.0, requesting 40 percent of the loans, and 11 borrowed in TALF 2.0, requesting 92 percent of loans. In addition to the TALF-only funds, an additional eight fixed-life partnerships with broader investment mandates borrowed from TALF 1.0, and four borrowed from TALF 2.0.

Long-term investors also came under stress during and after the GFC. Bond mutual funds experienced large withdrawals, for example, and life insurance companies suffered large losses on the variable-rate annuities. However, these strains were less acute by the time of the TALF program. In addition, the particular strain that we are focused on in this paper—an acute tightening of repo funding that

[18] By March 2010, mortgage REIT prices had been rising for more than a year, after falling by 20 percent year-over-year in March 2009 and 47 percent in March 2008.

[19] Net assets are measured at the level of the operating entity and from statutory financial statements accessed through S&P Global. We thank Mike Batty for his help with this calculation.

[20] We can observe whether a pension fund invested in a TALF-only fund by examining the list of material investors (any entity or individual with a 10 percent or greater beneficial ownership interest in any class of securities of a TALF borrower) provided on the Federal Reserve website (https://www.federalreserve.gov/regreform/files/talf.borrower.xls).

exacerbated leverage constraints—was not a major issue for these long-term investors given their funding model.

Loan Rejections in the Legacy CMBS program

The legacy CMBS program from TALF 1.0 provides the best setting for testing empirically the hypotheses from the GV model. Both arbitrageurs and long-term investors requested loans collateralized by CMBS. Further, a large number (nearly 1,350) of CMBS were eligible collateral at each subscription and those CMBS varied substantially in their riskiness despite their AAA rating.

CMBS were riskier than the new-issue ABS collateral (credit card ABS, auto loan ABS, etc.) for three reasons. First, CMBS are long-maturity (typically ten-year) fixed-rate securities and so their valuations can move considerably with interest rates. Second, CMBS are subject to considerable credit risk because the valuations on the underlying properties can change substantially. Credit risk was a particularly significant concern in 2009 because CMBS underwriting standards deteriorated in the years before the GFC (Stanton and Wallace, 2018; Ashcraft, Malz, and Poszar, 2012) and commercial real estate prices were in the midst of a 30 percent fall. Third, CMBS investors faced a material risk that FRBNY would reject their loan request.

Legacy CMBS posed a quandary for the Federal Reserve. For new-issue ABS, FRBNY could influence how the security was structured, both through detailed guidance published online and through credit reviews before the security was issued. For legacy CMBS, however, FRBNY was stuck with the existing stock of securities-- and the lax CMBS underwriting before the GFC and the contraction in CRE prices meant that some putatively triple-A rated CMBS could be downgraded or experience credit losses.

Instead, FRBNY required investors to purchase CMBS in an arms-length transaction in the secondary market in the 30-day period before the TALF loan subscription, and then submit a loan request. FRBNY published on its web page five days later which CMBS CUSIPs were acceptable collateral for this loan submission and which were not, but did not release the name of the rejected borrower. Investors who owned CMBS that were rejected as TALF loan collateral would need to find alternative private market funding or sell the CMBS, likely at a loss. Since the private-market funding would lack the features of the TALF loan that were attractive to leverage-constrained arbitrageurs—lower haircuts, no margin calls, nonrecourse—a rejection significantly increased the return an arbitrageur would require to hold the security.

The Federal Reserve published broad guidance on its CMBS credit review process but did not release its exact stress-testing algorithm because it wanted to give investors an incentive to do their own due diligence. Investors, however, were able to discern broad patterns about which types of CMBS were more likely to be rejected. As we show in Table 2, rejected CMBS were more likely to have long weighted average lives and had more loans that were delinquent or in special servicing. Campbell et al. (2011) also show that rejected CUSIPs had higher yields than accepted CUSIPs.

Table 2. TALF 1.0 CMBS Characteristics and Outcomes

	Accepted	Rejected
CUSIP Count	265	41
Average 90+ Days Delinquent at Subscription	2.36%	3.54%
Average Special Servicing at Subscription	7.81%	8.74%
% of Total Downgraded (lifetime)	2.64%	14.63%
Average Months to First Downgrade	30	16
WAL, 25th percentile	2.02	4.25
WAL, Median	2.80	5.68
WAL, 75th percentile	5.19	6.51

Note. For CUSIPs that were accepted or rejected multiple times, statistics are for the first acceptance or rejection.
Source. Trepp (for WAL). Jeremy Brizzi at the Federal Reserve Bank of Philadelphia based on data from Intex Solutions (for delinquency statistics).

Arbitrageurs' Avoidance of Riskier CMBS

We first show that arbitrageurs were less likely than long-term investors to request TALF loans collateralized by CMBS with long WALs and high yields (hypothesis 3). We estimate the following regression:

$$Risk_{it} = \beta_1 Hedge\ Fund + \beta_2 Mutual\ Fund + \beta_3 TALF - only\ Fund + \beta_4 FL\ Partnership + \varepsilon_{it}$$

where $Risk_{it}$ is measured with either WAL or yield of the respective security *i* at time *t*. We control for month of subscription because as we show later the WAL rose over time as arbitrageurs' funding constraints abated. Arbitrageurs are mREITs (omitted category) and hedge funds, and long-term investors are mutual funds, TALF-only funds, and fixed-life partnerships. We exclude insurance companies, pension funds, banks, and private investors from the sample because they submitted so few CMBS loan requests.

As shown in Table 3, mREITs and hedge funds submitted loan requests collateralized by CMBS with significantly shorter WALs. On average (OLS regression in column 1), the WALs for CMBS collateralizing loans requested by fixed-life partnerships were more than two years greater than for mREITs; in the median regression (column 2), the equivalent difference is almost four years. Mutual funds and TALF-only funds also have longer-WAL loan requests than mREITs. Meanwhile, the WALs for hedge fund and mREIT requests are almost indistinguishable. Likewise, the yields on CMBS submitted by fixed-life partnerships are higher than on those submitted by mREITs, even controlling for WAL (columns 4 and 5).[21] In sum, this evidence supports the hypothesis that arbitrageurs chose CMBS for TALF loan collateral that were less likely to be rejected.

[21] This finding is consistent with reach-for-yield documented for insurance companies by Becker and Ivashina (2015).

Table 3: WAL and Yields on CMBS Loan Requests

	WAL Regressions		Yield Regressions		
	OLS	Median	OLS	OLS	Median
	(1)	(2)	(3)	(4)	(5)
Hedge Fund	0.209	0.200	0.224	0.205	0.0200
	(0.649)	(0.155)	(0.441)	(0.158)	(0.0619)
Mutual Fund	0.712	0.440**	0.355	0.00797	0
	(0.552)	(0.204)	(0.282)	(0.0824)	(0.0642)
TALF-Only Fund	1.195**	1.450***	0.627**	0.0497	0
	(0.509)	(0.316)	(0.252)	(0.0669)	(0.0543)
Fixed Life Partnership	2.262***	3.980***	1.268***	0.307***	0.350***
	(0.756)	(0.479)	(0.341)	(0.0950)	(0.0875)
Month FE	Yes	Yes	Yes	Yes	Yes
WAL Bucket FE	No	No	No	Yes	Yes
Observations	831	831	826	826	826
R^2	0.194		0.156	0.773	

Notes. Includes CMBS loan requests that were rejected by FRBNY. Omitted borrower type is mortgage REITs. Insurance companies, pension funds, and private individuals are excluded from the sample. WAL obtained from Trepp. All other data are from FRBNY or authors' research. OLS standard errors (in parentheses) are robust and clustered by the borrower. CMBS

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Arbitrageurs' Responses to Changes in Perceived Rejection Risk

We next use investors' responses to an increase in the perceived risk of CMBS rejections to illustrate that rejection risk weighed heavily on arbitrageurs' behavior in the TALF program. Figure 5 shows the breadth of program participation (as gauged by number of borrowers), the number of CUSIPs rejected, and a measure of borrower risk aversion (the share of submitted CUSIPs that were accepted at an earlier subscription). Participation was low in the first subscription in July 2009, with only [x] participants, in part because of investor uncertainty about which CMBS would be accepted as collateral.[22] After FRBNY rejected only one CUSIP (grey bar) at the July 2009 subscription, three at the August 2009 subscription, and none at the September 2009 subscription, investors became more confident that they understood FRBNY's risk parameters.[23] The number of investors participating in the program (the black line) reached a peak in October 2009 of 43 borrowers.

However, at the October subscription, FRBNY surprised the market by rejecting five CUSIPs, including rejecting a triple-A tranche from one CMBS when a longer-maturity triple-A tranche from the same deal was accepted at both the August and September subscriptions.[24] An industry publication noted that the

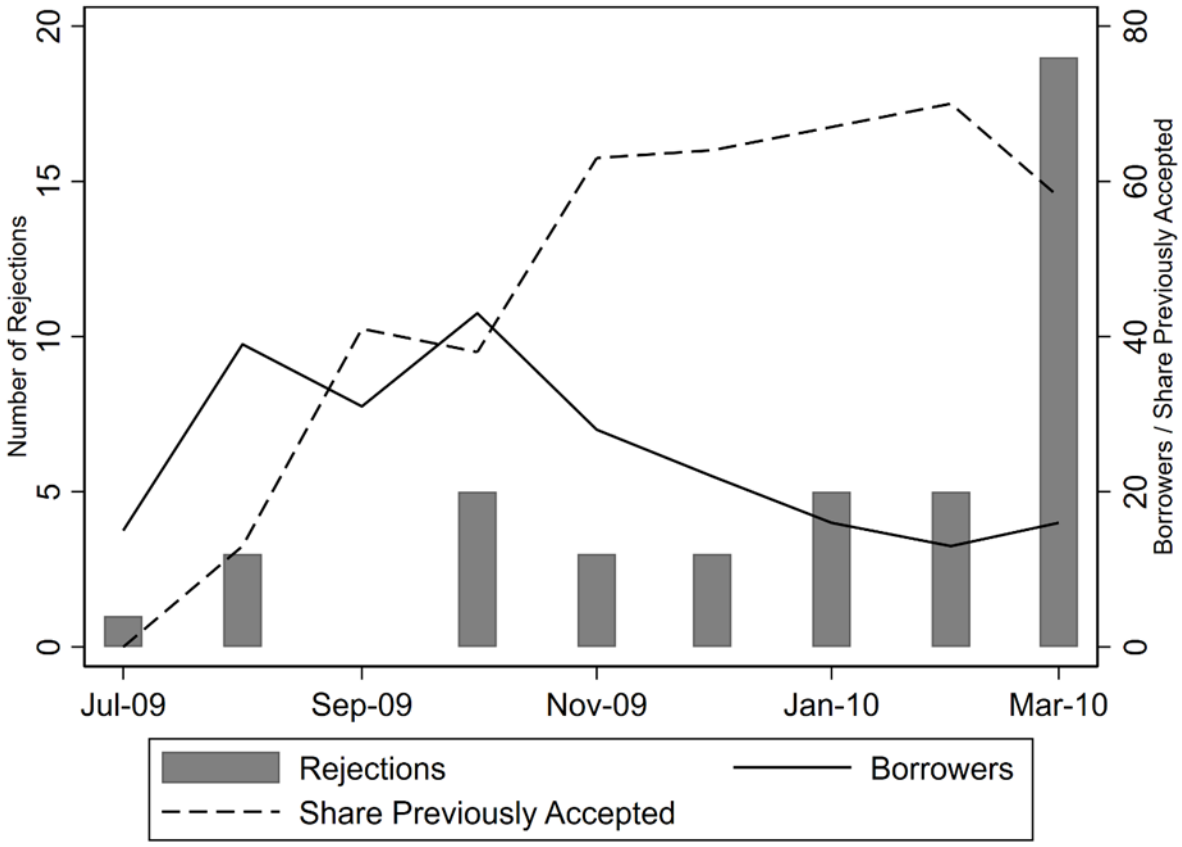
[22] Commercial Mortgage Alert, July 10, 2009.

[23] "TALF Loan Rejections Befuddle Investors," Commercial Mortgage Alert, October 30, 2009.

[24] CMBS generally have multiple AAA tranches that differ in the timing of when the investor receives various cash flows. Investors in an A3 tranche would get their money back sooner than investors in an A4 tranche.

rejections "roiled the market" and quoted one analyst as saying that "Several investors have started to compare the TALF rejection process to a random number generator."[25] The number of borrowers fell to 30 at the November 2009 subscription and the borrowers became much more risk averse: the share of submitted CUSIPs that had been accepted at a previous submission surged from 43 percent to 69 percent.

Figure 5: Number of CUSIP Rejections and CMBS Borrowers, and Share of Loan Requests Collateralized by a Previously Accepted CUSIPs, TALF 1.0



Source. Authors' calculations, public data disclosures on Federal Reserve website, and internal FRBNY data.

The unexpected rejections in the October 2009 subscription allow us to test our fourth hypothesis. Note that in terms of the GV model, rejections increase arbitrageurs' leverage constraints and arbitrageurs should require higher compensation to engage in these trades. Arbitrageurs should react to an unexpected increase in the perceived probability of rejection by decreasing their participation in the program and re-focusing their investments on CMBS that were less likely to be rejected.

Consistent with the hypothesis, as noted earlier, the number of borrowers fell substantially after the unexpected rejections in October 2009. However, this pullback was not uniform across types of

[25] "TALF Loan Rejections Befuddle Investors," Commercial Mortgage Alert, October 30, 2009.

borrowers (Table 4). Hedge funds and mREITs pulled back significantly: the number of hedge funds submitting loan requests fell from 11 to 8, for example, and the number of mREITs fell from 4 to 1. Both types of arbitrageurs had an approximately 35 percentage point rise in the share of submitted CUSIPs that had been accepted at an earlier subscription: from 35 to 71 percent for hedge funds and from 21 to 56 percent for mREITs.[26]

Long-term investors, however, pulled back less. The same number of mutual funds (7) participated in the October and November subscriptions, although the number of fixed-life partnerships fell from 3 to 1. Both types of investors increased the share of submitted CUSIPs that had been accepted earlier by about 15 percentage points. Some TALF-only funds pulled back after the October subscription, but that was because the funds were formed before the terms of the CMBS program were announced, and so the funds' PPMs did not have any provisions that allowed the funds to hold rejected CMBS. When we divide funds by whether their PPMs have this provision (we can determine this for 11 funds), we see that retrenchment is centered on funds with PPMs that do not allow for rejection.[27] Participation by TALF-only funds that were allowed to hold rejected CMBS was the same in October and November.

Table 4: Change in CMBS Participation by Investor Type, October-November 2009

	Borrowers (number)		Loan requests ($million)		CUSIP accepted before (percent)	
	Oct 2009	Nov 2009	Oct 2009	Nov 2009	Oct 2009	Nov 2009
Arbitrageurs						
Hedge fund	11	8	509	384	35	71
mREIT	4	1	281	145	21	56
Long-Term Investors						
Mutual fund	7	7	327	351	60	76
Fixed-life partnership	3	1	102	78	33	50
TALF-only fund	16	11	746	488	48	65
PPM allows for Rejection	3	3	119	97	44	43
PPM doesn't allow for rejection	8	4	448	183	44	100
All	43	30	2,005	1,475	43	68

Note. No insurance companies or pension funds participated in the CMBS program in October or November 2009.

FRBNY's credit-review algorithm remained somewhat opaque to investors throughout the TALF program. In November 2009, FRBNY rejected three CUSIPs that had been accepted in previous subscriptions; two of these had been accepted the previous month. In subsequent months, FRBNY

[26] One would expect the share of previously accepted CUSIP to go up mechanically over time. However, borrowers submitted only 306 different CUSIPs out of over 1,300 eligible CUSIPs.

[27] For example, TALF-only funds that were created before the terms of the CMBS program were announced commonly described their investment parameters as encompassing TALF eligible securities, whereas at least one later PPM stated that the fund is allowed to invest in "assets that the Adviser *believes* are eligible to be financed through TALF" (emphasis added).

rejected another nine CUSIPs that had been accepted at earlier subscriptions. In January 2010, one news story was headlined "Fickle Fed Irking TALF Applicants",[28] while a Financial Times columnist observed "The Fed's Talf reasoning is always a bit mysterious… it looks like the Fed's Talf-thinking doesn't make much sense to bond investors either" (Alloway, 2010). This narrative evidence supports our identification strategy that TALF borrowers perceived rejections as quasi-exogeneous.

Changes in Arbitrageurs' Risk Aversion Over Time

As the private-market repo market stabilized, arbitrageurs' external leverage constraints eased. Figure 2 indicated that private-market repo haircuts decreased steadily over the life of the TALF program, and the narrative evidence presented earlier in this section indicated that REITs perceived external financing to be substantially more available in 2010:Q1 than in 2009. We hypothesize (hypothesis 5) that arbitrageurs should submit more risky CMBS as collateral for TALF loan requests over the course of the program.

We first examine whether the WAL of CMBS that arbitrageurs submitted as TALF loan collateral increased over time relative to that of long-term investors. We estimate the following loan-level regression:

$$\mathrm{WAL}_{it} = \sum_{t=Aug\ 2009}^{Mar\ 2010} \beta_t \alpha_t + \epsilon_{it}$$

where WAL_{it} is the weighted average life of security *i* that was submitted as collateral at time *t* and α_t is an indicator that is equal to 1 at time *t*. Figure 6, panel a) shows the results for all TALF borrowers over time. The WAL on loan requests is about constant through the August, September, and October subscriptions, and then increases by a statistically significant 0.6 years for the next four subscriptions before surging at the final subscription.

When we split the sample by CUSIPs on loan requests submitted by arbitrageurs and long-term investors, we find that the aggregate pattern is driven mostly by the arbitrageurs (panel b). We do not detect significant changes in WAL for long-term investors across the subscriptions. In contrast, the WAL on loan requests submitted by arbitrageurs increased by a statistically significant amount starting with the January 2010 subscription.

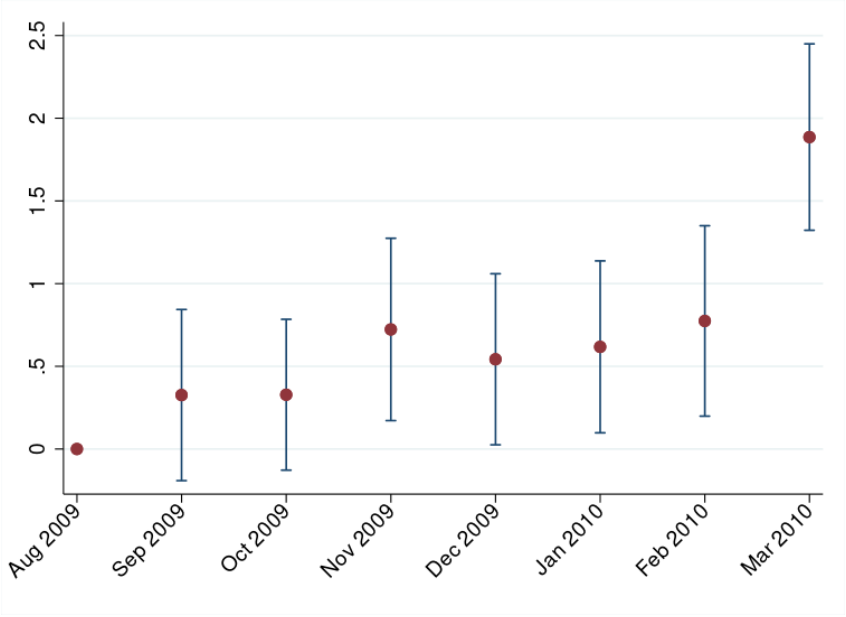
We next examine whether arbitrageurs' loan requests became more likely to be rejected over time, as might be expected given the increase in the WALs. We estimate the following regression on all TALF loan requests collateralized by CMBS:

$$\mathrm{Rejected}_{it} = \beta_1 Arbitrageur + \beta_2 Arbitrageur * Late\ +\ \alpha_t + \epsilon_{it}$$

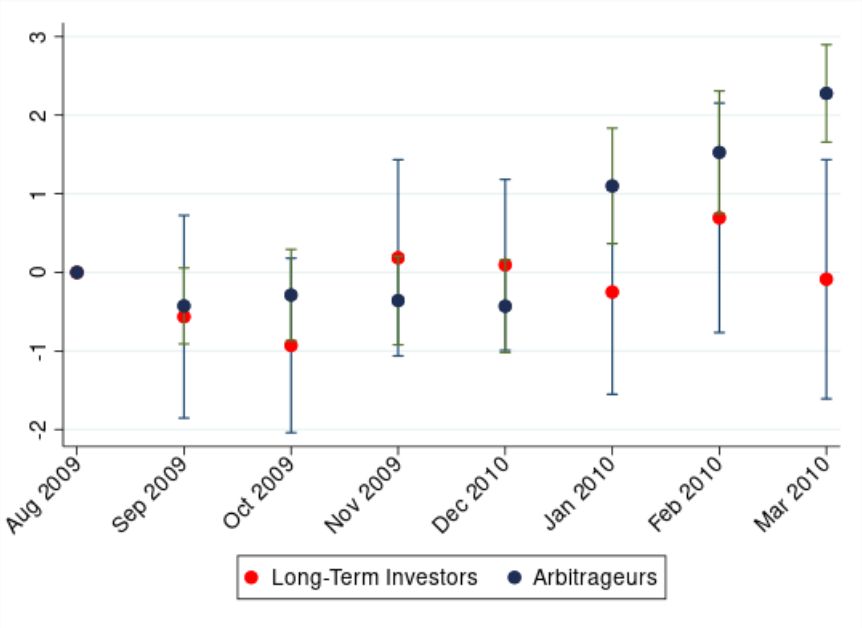
where *rejected*$_{it}$ is a dummy that is equal to 1 if the loan request for CUSIP *i* was rejected in subscription *t*, *Arbitrageur* is a dummy that is equal to 1 if the borrower is either a hedge fund or an mREIT, *Late* is an indicator that is equal to 1 from Dec 2009-March 2010, and α_t is the subscription fixed effect.

[28] "Fickle Fed Irking TALF Applicants," Commercial Mortgage Alert, January 29, 2010

Figure 6: WAL over time



a) All Borrowers



b) Split by Borrower Type

Note: This figure shows the regressions results of estimating monthly dummy variables on WAL for arbitrageurs (hedge funds, mREITS) and long-term investors (TALF-only funds, fixed life partnerships, and mutual funds). 95% confidence intervals are indicated for each point estimate. Source: Trepp, Authors' calculations

In the specification that groups all subscriptions together (Table 5, column 1), the results indicate that arbitrageurs were, on average, 4 percent more likely to submit a TALF loan request that was rejected by

FRBNY. However, when we allow the effect to differ by the early and the late subscriptions, we find that the result is driven by the late subscription (column 2): there is no difference in the early subscriptions in the rejection probabilities of arbitrageurs and long-term investors, but in the later subscriptions arbitrageurs were 10 percentage points more likely to submit a loan request that was rejected.

Table 5. Propensity of Loan Rejection over time

	Unweighted		Weighted
	(1)	(2)	(3)
Constrained	0.040**	-0.003	-0.009
	(0.019)	(0.191)	(0.029)
Constrained * Late		0.106**	0.103**
		(0.042)	(0.052)
Time FE	Yes	Yes	Yes
Observations	710	710	710
R^2	0.19	0.20	0.15

Note. The dependent variable is Rejected_{it}---a dummy whether the loan requestion for CUSIP *i* was rejected in subscription t. We only keep loan applications by hedge funds, mREITs, TALF-only funds and fixed life funds. We consider all subscriptions from July 2009 to March 2010. In columns 1 and 2 all loan requests have equal weight. Column 3 weighs the observations by their principal loan amounts. The late period is Dec 2009-March 2010. Robust standard errors in parenthesis. No CMBS were rejected in September 2009. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Source. Public data disclosures on Federal Reserve website and internal FRBNY data.

Spreads on Rejected CUSIPs

Following the intuition from the GV model, we hypothesize that arbitrageurs should require higher compensation to hold a CMBS that is rejected as TALF loan collateral. Rejected CMBS can only be funded with the higher haircuts associated with the private repo market and thus require more of the arbitrageur's scarce capital (hypothesis 6a). We predict the effect should be larger for CMBS with high WALs, following the logic outlined earlier that high-WAL CMBS have higher price volatility and thus arbitrageurs who fund these securities with private repo are more likely to be subject to capital-depleting margin calls (hypothesis 6b). However, we hypothesize that as the private repo market recovers and arbitrageurs' leverage constraints ease, they should require less compensation to hold a rejected CMBS (hypothesis 6c).

To test these hypotheses, we refine the approach of Campbell et al. (2011). Their approach compares the change in the spread on the rejected CUSIP with the change at the same time in an equally weighted average of spreads on all CMBS that met the broad TALF parameters. That design controls for market-wide moves in CMBS spreads, but does not control for the fact that some securities inherently have more price volatility than others. In order to control for both these market-wide and security specific factors, we construct a full panel with daily spread data from Trepp for the 294 CUSIPs submitted as collateral for TALF loan requests from August 1, 2009 to March 31, 2010 (174 trading days).[29] This setup allows us to control for trading-day fixed effects and CUSIP fixed characteristics and thus both for market-wide changes in CMBS spreads and CUSIP-specific factors.

[29] We drop the first subscription in July 2009 as it was small in size and included a significant share of traditional investors. We obtain similar results when we include the July 2009 subscription.

We estimate the following regression:

$$\Delta Spread_{it} = \beta_1 Rejected_{it} + \theta_i + \alpha_t + \epsilon_{it}$$

where $\Delta Spread_{it}$ is the change in the spread of CUSIP *i* during a 5-, 7-, 9-, or 11- trading-day window centered on date *t*. We consider different time windows because CMBS do not necessarily trade every day and so it may take a couple days for trading activity to inform the Trepp estimates. $Rejected_{it}$ is an indicator variable that is equal to 1 on the trading day on which the CUSIP rejection was announced, θ_i are CUSIP fixed effects and α_t are trading-day fixed effects. In the second set of regressions, $Rejected_{it}$ is interacted with a high WAL (WAL in the 75th percentile) indicator.

As shown in Table 6, panel a, spreads increased on rejected CUSIPs regardless of the time window around the rejection. The effect is economically significant, ranging from about 9 bps in the 5-day window to 23.5 bps in the 11-day window, and consistent with our hypothesis that spreads should increase after rejection.

Table 6. Spread Change after Loan Rejection

Panel A: All subscriptions

	5-day window	7-day window	9-day window	11-day window
	(1)	(2)	(3)	(4)
Rejected	8.87**	13.45***	22.44***	23.53***
	(3.60)	(4.09)	(6.55)	(7.57)
Time FE	Yes	Yes	Yes	Yes
CUSIP FE	Yes	Yes	Yes	Yes
Observations	49,920	49,913	49.906	49,899
R^2	0.41	0.42	0.40	0.39

Panel B: WAL Interactions

	(1)	(2)	(3)	(4)
Rejected x High WAL	10.56	32.45**	47.78***	46.26***
	(7.91)	(13.10)	(8.78)	(10.57)
Rejected	3.50	-3.10	-1.93	-0.04
	(5.34)	(7.38)	(7.77)	(10.28
High WAL	-0.44	0.97	1.42	0.25
	(1.33)	(1.91)	(2.44)	(2.64)
Time FE	Yes	Yes	Yes	Yes
CUSIP FE	Yes	Yes	Yes	Yes
Observations	49,920	49,913	49.906	49,899
R^2	0.42	0.42	0.40	0.399

Note. The dependent variable is $\Delta Spread_{it}$---the change in the spread of CUSIP *i* during a window indicated in each column centered on date t. We consider all subscriptions from August 2009 to March 2010. High WAL is an indicator that is equal to one if the WAL is in the 75th percentile. Changes in spreads are winsorized at the 1 percent level. Standard errors clustered are clustered on the CUSIP and Trading Day level. No CMBS were rejected in September 2009. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Source. Trepp, authors' calculations, public data disclosures on Federal Reserve website, and internal FRBNY data.

To see if the effect is larger for high-WAL securities (hypothesis 6b), we interact the loan rejection indicator with an indicator equal to 1 if the WAL of the security is in the 75th percentile of the

distribution. As shown in Table 6, Panel B, the *Rejected x High WAL* coefficient is more than twice as large as the *Rejected* coefficient baseline in panel a) for windows of 7 days or longer. For the 11-day window specification, the estimated effect is almost 50 bps. Moreover, the *Reject* coefficient—which captures the effect of rejection on low-WAL CUSIPs—is no longer sizable or statistically significant.

As the private repo market recovered, funding a security purchase with private repo became less onerous for arbitrageurs, and thus arbitrageurs should require less compensation for holding a rejected security (hypothesis 6c). To test this hypothesis, we interact with *Rejected* indicator variable with an *Early* indicator variable that takes the value 1 if the CUSIP was rejected between August and November 2009, and with a *Late* indicator variable that takes the value 1 if the CUSIP was rejected December 2010 or later. As shown in Table 7, early rejections are associated with large and statistically significant increases in spreads for all time windows. Economically, the effects are as large as nearly 60 bps and double the effects estimated in the baseline regressions (table 6, panel a)). Late rejections are associated with much smaller increases in spreads—up to 14 bps–and in shorter time windows the coefficients are not statistically significantly different from zero

Table 7. Spread Change after Loan Rejection over Time

	5-day window	7-day window	9-day window	11-day window
	(1)	(2)	(3)	(4)
Rejected * Early	22.00***	20.59***	47.29***	57.55***
	(3.82)	(2.50)	(15.84)	(15.58)
Rejected * Late	4.21	10.92*	13.62**	11.45**
	(2.91)	(6.16)	(6.15)	(5.28)
Time FE	Yes	Yes	Yes	Yes
CUSIP FE	Yes	Yes	Yes	Yes
Observations	49,920	49,913	49.906	49,899
R^2	0.41	0.42	0.40	0.39

Note. The dependent variable is $\Delta Spread_{it}$---the change in the spread of CUSIP *i* during a window indicated in each column centered on date t. We consider all subscriptions from August 2009 to March 2010. The early period is August – November 2009 and the late period is Dec 2009-March 2010. Changes in spreads are winsorized at the 1 percent level. Standard errors clustered are clustered on the CUSIP and Trading Day level. No CMBS were rejected in September 2009. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Source. Trepp, authors' calculations, public data disclosures on Federal Reserve website, and internal FRBNY data.

6. Conclusion

We show that the dynamics hypothesized in limits-to-arbitrage models—that at times of strain, leverage-constrained arbitrageurs eschew capital-intensive investments and thereby exacerbate price dislocations—unfolded in line with model predictions in the asset-backed securitization market during the Global Financial Crisis and the Covid crisis. Our unique loan-level data allows us to contrast the investment behavior of arbitrageurs and long-term investors that borrowed from TALF and show that leverage constraints were a significant factor restraining arbitrageurs from bridging price dislocations.

Our findings have important implications for the design of policy interventions. Interventions such as TALF that alleviate leverage constraints can be a powerful tool in restoring market functioning, while at the same time preserve the market infrastructure and more importantly price discovery in the secondary markets. The latter is an important advance over outright purchases, which central banks

may find hard to exit without significant market disruptions. Our context also illustrates how central bank interventions that include market participants can foster financial market innovations, here TALF-only funds, that support market functioning in times of stress.

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Data Appendix

Borrower Type Classification

The TALF agents provided a classification for the type for each borrower. That classification was our starting point. For the TALF 2.0 borrowers, we checked the TALF agent classification against publicly available SEC filings, and followed up with the TALF agent if the classification seemed erroneous. We did not have this option for the TALF 1.0 borrowers because we reviewed the TALF agent classification several years after the program ended. Instead, we checked the classification against publicly available SEC filings, material investors listed in the public data disclosure, proprietary databases, news reports, and private placement memoranda and other "know your customer" materials collected by the New York Fed as part of its due diligence. This review resulted in changes to the classifications of about 20 percent of the borrowers for the TALF 1.0 program.

REITs often have multiple subsidiaries. Investors purchase shares in the parent REIT, but in five cases REITs borrowed from TALF through multiple subsidiaries. We consolidated these subsidiaries into one record for each parent REIT because the REIT makes its investment decisions at the parent level. In practice, this decision only affects the columns with borrower-level statistics in Tables 2 and 8.

The specific sources we consulted for different borrower types are:

Fixed-life partnerships: publicly available SEC Form D filings in which the TALF borrower or borrower's parent company self-identifies as "private equity fund" or "other investment fund"; private placement memorandum that indicate that fund had a fixed end date and severely restricted redemption rights; references to the fund in other Know Your Customer materials or news reports that were not consistent with hedge funds.

Hedge funds: publicly available SEC Form D filings in which the TALF borrower or borrower's parent company self-identifies as a hedge fund; fund is listed in the Refinitiv, Lipper TASS or Hedge Fund Research hedge fund databases; private placement memorandum that indicate that the fund is an ongoing entity and generally allows redemptions; references to the fund as a hedge fund in other Know Your Customer materials or news reports; material investors that are hedge funds.

Private individuals: news stories about material investors in the funds, and Know Your Customer materials.

Mutual funds and closed-end funds: publicly available shareholder reports, prospectuses, Morningstar write-ups, or fund family websites. This category also includes one vehicle set up by a fund family as a way for several mutual funds to participate in TALF 1.0.

REITs: publicly available 10Ks (for publicly listed REITs) or private placement memoranda (for private REITs), material investor listing in public data disclosure, news reports, and Nareit website.

Banks, insurance companies, and pension funds: company websites

Data Sets

Administrative data from the Federal Reserve Bank of New York

Data on TALF borrowers and on the characteristics of their loans and the securities that collateralize the loans are available on the Federal Reserve Board website at http://www.federalreserve.gov/newsevents/reform_talf.htm for TALF 1.0 and at Federal Reserve Board - Term Asset-Backed Securities Loan Facility for TALF 2.0. We use the borrower name; the TALF loan amount; the day that the loan was originated; the day that the loan was repaid; the CUSIP of the ABS collateralizing the loan; and the ABS asset class. The list of CUSIPs that were accepted or rejected at each TALF 1.0 CMBS subscription are available at https://www.newyorkfed.org/markets/talf_cusips.html. No CUSIPs were rejected in TALF 2.0.

For borrowers in the TALF 1.0 program, we augment these data with internal data on the date of loan repayment, if that repayment occurred after September 30, 2010, and data on rejected CMBS loan requests. As described above, we also use internal data to classify the borrower type.

Weighted average life and yield

We obtain the CMBS weighted average life and yield from Trepp for the TALF 1.0 program and from Bloomberg for the TALF 2.0 program. In a couple cases where these data were missing, we imputed them by looking up the securities on Structured Finance Portal, a product offered by Moody's Analytics that has information on individual ABS, or by looking at the values of the variables in the months before and after the month in which they are missing.

Calculation of Key Variables

Number and dollar amount of loans outstanding

Our total number and dollar of loan requests do not match the totals in the public-release data files for several reasons.

1. We include loan requests for CMBS that were rejected by FRBNY. In the TALF 1.0 program, 47 loan requests totaling $940 million were rejected.
2. We combine loans that were refinanced in May 2009 into one record. In May 2009, FRBNY introduced two new interest rates—the one-year and two-year Libor swap rates plus 100 basis points (http://www.federalreserve.gov/newsevents/press/monetary/20090421b.htm)—that were intended to correspond more closely to the appropriate base rates for fixed-rate ABS with one-year and two-year weighted average lives. Sixty-three loans collateralized by short-WAL ABS that were taken out at the March or April subscriptions were refinanced into the lower interest rate at the May subscription. These loans each appear as two records in the publicly available data and one loan in our data.
3. We combine assigned loans into one loan if the loan was transferred within the same parent company. TALF borrowers had the option to sell their ABS and assign the TALF financing to the new owner during the period while TALF was still accepting new loan requests. Of the 159 loans in the TALF 1.0 program that were assigned to a new borrower, 115 appear to have been assigned to another company within the same parent financial institution; the remainder were transferred to outside companies with no affiliation with the borrower. We determine this by whether the first four letters of the names of the original borrower and the new borrower are the same. Most of these same-organization transfers appear to have happened within the same private-equity firm.

4. In 74 cases in the TALF 1.0 program, borrowers chose to break up their loans into smaller loans to provide more repayment flexibility. These 74 cases correspond to 341 loans. We weighted the data so that these loans sum to 74 loans in the total of loans.

In the TALF 2.0 program, some loan requests are split into two or more loans in the public-use database. These are loans collateralized by two or more portions of the same CUSIP; since the pieces of the underlying security were acquired separately, they represent more than one record in the database. We combine these into one record each.