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Treasury safety, liquidity, and money premium dynamics: Evidence from recent debt limit impasses

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Abstract

Treasury securities normally possess unparalleled safety and liquidity and, consequently, carry a money premium. We use recent debt limit impasses, which temporarily increased the riskiness of Treasuries, to investigate the relationship between the money premium, safety, and liquidity. Our results shed light on Treasury market dynamics specifically, and debt more generally. We first establish that a decline in the perceived safety of Treasuries erodes the money premium at all times. Meanwhile, changes in liquidity only affected the money premium during the impasses. Next, we show that Treasury safety and liquidity dynamics are generally consistent with the theory of the information sensitivity of debt.

JEL Classification: G12, G14, G18, E43, E63, H63

Keywords: Treasury securities, money premium, default risk, liquidity, information sensitivity of debt, debt limit

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1 Introduction

For the past 50 years or so, Treasury securities have been the quintessential riskless asset. Of these, Treasury bills - securities with less than one year remaining maturity at issuance - generally possess unparalleled safety and liquidity relative to other debt instruments, public and private. Because of this safety and liquidity, bills are usually considered "money" and their yields reflect a money premium, or a lower yield than would be expected from a typical asset pricing model. But every so often, a legislative quirk calls the full faith and credit of the U.S government into question. Treasury securities can be issued up to a debt limit, or a ceiling on U.S. Treasury debt outstanding set by the Congress. If the amount of Treasury debt approaches the limit, and Congress fails to raise it, the U.S. government could default on its debt. Over the past decade, these debt limit episodes have occurred nearly biennially. The 2011 and 2013 episodes were the most notable, with extensive news coverage and brinkmanship by legislators up to the final hour before the deadline.

In this paper, we compare Treasury market outcomes during debt limit episodes to those during normal times to explore theories about Treasury debt and the money premium specifically, and the safety and liquidity of debt more generally. We contribute to the literature in two ways. First, we provide estimates of how the money premium varies with its two (admittedly related) components, safety and liquidity. Other authors explore how the magnitude of the money premium varies with other factors (e.g. debt outstanding, Krishnamurthy and Vissing-Jorgensen [2012]; interest rates, Nagel [2016]; and flight-to-liquidity, Longstaff [2004]). This previous research on the money premium takes the ultra-safety and liquidity of Treasuries as a given and estimates how the money premium varies with other factors. Our contribution does the opposite. We estimate how the money premium varies with proxies for Treasury safety and liquidity attributes while holding other factors such as the quantity of Treasury debt outstanding roughly constant.

Second, we provide empirical evidence to assess whether Treasury debt safety and liquidity dynamics are consistent with broader theories of the information sensitivity of debt (Dang, Gorton, and Hölmstrom [2015] and Hölmstrom [2015]). Briefly, the theory suggests that debt is information insensitive up to a point - that is, the liquidity properties of debt hold up as long as information asymmetries among market participants regarding the underlying value of the asset backing debt do not lead to differential probabilities of default. However, there is a tipping point at which information asymmetries and solvency risk swamp the desire for liquid trading, leading debt to become information sensitive. Benmelech and Bergman [2018] and others have demonstrated these points empirically for several markets, including corporate debt. We add to the literature by illustrating on what dimensions Treasury markets conform to the theory.

Our approach is as follows. To investigate the Treasury money premium, we employ a factor model approach using business daily data on the yields of outstanding T-bills as our dependent variable, and a range of market characteristics as our control variables. Importantly, the approach allows us to explore components of the money premium related to safety and liquidity based on covariation between the money premium, market perceptions of Treasury safety - U.S. sovereign credit default swap (CDS) spreads and other factors - and market measures of T-bill liquidity - bid - ask spreads, in particular. With these estimates, we then examine the extent to which T-bill liquidity is sensitive to changes in Treasury market safety, a hallmark of the information sensitivity hypothesis. In particular, we focus on whether T-bill liquidity responds to sizeable changes in Treasury market safety, but not small ones. We also examine whether liquidity responds differentially to market perceptions of safety inside and outside of debt limit impasses.

We establish that the money premium on T-bills varies significantly with changes in market perceptions of Treasury safety and liquidity, in a manner generally consistent with the theory of the information sensitivity of debt. We find that the reaction of bill yields to declines in either safety or liquidity factors is similar: a one standard deviation decline in either the safety or liquidity of Treasury bills is associated with a roughly 1 basis point reduction in the average money premium across the T-bill yield curve. However, there is a key difference when we look at both safety and liquidity together. Changes in the safety factor have statistically significant effects on the money premium both in normal times and during the debt limit impasses. In contrast, changes in liquidity only significantly affect the money premium during the debt limit impasses. Our ability to identify the conditions under which and the sequence of how safety and liquidity change distinguishes our results from previous ones that explore the magnitude of the money premium.

We also find the money premium depends importantly on the information structure governing Treasury repo markets. In particular, if repo investors can identify which T-bills are more likely to default in a debt limit impasse, overall liquidity dries up more rapidly than if bills are indistinguishable. In the 2011 debt limit impasse, repo market participants were unable to distinguish Treasury collateral that was likely to be affected by the debt limit impasse from Treasury collateral that was not. As a result, equilibrium rates appeared to be consistent with a pooling equilibrium, and liquidity in Treasury markets was relatively stable. By contrast, in 2013, repo trading systems were reportedly able to distinguish these two types of collateral. Consequently, a separating equilibrium ensued and repo market liquidity suffered. Our regression results for both Treasury repo and the closely-related agency discount note market support these observations. More generally, these results are consistent with observations by Hölmstrom [2015] regarding information insensitivity of money markets, and build on existing empirical work summarized in Dang, Gorton, and

Hölmstrom [2019].

2 Related literature

Our paper contributes to three strands of research. The first focuses on the Treasury money premium; the second, the information sensitivity of debt; and the third, Treasury market dynamics during debt limit impasses.[1]

Turning first to the money premium, the literature generally defines the money premium as the amount by which Treasury yields fall below that predicted by a standard asset pricing model. As described by Gorton [2017], this premium has two pieces: the safety premium, attributable to a Treasury security's sure store of value; and the liquidity premium, attributable to its usefulness as a means of exchange.

Recent papers generally point to three factors that can boost or depress the money premium on Treasury securities: the quantity of Treasury debt outstanding, the level of interest rates, and market stress. For example, the quantity of Treasury debt outstanding can affect the liquidity premium, particularly for short-dated Treasury securities. A number of papers identify this effect, even when using different constructs. Greenwood, Hanson, and Stein [2015] illustrate the existence of a liquidity premium for Treasury bills over a very long period; rates on bills fall when the quantity of bills outstanding as a share of GDP drops. Longstaff [2004] also shows the existence of a liquidity premium for Treasury securities that depends on the quantity of debt outstanding; he points to changes in the spread between Refcorp bonds and Treasuries as evidence of this premium. Carlson et al. [2016] provide a similar analysis to show that the spread between private money-like instruments and Treasury bills declines as the the quantity of bills increases. Bansal and Coleman [1996] discuss the role of Treasury securities as money fund assets as contributing to their liquidity premium, and Williamson [2016] cites the importance of (short-dated) Treasury securities as collateral as contributing to the liquidity premium as well. In addition to these works, some papers find quantity-based evidence for both the safety and liquidity premiums. One example is Krishnamurthy and Vissing-Jorgensen [2012], who show that the quantity of Treasury securities outstanding affects both the liquidity and the safety premium.

Other authors focus on factors beyond outstanding debt quantities as determinants of the money premium. Nagel [2016] highlights the level of interest rates as a factor affecting the liquidity portion of the money premium. He finds that as rates rise, the money premium

[1] Our work is also loosely connected to two related literatures examining the effect of political uncertainty and sovereign default on asset prices. The former includes theoretical work by Pastor and Veronesi [2013], as well as empirical tests of the theory (e.g. Brogaard and Detzel [2015] and Leippold and Matthys [2017]), which make use of the economic policy uncertainty index of Baker, Bloom, and Davis [2016]. Examples of the latter include Hebert and Schreger [2017], Chari, Leary, and Phan [2017], and Acharya et al. [2018].

also rises, as the opportunity cost of holding money-like assets increases. Market stress can also affect the money premium, and in particular the safety premium. This dynamic came into sharp relief in the 2008 financial crisis. This safety premium can become larger as the safety of other assets comes into question, as demonstrated by Baele et al. [2014] and Longstaff [2004].

To summarize, much of the previous research takes the ultra-safety and liquidity of Treasury securities as given and focuses instead on how relatively low-frequency variation in factors such as debt outstanding affect the overall magnitude of the money premium.[2] In contrast, we exploit debt limit impasses – periods in which Treasury securities temporarily became more risky – to determine whether and how the money premium varies with safety and liquidity attributes, while holding these other factors roughly constant.

There is also a recent literature on the informational sensitivity of debt and its impact on liquidity and yields. Hölmstrom [2015] and Dang, Gorton, and Hölmstrom [2015] postulate that when the distribution of the value of the underlying asset backing debt is concentrated in the right tail and default probability is low, debt will be informationally insensitive. That is, even though some market participants may have an informational advantage regarding the value of the underlying asset, this advantage will not affect the value of the debt. Liquidity should be high in this informationally insensitive region. In contrast, when the distribution of the underlying asset value shifts sufficiently to the left and default probability rises, market participants have strong incentives to acquire information about the value of the debt. In this informationally sensitive region, information asymmetries are expected to be high. Liquidity deteriorates and yields, in turn, should also be affected. Dang, Gorton, and Hölmstrom [2019] describes the empirical evidence for several types of securities. For instance, Benmelech and Bergman [2018] examine the implications of this model for the corporate bond market. Brancati and Macchiavelli [2019] shows how the information sensitivity of bank debt evolved around the global financial crisis. Gallagher et al. [2019] test pieces of the model within money market funds. Our contribution to this literature is to be the first to provide evidence for informational sensitivity of one of the safest and most liquid debt instruments, U.S. Treasury bills.

Finally, the debt limit impasses have spawned a literature of their own.[3] Like our paper, Macchiavelli [2019] uses the debt limit episodes to test a theory. In his case, he finds that access to a safe asset during a crisis does not lead to a flight to safety. Much of the remainder of the literature analyzes the impact of potential breaches of the debt limit on the market for Treasury securities by examining changes in yield spreads between

[2] Some recent research questions the ultra-safety of U.S. Treasury securities (see Augustin et al. [2019] and Klingler and Sundaresan [2019]).

[3] Examples include Nippani, Liu, and Schulman [2001], Liu, Shao, and Yeager [2009], Nippani and Smith [2014], and Cole [2012].

constant maturity commercial paper (CP) and Treasury bills. The underlying identification assumption is that yields on CP and Treasury bills generally track one another (with CP yields generally higher than Treasury yields), but that CP yields should not be affected by a debt limit episode. While the studies employing this identification strategy generally find that Treasury security yields were only affected at the front end of the yield curve, one might question the validity of their underlying identification assumption. That is, it seems plausible that CP yields also respond to debt limit episodes, particularly through a contagion channel. Ozdagli and Peek [2013] demonstrate that the term structure of the CP market increased and steepened during the 2013 debt limit episode. As a result, the identification approach used in previous studies may lead to estimates of default risk premiums that are biased downwards, and increasingly so as one moves along the yield curve.

We improve upon the previous identification strategy by relying instead on movements in T-bill yields relative to overnight indexed swap (OIS) rates. Overnight indexed swaps are derivative instruments that are used to hedge movements in overnight unsecured money market rates. Because no principal is exchanged in the transaction, they are close to an ideal measure of a riskless overnight rate. Moreover, we view this rate as unlikely to be affected by a debt limit impasse or market stress in general. (For example, the Libor-OIS spread is often used to measure market stress, with Libor capturing credit risk and OIS encompassing the risk-free rate.) We see this as a strength of our analysis relative to studies that use CP rates, which have been shown to move in reaction to debt limit impasses.

3 Recent debt limit impasses and their potential impact on Treasury market dynamics

The debt limit is an aggregate limit on nearly all federal debt outstanding.[4] Increases in the debt limit require the approval of Congress and the President.[5] If there is no agreement to increase the statutory debt limit once it is reached, then the Treasury Secretary declares a Debt Issuance Suspension Period (DISP). A DISP enables the Treasury to invoke "extraordinary measures" that temporarily extend its borrowing capacity. Once these measures are exhausted – known as the "breach" date – the Treasury is no longer able to issue additional marketable debt and can only make payments with cash on hand in the Treasury General Account and incoming revenues. If payments exceed cash on hand and incoming revenues, then the Treasury may be forced to delay principal payments on maturing Treasury securities (as well as coupon payments on notes and bonds, which are not the focus of this study),

[4] For additional background information, see Appendix A.

[5] In recent years, rather than increasing the debt limit by a specified dollar value, legislators have sometimes opted to temporarily suspend the debt limit until a specified date. Nevertheless, a temporary suspension of the debt limit is effectively an increase in the limit.

triggering a default.[6]

Given the potential for a default in the event of a debt limit breach, market perceptions of Treasury safety may decline as the breach date approaches. And as suggested by the theory of the information sensitivity of debt, Treasury liquidity could also deteriorate if there is a sufficient reduction in perceptions of Treasury safety. Moreover, because safety and liquidity are the two primary components of the Treasury money premium, we would expect to observe erosion of this premium. Any erosion should be particularly pronounced for T-bills, which have maturities of one year or less, because the money premium is larger at the front end of the yield curve (Greenwood, Hanson, and Stein [2015]) and bills with short remaining maturities would be at the greatest threat of a delayed principal payment in the event of a breach. Once a debt limit impasse is resolved, we would expect Treasury safety, liquidity, and the money premium to be restored unless the impasse calls into question Treasuries' role as the quintessential riskless asset going forward.

Debt limit impasses have become a biennial occurrence over the past decade, but the 2011 and 2013 episodes were particularly noteworthy in regards to their resolution at the eleventh hour and heavy news coverage. Hence, Treasury market dynamics inside and outside these two impasses are the focus of this study. In both May 2011 and 2013, Congress could not reach an agreement to increase the debt limit, and consequently the Treasury Secretary declared a DISP. Throughout both impasses, the Treasury made several announcements that informed Congress and the public of extensions to the DISP, as well as revisions to or affirmations of the projected debt limit breach date.[7] Ultimately, the Treasury declared August 2, 2011 and October 17, 2013 to be the projected breach dates during the 2011 and 2013 episodes, respectively. As these dates approached, news coverage was intense, suggesting that market participants were keenly aware of the potential consequences associated with a debt limit breach. Figure 1 displays a daily version of the Debt Ceiling News Index created by Scott Baker, Nicholas Bloom, and Steven J. Davis.[8] Just prior to the projected breach dates in 2011 and 2013, a remarkable 3.5 and 1.5 percent of all news articles covered by the index mentioned the phrase "debt ceiling". Beyond the news coverage, the 2011 and 2013 impasses were unique in that some members of Congress were perceived as believing that default was a viable option. Nonetheless, Congress and the President eventually resolved both impasses on their respective breach dates.

And while the 2011 and 2013 impasses were similar in many respects, there were im-

[6] Approximately five (three) years after the 2011 (2013) impasses on which we focus in this study, information released by the Federal Open Market Committee suggested that the Treasury would have opted to prioritize principal and interest payments on Treasury securities over other types of payments. For details, refer to https://www.federalreserve.gov/monetarypolicy/files/FOMC20110801confcall.pdf.

[7] See Appendix Tables A.1 and A.2 for important announcements and events associated with these impasses.

[8] We are grateful to Scott Baker for providing us with the daily version of this index.

portant differences in the information structure of money markets across the episodes that may have led to differences in Treasury safety, liquidity, and money premium dynamics. A GAO study reports that

> ...during the 2013 debt limit impasse, investors reported taking the unprecedented action of systematically avoiding certain Treasury securities – those that matured around the dates when the Department of the Treasury (Treasury) projected it would exhaust the extraordinary measures.

In addition to avoiding holding the securities outright, the report notes that some investors did not accept the securities as collateral in repurchase agreements.[9] Consequently, liquidity for securities at the greatest risk of delayed principal payments may have been particularly adversely affected in 2013.

4 Data

Our analysis focuses on yields for T-bills, which are Treasury securities issued at a discount relative to their par value with an original maturity of less than one year. Our data set includes information on T-bills outstanding from January 2011 to December 2013, with one observation per business day per outstanding CUSIP (unique identifier).[10] The primary data source is the Center for Research in Security Prices U.S. Treasury Database (CRSP). Each observation from CRSP contains the CUSIP, issue date, maturity date, bid price, ask price, and yield. The dataset includes 24,494 observations on 185 CUSIPs. Summary statistics are displayed in Table 1 for the entire sample period, as well as (roughly) the three weeks before and one week after the projected breach dates during the 2011 and 2013 debt limit impasses. During our sample period, the average T-bill yield was just 7.4 bps, reflecting the fact that the federal funds rate was at the zero lower bound.

As the projected breach dates neared and legislators failed to increase the debt limit, yields on Treasury bills increased (Figure 2). This was especially true for bills maturing soon after the projected breach dates (Figure 3), which likely reflected concerns about possible delayed principal payments in the event of a debt limit breach. And while yields on these relatively risky bills jumped during both impasses, the increase was more pronounced in

[9]See Government Accountability Office [2015] for further details.

[10]We use nearly all outstanding T-bill issues to estimate our econometric model, but we exclude cash management bills (CMBs) from our analysis to ensure the robustness of our estimates. CMBs are T-bills with non-standard maturities that are issued to meet temporary financing shortfalls, and often trade at slightly higher rates than regular bills. As such, including them in the analysis may distort the results. In the lead-up to the 2013 debt limit episode, Treasury issued a CMB that cleared at a very low price relative to other bills issued in the surrounding weeks. Including this bill in the analysis would likely boost our estimates of the erosion of the money premium.

2013 than 2011. Both episodes were officially resolved on their projected breach dates, and yields appear to have dropped back to more normal levels fairly quickly.

We augment our T-bill yield data with information on OIS rates of comparable remaining maturity to each outstanding bill. For the OIS rates, we use information available on Bloomberg for weekly tenors in the first month and monthly tenors thereafter. We then interpolate these tenors using a quadratic spline technique to match the maturities to the T-bills in our analysis. We find that OIS rates were about 5 bps higher than T-bills, on average, throughout our sample period.

To proxy for market perceptions of Treasury securities' safety, we use the 5-year U.S. CDS spread (bps), which we obtained from Markit.[11] While the average CDS spread was higher in 2011 than 2013, Figure 4 (orange line; right axis) reveals that this spread widened and narrowed by a similar amount (about 10 bps) over the course of both impasses. We also proxy for potential flight-to-safety effects with the daily differential between 5-year Spanish and U.S. CDS spreads (bps). This differential is intended to capture any changes in demand for safe-haven assets precipitated by the European sovereign debt crisis in 2011, which overlapped with that year's debt limit impasse. Note that the differential was considerably larger on average and exhibited more variation during the 2011 impasse (Table 1).

Our main liquidity proxy, which we obtain from CRSP, is the daily average bid-ask spread on outstanding T-bills (bps). We normalize the bid-ask spread due to a change in both the level and variance in the first quarter of 2012.[12] As with T-bill yields, we observe more variation in these spreads during the 2013 debt limit impasse. Moreover, Figure 4 shows that the movement in the daily average bid-ask spread tracked movement in T-bill yields more closely during the 2013 impasse. Also note that T-bill liquidity did not deteriorate in 2013 until after CDS spreads became elevated.

To evaluate the effect of the information structure of money markets on Treasury securities, we incorporate data on two financial instruments that normally closely track the Treasury market: the overnight Treasury General Collateral (GC) repo rate and yields on Fannie Mae and Freddie Mac Discount Notes (DNs) of comparable remaining maturity to our outstanding T-bills. The repo rate we use in our study is the Federal Reserve Bank of New York's (FRBNY) volume-weighted mean rate of the daily survey of primary dealers' GC repo borrowing activity.[13] What is noteworthy from the Table 1 summary statistics on

[11] Generally, 5-year CDS contracts are the most liquid. We find similar results using 6-month CDS.

[12] We normalize the data to create a standard normal distribution by subtracting the mean and dividing by the variance (excluding the debt limit impasses) in each sub - sample. Prior to the structural break in the data, the bid-ask spread averaged 1.77 basis points and had a standard deviation of 0.69 basis points. After the structure break, the mean was 0.99 basis points, and the standard deviation was 0.35 basis points. The results are similar using either the normalized bid-ask spread or allowing a differential effect after the change in the data.

[13] The data can be downloaded directly from the FRBNY's website. https://www.newyorkfed.org/markets/opolicy/operating_policy_180309

the repo market is that the rate varied to a greater extent during the 2011 impasse than in 2013, despite the fact that T-bill yields showed greater variation in 2013. This may indicate that dealers in the repo market were able to avoid accepting the most at-risk T-bills as collateral in 2013. For the DNs, we use secondary-market yields that we obtained from Bloomberg. Like T-bills, DNs mature within one year. In constructing our data set, we pair Fannie Mae and Freddie Mac DNs with our set of T-bills, using maturity dates as the matching criteria. As shown in Table 1, their yields are a few basis points above T-bills on average. During the 2013 impasse, the spread between DN and T-bill yields was lower, on average, than in 2011. Moreover, DN yields exhibited less variation in 2013 than during the 2011 impasse. The lower spread and lack of variation in 2013 could be indicative of substitution away from the riskiest T-bills to DNs of comparable remaining maturity.

5 Safety, liquidity, and the money premium

In this section, we employ a factor model to characterize variation in the money premium; examine how the premium varies with its safety and liquidity components inside and outside of debt limit impasses; and explore how the erosion of the premium is related to safety and liquidity proxies in the days leading up to the projected breach dates. But first, we briefly discuss why we use OIS rates to isolate variation in the Treasury money premium.

5.1 Isolating variation in the money premium with OIS rates

To identify any variation in the Treasury money premium induced by a debt limit impasse, we must control for general changes in the level of interest rates that were unrelated to the impasse itself. To do so, we include the term structure of OIS rates.

First, because it is a swap and no principal is exchanged in the transaction, OIS are virtually risk free and, thus, their rates should not be affected by a debt limit impasse. Second, changes in OIS rates capture general movements in market rates. The OIS rate is the fixed amount a market participant is willing to pay for receiving the federal funds rate over a specified time period (e.g. 3 months), so it is a geometric average of the expected federal funds rate over that period plus a "term premium" for holding a longer-term instrument.[14] Third, Treasury yields track OIS rates via the expectations hypothesis. In the classic model for a Treasury security's yield, the yield should be equal to the market's expectation for future short-term interest rates over the term plus its own term premium. Several authors (e.g. Sarno and Thornton [2003]) have argued that the federal funds rate and Treasury security yields track each other because they are linked by the expectations

[14] During each impasse, the federal funds rate was at the effective lower bound. We implicitly assume that the Federal Reserve will not react to a debt limit impasse by raising the federal funds rate.

hypothesis. By extension, OIS rates and Treasury yields should also track each other. Fourth, we have no reason to presume that the term premia for Treasury yields and OIS rates, which would encompass attributes such as inflation risk and supply effects, adjusted differently during the debt limit impasses. Given this assumption, it follows that any change in the spread between the two instruments is due to a change in the money premium on T-bills.[15]

5.2 Does the money premium vary with safety and liquidity?

5.2.1 Safety, liquidity, and the money premium inside and outside of debt limit impasses

To determine whether and how the money premium varies with safety and liquidity, we regress business daily first-differenced T-bill yields on market proxies for safety and liquidity, as well as the OIS control, as shown in Equation 1:

$$\begin{aligned}\Delta y_{c,t} = \beta^1 \Delta S_t + \beta^2 \Delta L_t + \beta^3 \Delta L_{c,t} + \beta^4 1(t \in D)\Delta S_t + \beta^5 1(t \in D)\Delta L_t \\ + \beta^6 1(t \in D)\Delta L_{c,t} + \beta^7 \Delta \Omega_{c,t} + \mu_{c,t}\end{aligned} \quad (1)$$

Our outcome variable is $\Delta y_{c,t}$, the business daily change in the annualized yield (in bps) for T-bill CUSIP c on date t. S_t is a vector of safety factors; L_t is a vector of liquidity factors; $L_{c,t}$ is a vector of CUSIP-specific liquidity factors; and $\Omega_{c,t}$ is the rate on an OIS of comparable remaining maturity to T-bill, c. For the safety and liquidity factors, we allow for differential yield effects inside and outside of our chosen debt limit impasse windows, D, July 14, 2011 to August 12, 2011 and September 25, 2013 to October 25, 2013. Standard errors are robust.[16]

We use a first-differenced specification for a few reasons. First, many of the panels have non-stationary yields. Second, yields on Treasury bills and OIS rates, a right-hand side variable, are cointegrated. However, in first differences all yields are stationary and the series are not cointegrated. Third, there may be time-invariant characteristics of a Treasury security that affect its yield, such as whether the security matures at quarter end when firms are often in need of cash, and thus sells at a premium relative to other Treasury securities.[17] Using yield changes eliminates these fixed effects.

[15] Because our period of interest is relatively short, the term premia assumption seems reasonable. If anything, given contemporaneous quantitative easing purchases by the Federal Reserve as well as continued low readings on inflation expectations, the term premium likely declined. However, there is no reason to believe a priori that such a decline in term premia would differ across Treasury securities and OIS of comparable remaining maturity.

[16] We obtain quantitatively similar results with bootstrapped standard errors.

[17] Refer to Garbade [1996] for a discussion.

For the safety factors, we incorporate the 5-year CDS spread on U.S. sovereign debt, which by construction provides a measure of investors' perception of the default risk on Treasury securities within the next five years. In addition to U.S. sovereign CDS spreads, we proxy for potential flight-to-U.S. safety effects with the differential between 5-year Spanish and U.S. CDS spreads. This differential is of particular interest during the 2011 debt limit episode, when the European debt crisis was near its zenith. In contrast, economic conditions in Europe had stabilized by the 2013 debt limit episode.

For liquidity, our main proxy is the normalized daily average bid-ask spread on all outstanding T-bills. We also include normalized bid-ask spreads for individual T-bills, as their liquidity may deviate from the T-bill market as a whole – especially if particular Treasuries become riskier than others in a debt limit impasse.

Table 2 displays first-stage regression results based on Equation 1. Column 1 provides estimates of how the money premium varies with our measure of market perceptions of Treasury safety. We find that, in normal times outside a debt limit impasse, an increase of 1 bp in 5-year U.S. CDS spreads erodes the money premium by a statistically significant 1.3 percent of that amount (line 2). This effect is magnified eight-fold during a debt limit impasse (line 6), such that a 1 standard deviation increase in U.S. CDS spreads during our sample period (9.1 bps) implies erosion of the money premium of 0.95 bp. In Column 2, we add the spread between Spanish CDS and U.S. CDS to account for potential flight-to-safety concerns. We find evidence that heightened default risk abroad attenuates erosion of the Treasury money premium. A 1 standard deviation increase in the spread between Spanish and U.S. CDS (106 bps), which is roughly the amount the spread rose during the final two weeks of the 2011 impasse, is associated with a 1.25 bp increase in the money premium during a debt limit impasse.

Column 3 displays estimates of how the money premium on T-bills varies with market-wide and CUSIP-specific liquidity factors. As shown in line 4, changes in T-bill market liquidity have a very small (although negative and statistically significant) effect on the money premium outside the designated debt limit window. That is not the case once in a debt limit impasse, as we estimate that a 1 standard deviation increase in T-bill market illiquidity (i.e. increases in bid-ask spreads) erodes the money premium (i.e. increases T-bill yields) by about 1.6 bps (line 8). After accounting for the impact of changes in overall Treasury market liquidity on the money premium, the effect of a change in the CUSIP-specific bid-ask spread is small (lines 5 and 9).

When we include the liquidity and safety factors in one regression (Column 4), the results are revealing. We find that an increase in U.S. CDS spreads erodes the money premium at all times. However, there is no significant differential effect during a debt limit impasse (line 6). In contrast, changes in T-bill market liquidity only have a large and significant effect on the money premium during the impasse (line 7), a period of market stress where the safety of Treasury securities came into question. These non-linear safety and liquidity effects would appear to be consistent with the theory of information sensitivity of debt, which we examine further in Section 6.

5.2.2 Money premium erosion during the impasses

Whereas the previous section focused on safety, liquidity, and money premium dynamics inside and outside of the debt limit impasses, this section investigates daily dynamics during the height of the 2011 and 2013 debt limit impasses. Specifically, we decompose daily money premium erosion estimates during the impasses into their safety and liquidity components.

To do so, we first estimate the following regression equation to obtain daily estimates of the average erosion of the money premium across the T-bill yield curve, as well as any excess erosion on the T-bills that matured around the projected breach limit dates:

$$\Delta y_{c,t} = \alpha + \Delta 1(t \in D)\omega_t + \Delta 1(t \in D, c \in B)\chi_{c,t} + \beta \Delta\Omega_{c,t} + \epsilon_{c,t} \tag{2}$$

where $\Delta y_{c,t}$ is the business-daily first differenced yield for T-bill CUSIP c on date t and $\Omega_{c,t}$ is the rate on an OIS of comparable remaining maturity to T-bill, c, as in Equation 1.[18] $1(t \in D)$ is a date-specific fixed effect that takes on a value of one if date t occurs during the weeks just prior to or following the projected breach dates during a debt limit impasse, D, and zero otherwise. Similarly, $1(t \in D, c \in B)$ is a date- and CUSIP-specific fixed effect that takes on a value of one if date t occurred during D and CUSIP c matured on or soon after a projected breach date, B, and zero otherwise. We set these indicators equal to 1 for each bill maturing between July 28 and September 8 during the 2011 debt limit impasse, and between October 10 and November 21 during the 2013 impasse.

The ω_t coefficient captures the average deviation in outstanding T-bill yields beyond changes in the general level of interest rates. $\chi_{c,t}$ comprises any deviation in CUSIP-specific T-bill yields above and beyond the average deviation across the bill yield curve. Given our identification assumptions discussed in Section 5.1, the ω_t and $\chi_{c,t}$ coefficients thus capture the daily erosion of the money premium across the T-bill yield curve and for the bills at the greatest risk of a delayed principal payment, respectively.

With estimates of the erosion of the money premium for the most at-risk T-bills and across the bill yield curve in hand, we then employ a factor model strategy to first estimate the effect of variation in Treasury liquidity and safety proxies on the money premium and

[18] We have considered other controls in the analysis, including market stress indicators (the VIX, excess bond premium and oil price data), financing conditions, dealer positions, foriegn bond yields and bills outstanding. The results were generally invariant to the additional controls.

then explore how much of the erosion of the money premium can be explained by these proxies.

To do so, we estimate "unconstrained" versions of Equation 1, in which the regression coefficients on the safety and liquidity factors are allowed to vary by CUSIP, c:

$$\begin{aligned}\Delta y_{c,t} = \beta_c^1 \Delta S_t + \beta_c^2 \Delta L_t + \beta_c^3 \Delta L_{c,t} + \beta_c^4 1(t \in D)\Delta S_t + \beta_c^5 1(t \in D)\Delta L_t \\ + \beta_c^6 1(t \in D)\Delta L_{c,t} + \beta_c^7 \Delta \Omega_{c,t} + \mu_{c,t} \qquad (3)\end{aligned}$$

We estimate this regression twice; once excluding the liquidity factors and once excluding the safety factors. By construction, the $\mu_{c,t}$ residuals from the regression excluding the liquidity factors will be devoid of the effects of safety on the money premium. We then regress these residuals on a modified version of Equation 2:

$$\widehat{\mu_{c,t}} = \tilde{\alpha} + \Delta 1(t \in D)\tilde{\omega}_t + \Delta 1(t \in D, c \in B)\tilde{\chi}_{c,t} + \tilde{\epsilon}_{c,t}. \qquad (4)$$

It follows that the coefficient, $\tilde{\omega}_t$ ($\tilde{\chi}_{c,t}$), will yield the portion of the daily average erosion (excess erosion) of the money premium that is unrelated to safety. Finally, by subtracting our estimate of $\tilde{\omega}_t$ ($\tilde{\chi}_{c,t}$) from ω_t ($\chi_{c,t}$), we obtain the portion of the daily average erosion (excess erosion) of the money premium that is attribute to a decline in market perceptions of Treasury safety. A similar process enables us to obtain the liquidity component of the money premium erosion.

Figure 5 displays the daily average money premium erosion estimates (black line) in 2011 (top panel) and 2013 (bottom panel) for all outstanding T-bills, as well as the portion of the erosion attributable to the safety (orange bars) and liquidity factors (blue bars).[19] Beginning with 2013, we observe that as the projected breach date neared, the deterioration in the perceived safety of Treasury securities had a relatively constant effect on the money premium, accounting for 1 to 2 basis points of the erosion. In contrast, illiquidity played a relatively minor role until the last few days prior to the projected breach, when its contribution spiked.

Summing over the two components, our safety and liquidity factors explain most of the daily average erosion of the money premium estimated in Equation 2. In Section 5.2.1, we showed that safety mattered in all times, and liquidity mattered in times of stress. In addition, safety did not differentially affect the yields of Treasury securities during times of stress once we included liquidity. The estimates provided here capture safety and liquidity individually. Given the previous finding, summing the two components may overstate the combined effect. Indeed, we find the components are not additive when estimated together.

[19] The estimates shown in Figure 5 are reported with standard errors in Appendix Tables B.1 and B.2.

On the day with the greatest money premium erosion in 2013, safety does not add any explanatory power. We take this as evidence for theoretical results in the information insensitivity literature. These results suggest that once safety deteriorates past a certain point, liquidity is encumbered. Consequently, the two effects are not separable.

Moreover, it is reassuring that the contribution of the safety and liquidity factors quickly dissipated along with the money premium erosion estimate upon resolution of the debt limit impasse. Unlike the 2013 impasse, we find that our chosen safety and liquidity factors explain little of the observed daily average erosion of the money premium in 2011. While a bit of a puzzle, we believe that liquidity likely played a smaller role in the 2011 impasse due to a difference in the information structure of money markets. We discuss this issue further in Section 6.

5.2.3 Safety, liquidity, and money premium dynamics for the riskiest T-bills

We now turn our attention to the T-bills that experienced the largest excess erosion of the money premium during each of the 2011 and 2013 debt limit impasses; the bills maturing on August 11, 2011 and October 31, 2013, respectively. Columns 5 and 6 of table 2 present regression estimates based on equation 1 for the two respective T-bills. Notably, during the 2013 impasse the money premium was much more sensitive to a given change in Treasury market liquidity than in 2011 (line 8). And in part for this reason, the excess erosion of the money premium was much greater in 2013, as shown by the black lines in Figure 6. However, it was also the case that Treasury market liquidity deteriorated to a greater degree in 2013, as illustrated in Figure 4. It follows then that in 2013 illiquidity (blue bars in Figure 6) played a larger role in excess erosion of the money premium, especially in the final days before the projected breach.

To summarize our results to this point, we have established that variation in market perceptions of Treasury safety affect the money premium at all times. In contrast, variation in liquidity only affected the money premium during the debt limit impasses, a period of Treasury market stress where the "full faith and credit" guarantee backing Treasuries was called into question. Within the debt limit impasses, we find a similar construct where safety has a relatively constant effect on erosion of the money premium and illiquidity "kicks" in just prior to the projected breach. These results appear to be consistent with the non-linear relationship between safety and liquidity emphasized in the theory of the information sensitivity of debt.

That said, some of our results suggest that large declines in safety are a necessary, but not sufficient condition to induce illiquidity. For example, we observed similar changes in U.S. CDS spreads and obtained similar estimates of the daily average erosion of the money premium during the 2011 and 2013 impasses, but only in 2013 did illiquidity play a prominent role. In the next section, we present empirical evidence suggesting that the information structure of money markets also play an important part in driving T-bill liquidity.

6 Is Treasury debt information sensitive?

The results of the previous section suggest that, in line with the literature on the information sensitivity of debt, T-bill illiquidity picks up only after sufficient declines in safety. That said, we also observe differential liquidity effects across the 2011 and 2013 debt limit impasses that point to additional factors, and in particular the information structure of money markets, as playing a significant role in T-bill liquidity. In this section, we first assess to what extent our results corroborate the theory of the information sensitivity of debt. We then examine whether yield movements in two markets closely related to T-bills support the anecdotal evidence that changes in the information structure of money markets across the 2011 and 2013 debt limit impasses were responsible for the differences observed in T-bill liquidity.

6.1 How do market perceptions of Treasury safety affect T-bill liquidity?

In Section 5.2, we found that safety affected the money premium at all times, but that liquidity affected it only during the debt limit impasses, when the "full faith and credit" guarantee backing Treasuries was in question. We also showed in Figure 4 that daily average T-bill illiquidity did not spike until after the safety component during the 2013 debt limit impasse. In a similar vein, the information sensitivity of debt literature theorizes that debt becomes illiquid only after the distribution of market perceptions of the debt's safety have declined to a point where default is possible, as might be the case during an impasse.

In column 1 of table 3, we directly examine the relationship between market perceptions of Treasury safety (U.S CDS spreads) and T-bill liquidity (normalized daily average bid-ask spreads adjusted for the 2012 structural break) inside and outside of the debt limit impasses. We find that outside a debt limit impasse, a 1 bp increase in U.S. CDS spreads is associated with a statistically significant, though small decrease in daily average T-bill bid-ask spreads of roughly 1/50 of one standard deviation (line 1). In contrast, during a debt limit impasse a 1 bp increase in U.S. CDS spreads is associated with a statistically significant increase in the daily average T-bill bid-ask spread of 1/10 of one standard deviation (line 2). Put another way, during a debt limit impasse a one standard deviation reduction in market perceptions of Treasury safety (9.1 bps) is associated with roughly a one standard deviation increase in T-bill illiquidity.

While the 2011 and 2013 debt limit impasses represent periods of large and rapid increases in CDS spreads, there are other periods outside of the debt limit impasses during which CDS spreads exhibited significant variation over a relatively short period of time. In column 2, we investigate whether large increases in CDS spreads, defined as CDS spreads increasing by more than two standard deviations over a 10-day period, more generally affect T-bill liquidity. Line 3 shows that large changes in CDS spreads do in fact have a positive and statistically significant effect on the T-bill bid-ask spread. However, as we see in Column 3 this illiquidity effect is driven solely by the variation in CDS spreads during the debt limit impasses (line 2). In other words, a considerable deterioration in the perceived safety of Treasury securities appears to be a necessary condition for T-bill illiquidity, but there also appears to be something special about the debt limit impasses in particular. One potential explanation is that the debt limit impasses represented a plausibly exogenous shock to market perceptions of Treasury safety, whereas significant movements in CDS spreads outside of the debt limit impasses may have been driven by other factors to some extent.[20]

Of course, even across the debt limit impasses we observe differential liquidity effects and erosion of the money premium despite similar variation in market perceptions of Treasury safety. One explanation for these differential effects is that in 2013 money market participants were able to distinguish between the least- and most-risky T-bills, and consequently money markets were characterized by a separating equilibrium as opposed to a pooling equilibrium. If so, certain spillover effects should have been present in two markets closely related to the Treasury market – repo and agency discount notes.

6.2 Pooling v. separating equilibriums in the Treasury general collateral repo market during recent debt limit impasses

Treasury securities are used as collateral for overnight cash lending transactions between large financial institutions in the Treasury general collateral (GC) repo market. At the time of the debt limit impasses, volumes in this market were roughly $550 billion daily.[21] It is a key funding market and normally possesses the canonical features of an information-insensitive money market. Most of the time, investors and dealers in the GC repo market do not distinguish between different securities. In fact, in 2011, market participants were not able to make such distinctions. However, the structure of this market changed in advance of the 2013 episode, so that participants could distinguish between different Treasury securities issues. Against that backdrop, and as we demonstrate below, repo rate dynamics during the 2011 and 2013 impasses were consistent with money market participants being able to distinguish between specific T-bills in 2013, but not in 2011.

In a Treasury GC repo transaction, securities sellers (i.e. cash borrowers) sell a Treasury security overnight and agree to repurchase it the next day, instead of selling it outright.[22]

[20] For instance, Hui and Chung [2011] discuss the interaction of currency risk and soverign credit default swap pricing.

[21] Refer to https://www.newyorkfed.org/tripartyrepo/margin_data.html for 2012 statistics.

[22] Most transactions in this market are overnight, and so we focus on those. There is some term trading,

A key feature of this market is that any Treasury security can be used as collateral in the transaction and, moreover, the securities purchaser (i.e. cash lender) does not know the particular security to be delivered.[23] Therefore, the securities purchaser generally does not have any choice in the collateral it receives. However, as noted by Government Accountability Office [2015], in 2013 some securities purchasers reported taking the unprecedented step of refusing to accept as collateral T-bills maturing soon after the projected debt limit breach date.[24] Therefore, in 2013 we might expect repo rates to reflect, at least in part, a separating equilibrium that tracked the yields on the highest risk T-bills less closely.[25]

Indeed, as illustrated in Figure 7, the yield on the highest-risk T-bill and the Treasury GC repo rate tracked each other closely over time in 2011. Moreover, the rates peaked at roughly the same level. On the other hand, in 2013 the yield on the riskiest T-bill was considerably higher than the corresponding GC repo rate on any given day as the breach date neared.

To more formally test the relationship between the repo market rate and T-bill yields in 2011 and 2013, we use the repo rate as a factor in the following model, which is similar to equation 1:

$$\Delta y_{c,t} = \beta^1 \Delta R_t + \beta^2 1(t \in D) \Delta R_t + \beta^3 \Omega_{c,t} + \mu_{c,t} \tag{5}$$

where R_t is the overnight Treasury GC repo rate.[26] Once again, we allow for differential effects inside and outside the debt limit impasse windows. But in this case, we allow for differential effects across debt limit episodes given our interest in whether Treasury debt displayed evidence of being more informationally sensitive, and thus less liquid, in 2013 relative to 2011.

Table 4 reports the results. We find that the overnight GC repo rate and T-bill yields had a much stronger positive association during the 2011 impasse than 2013. The coefficients are statistically different at the 10 percent level. In light of our discussion above, we view

but at much lower volumes.

[23]The "specials" repo market is generally used for specific-security trading. Data on securities lending suggests that investors also did not persue the specials market for the most at-risk securities. Total volumes declined for the most at-risk securities following the 4 - week reissuance. Volumes then spiked on the resolution of the impasse. Comparable bills saw a smaller decline in securities lending after the 4 - week reissuance, and they did not spike a few weeks later.

[24]Investors may have learned from the 2011 impasse about the possible severity of a debt limit crisis. See Appendix A for additional information.

[25]This type of equilibrium could be in line with a money market mutual fund (MMF) manager restoring the information insensitivity of their funds and becoming less risky by not taking an at-risk security. This type of strategy has been used by MMF managers during the European crisis (Gallagher et al. [2019]) and by banks in the commercial deposit market (Pérignon, Thesmar, and Vuillemey [2018]). On the other hand, sometimes managers respond by increasing risk taking, such as in the MMFs during money fund reform (Baghai, Giannetti, and Jäger [2018] and Cipriani and La Spada [2017]).

[26]$\Omega_{c,t}$ also includes month- and quarter-end dummies. See Anbil and Senyuz [2018], Copeland, Martin, and Walker [2014], and Munyan [2015] for a discussion of month- and quarter-end effects in the repo market.

this as evidence corroborating heightened information sensitivity of Treasury debt in 2013, where market participants went to great lengths to avoid holding particular T-bills that matured soon after the projected breach dates.

6.3 The agency discount note market during recent debt limit impasses

Agency discount notes (DNs) issued by Fannie Mae and Freddie Mac provide further evidence regarding the role of the information structure of money markets in driving the differential liquidity effects observed in 2011 and 2013. DNs are generally used for the housing enterprises' short-term financing needs and mature within one year, like T-bills. In addition, we can easily match T-bills with outstanding DNs of comparable remaining maturity. While normally less liquid than T-bills, DNs share similar safety attributes given that they were under government conservatorship during our sample period. Importantly, DNs are not subject to the debt limit, and consequently are not at risk of a delayed principal payment in the event of a debt limit breach. As such, they could be viewed as a potential substitute for the riskiest T-bills during a debt limit impasse. Indeed, Government Accountability Office [2015] notes that some market participants reported that they began doing so in 2013.

If so, then we'd expect to observe the following. First, because DNs share a similar safety profile to T-bills but do not share their liquidity risk during a debt limit impasse, average yields on DNs should rise and fall with the T-bill average money premium erosion estimates, though to a lesser extent.[27] Second, if market participants were not substituting away from risky T-bills to DNs in 2011 but began to do so in 2013, then we would expect the excess yield on the DN of comparable remaining maturity to the riskiest T-bill to track the excess money premium erosion on that T-bill more closely in 2011 than 2013.

To test these hypotheses, we re-estimate Equation 2 on outstanding DN yields instead of T-bill yields. In Figure 8, we plot the daily average deviation in DN yields (green line) against the average money premium erosion estimates (black line) during the 2011 and 2013 impasses. As expected, yields on DNs rose and fell along with yields on Treasury securities in both 2011 and 2013, but to a lesser extent.

In figure 9, we plot the excess yields for the DNs of comparable remaining maturity to the riskiest T-bills (green lines) against the excess money premium erosion estimates for the riskiest T-bills (black lines). Whereas we observe a positive excess yield on the DN during the 2011 impasse, there was no excess yield for the DN maturing on October 31, 2013 until the excess money premium erosion on the T-bill began to plummet. These results

[27] In fact, under reasonable assumptions the average movement in DN yields above and beyond general movements in market rates provides an alternative method to identify the safety component of the erosion of the money premium.

strongly suggest that market participants substituted away from the riskiest T-bills to a much greater extent in 2013 than 2011. Moreover, they likely switched back to the risky T-bill once it became clear that a debt limit breach would not come to pass.

In sum, the results presented in this section indicate that Treasury debt can become information sensitive, and consequently less liquid, given a large enough decline in market perceptions of Treasury safety. However, the decline in safety appears to be a necessary, though not sufficient, condition for Treasury illiquidity. For one, we found that only deteriorations in safety during debt limit impasses were associated with T-bill illiquidity. Second, a market information structure where market participants can distinguish between relatively risky and less risky T-bills appears to be associated with considerably greater illiquidity.

7 Conclusion

This paper provides new evidence on factors affecting the money premium embedded in Treasury yields and on the information sensitivity of debt. It identifies these characteristics using changes in market outcomes during a debt limit impasse. It extends the literature by showing how the money premium varies with proxies for safety and liquidity, and demonstrate how theories of information insensitivity of debt apply to Treasury markets.

The results in this paper should inform future researchers on other aspects of the money premium, debt markets, and insensitivity. More granular trading data, while not available for the period studied in this paper, could provide a more nuanced view on the effect of dealer positions on these outcomes. In addition, a cross-country analysis could shed light on how episodes of sovereign risk affect money market outcomes. Finally, the results could be informative for understanding the potential effects of market reforms, and cases where transparency or opaqueness could be warranted.

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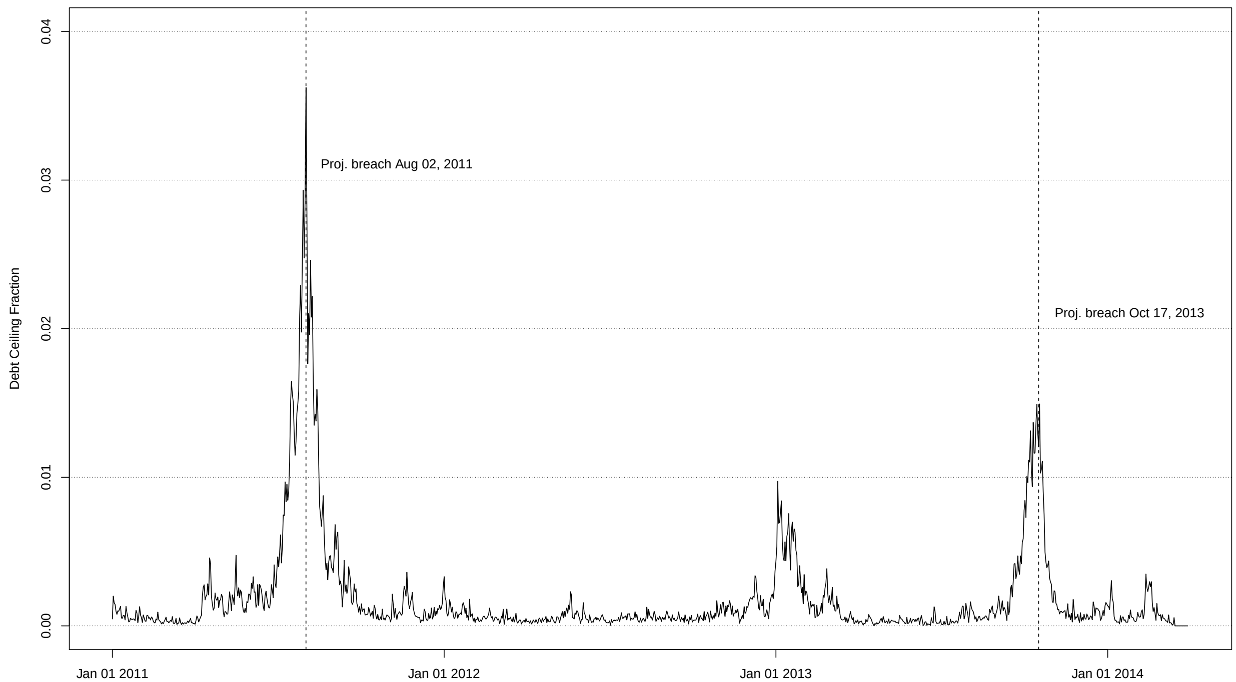
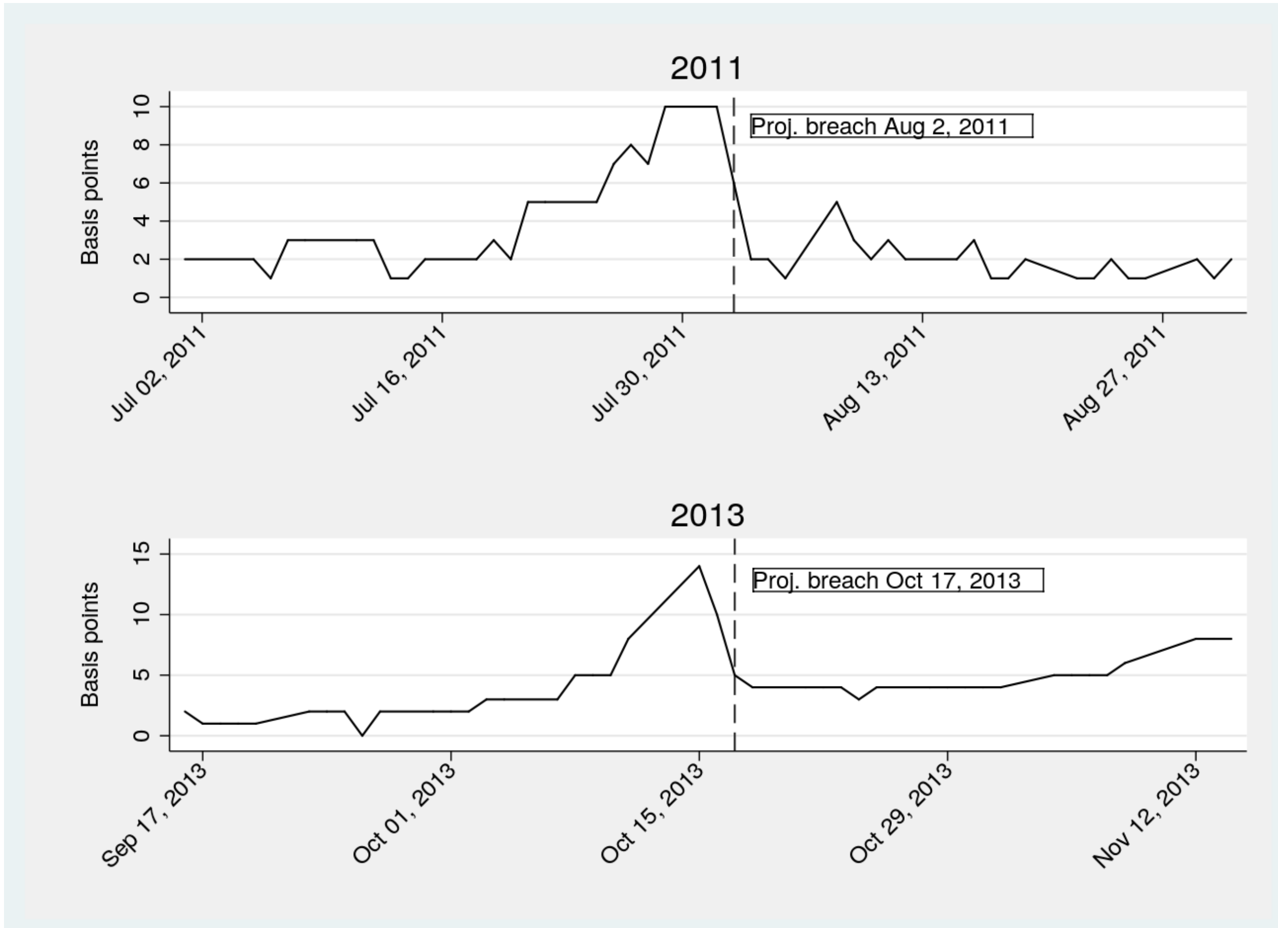
Figure 1: Daily debt ceiling article frequency in U.S. newspapers



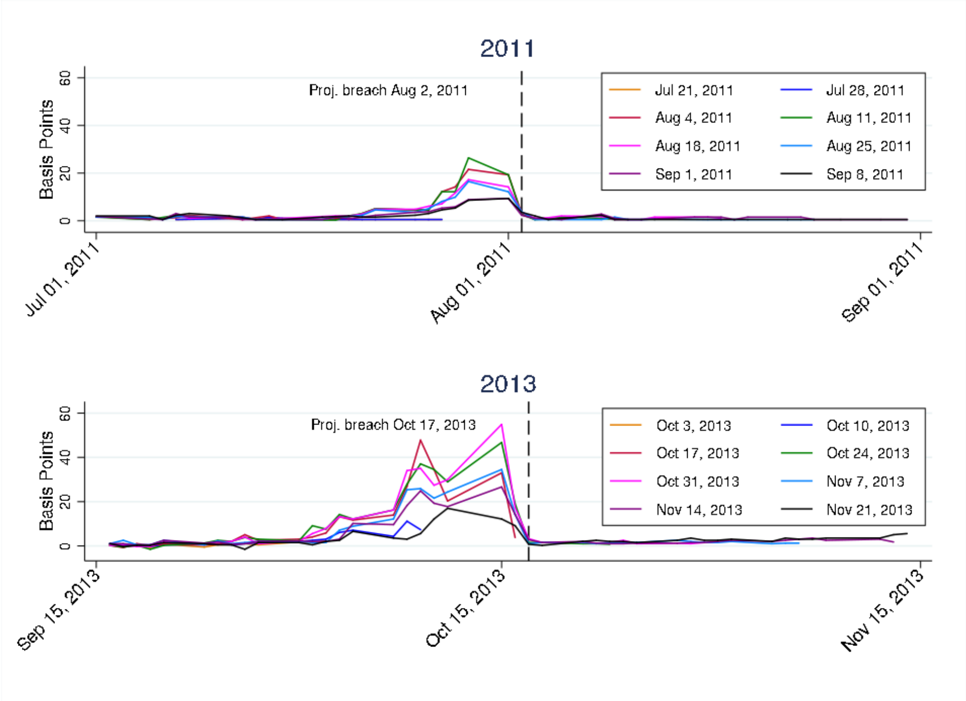
Source: Figure 1 displays the Debt Ceiling Index created by Scott Baker, Nicholas Bloom, and Steven J. Davis. The index is a measure of the fraction of articles appearing in major newspapers in the United States - the 1000+ newspapers covered by Access World News Newsbank Service - that use the phrase “debt ceiling”. We are grateful to Scott Baker for providing us with a daily version of the index. A value of 0.01 represents a day in which one percent of all newspaper articles mention the term in question.

Figure 2: Market yield on U.S. Treasury securities at 3-month constant maturity



Source: Federal Reserve Board, Statistical Release H.15, "Selected Interest Rates (Daily)."

Figure 3: Yields on T-bills maturing around projected breach dates



Source: Center for Research in Securities Pricing (CRSP). CRSP/U.S. Treasury Database, Wharton Research Data Services (WRDS), wrds-web.wharton.upenn.edu/wrds/about/databaselist.cfm.

Figure 4: Average normalized bid-ask spreads and U.S. CDS spreads across debt limit impasses

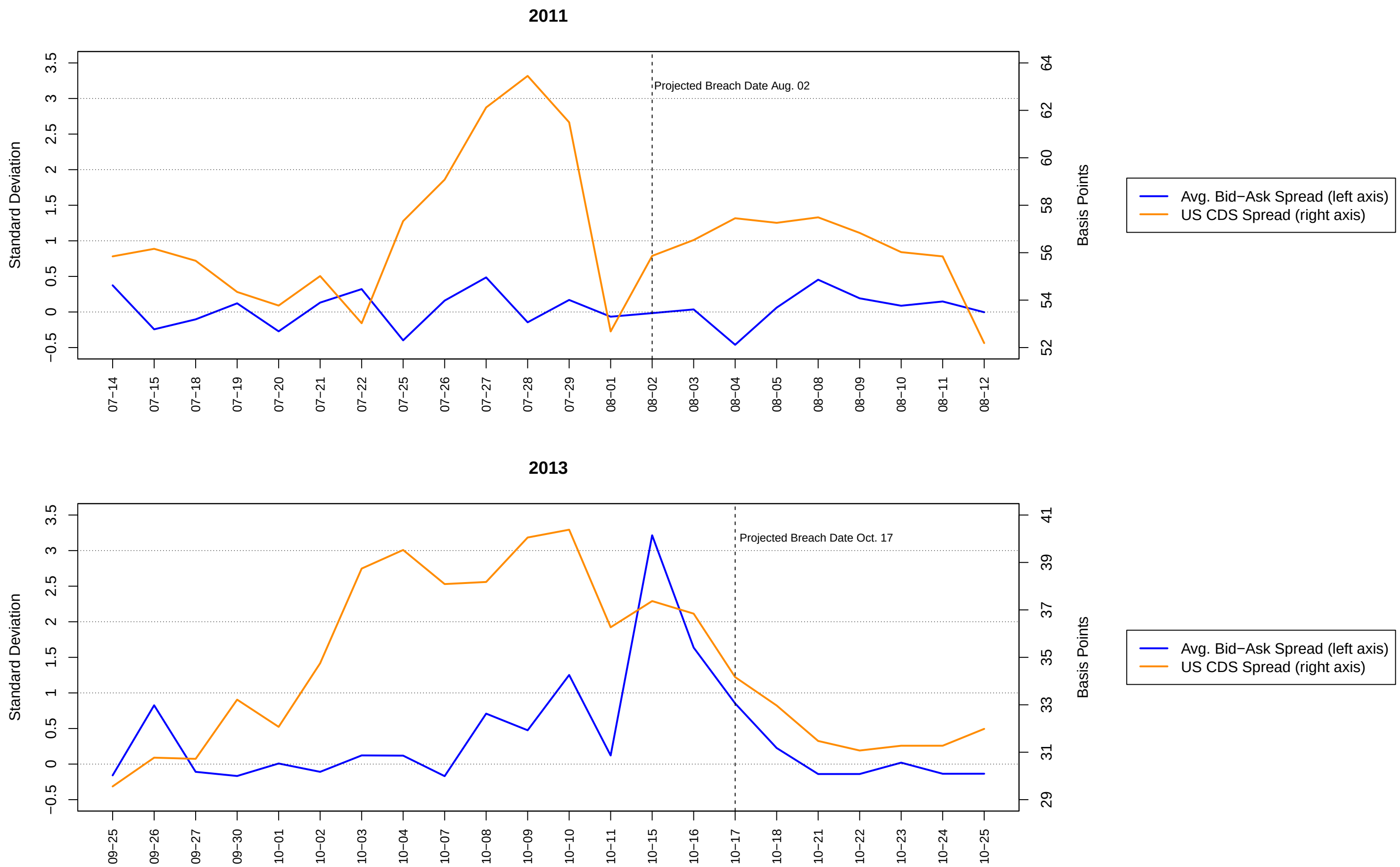
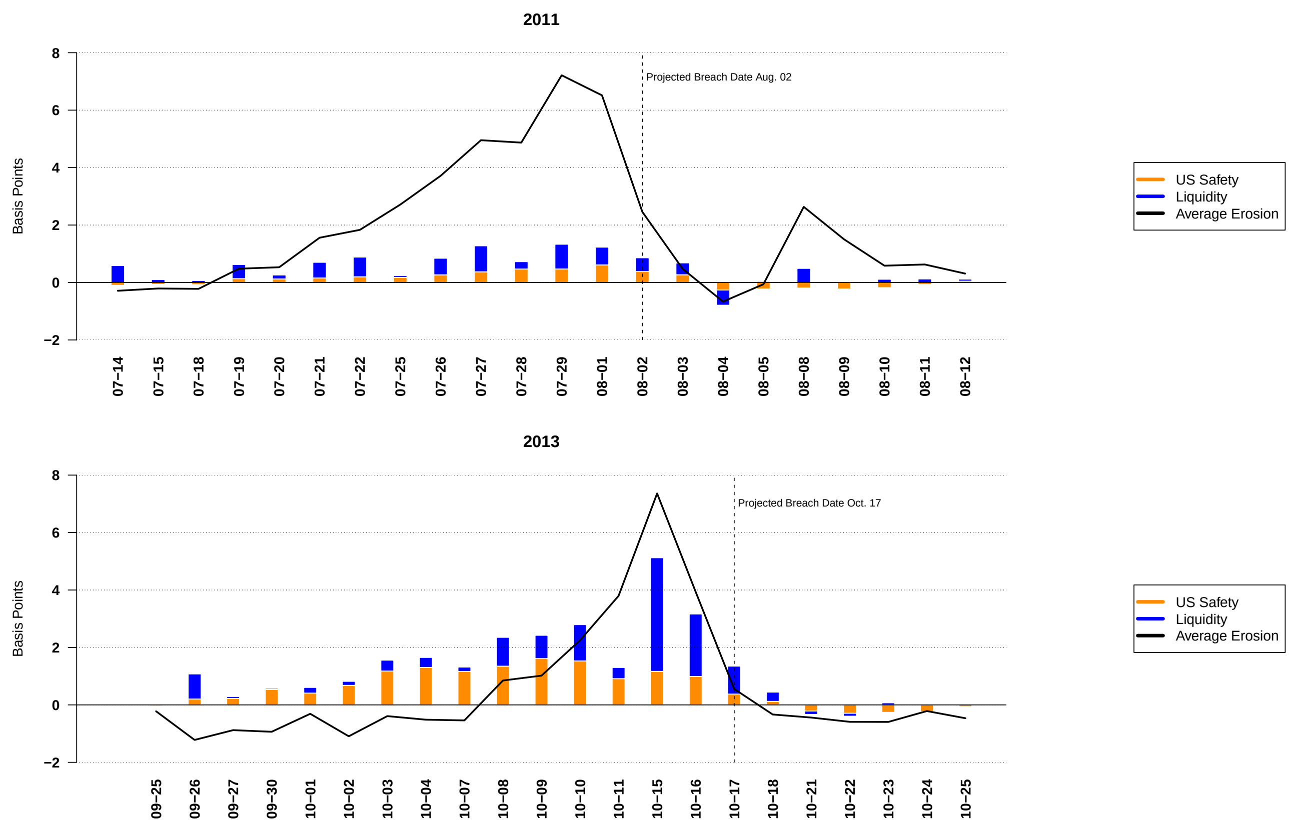
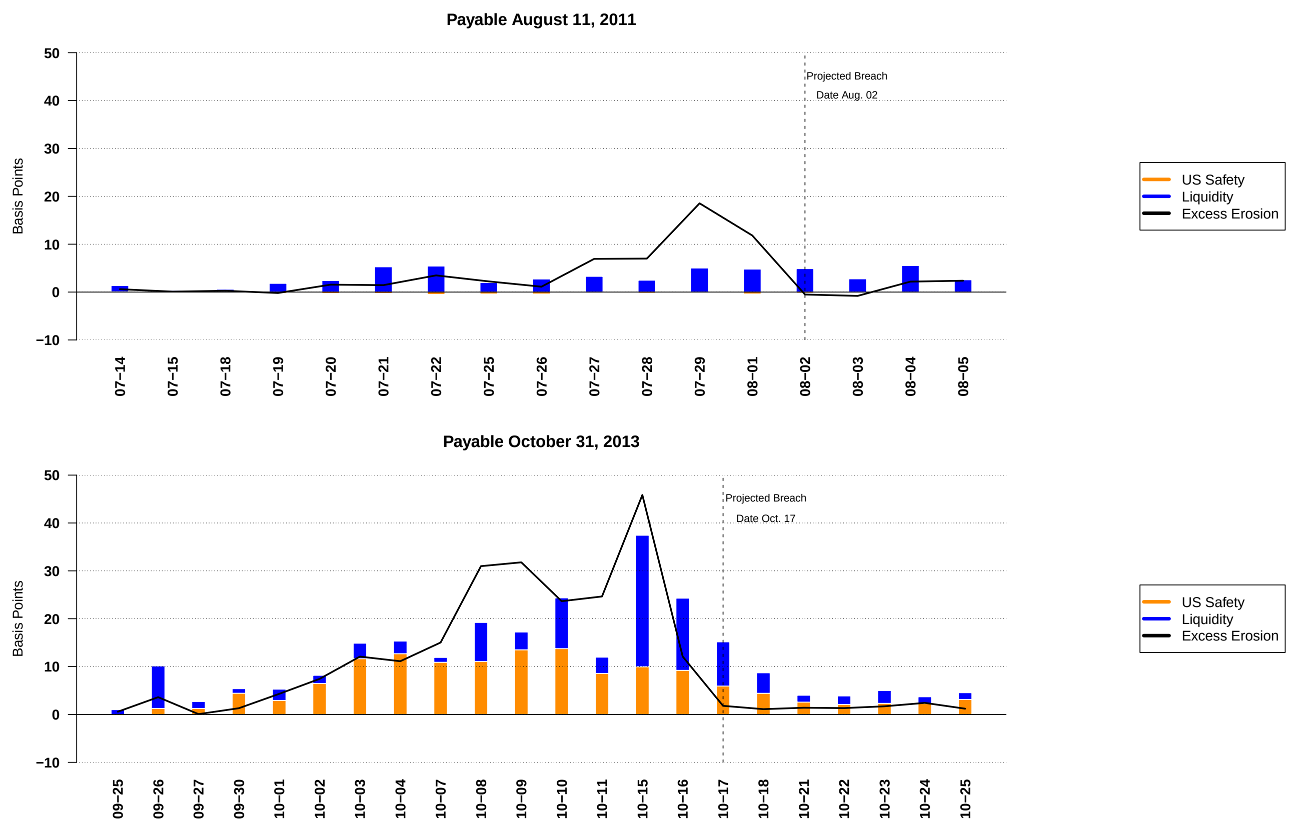


Figure 5: Decomposition of daily average money premium erosion



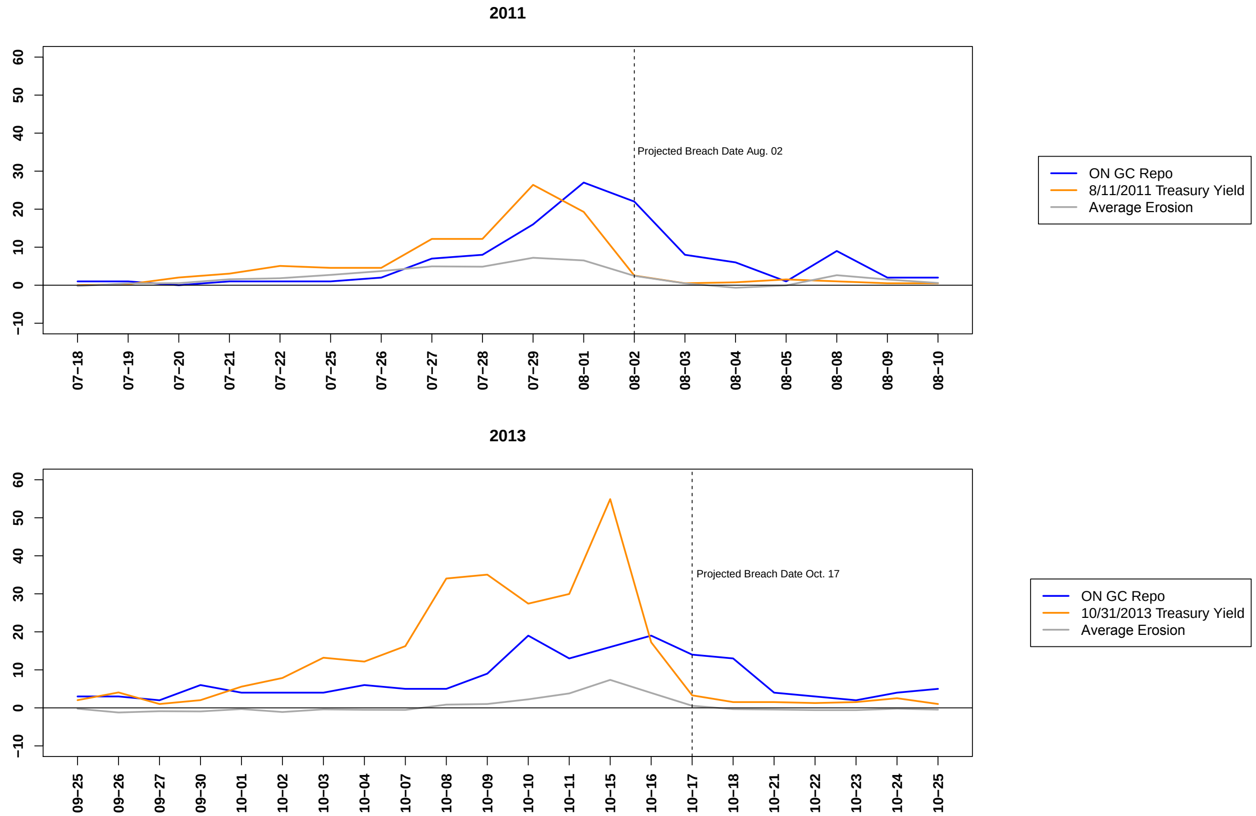
The solid black line in Figure 5 displays point estimates of the ω_t coefficients from Equation 2. The orange and blue bars represent the portion of the daily average money premium erosion estimate that we attribute to safety and liquidity factors, respectively, based on our decomposition exercise laid out in Section 5.

Figure 6: Decomposition of excess money premium erosion on the riskiest T-bills during debt limit impasses



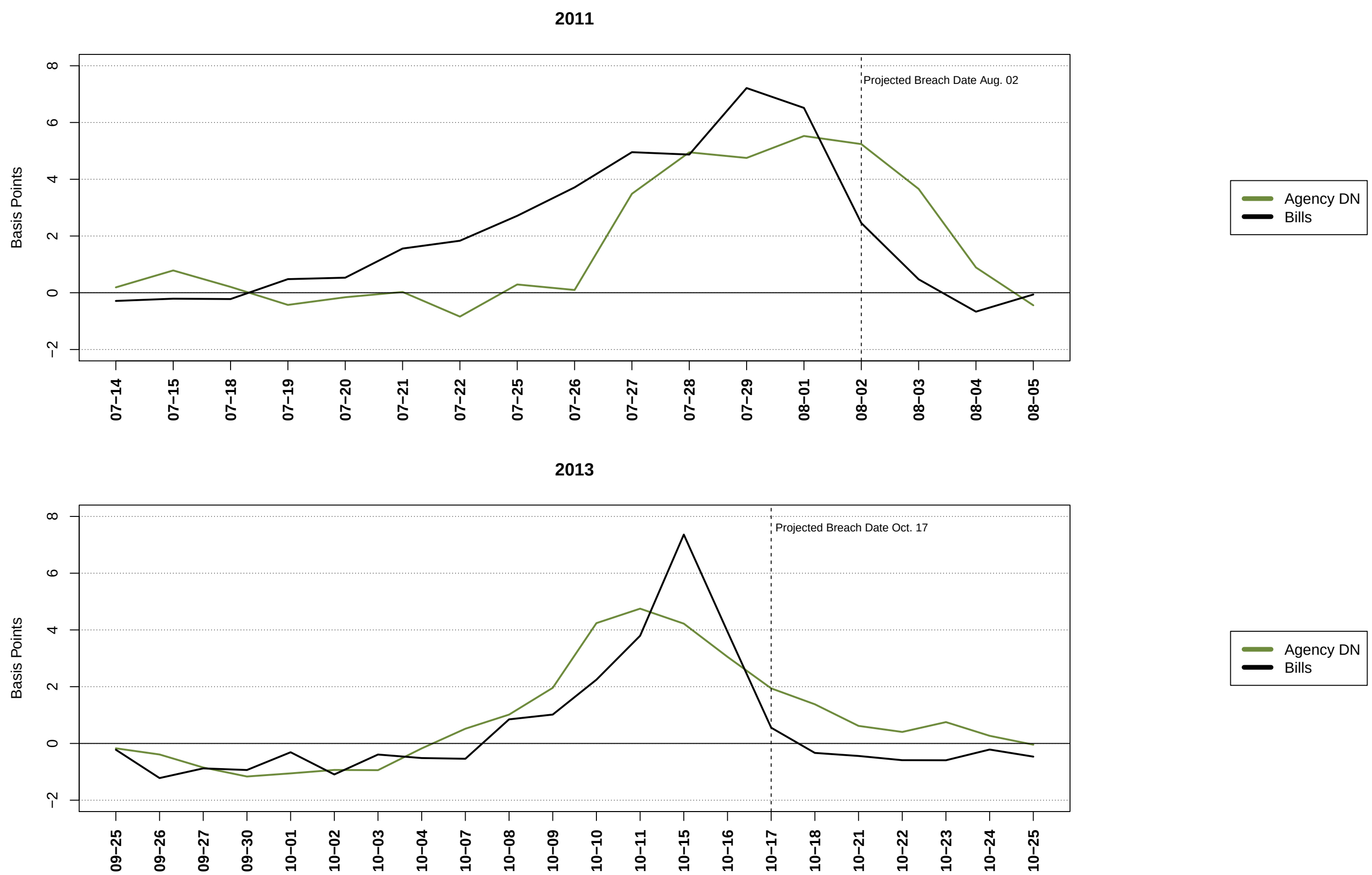
The solid black line in Figure 6 displays point estimates of the $\chi_{c,t}$ coefficients from Equation 2 for the T-bills that matured on August 11, 2011 and October 31, 2013. The orange and blue bars represent the portion of the excess money premium erosion estimate that we attribute to safety and liquidity factors, respectively, based on our decomposition exercise laid out in Section 5.

Figure 7: Repo rates and money premium erosion estimates during recent impasses



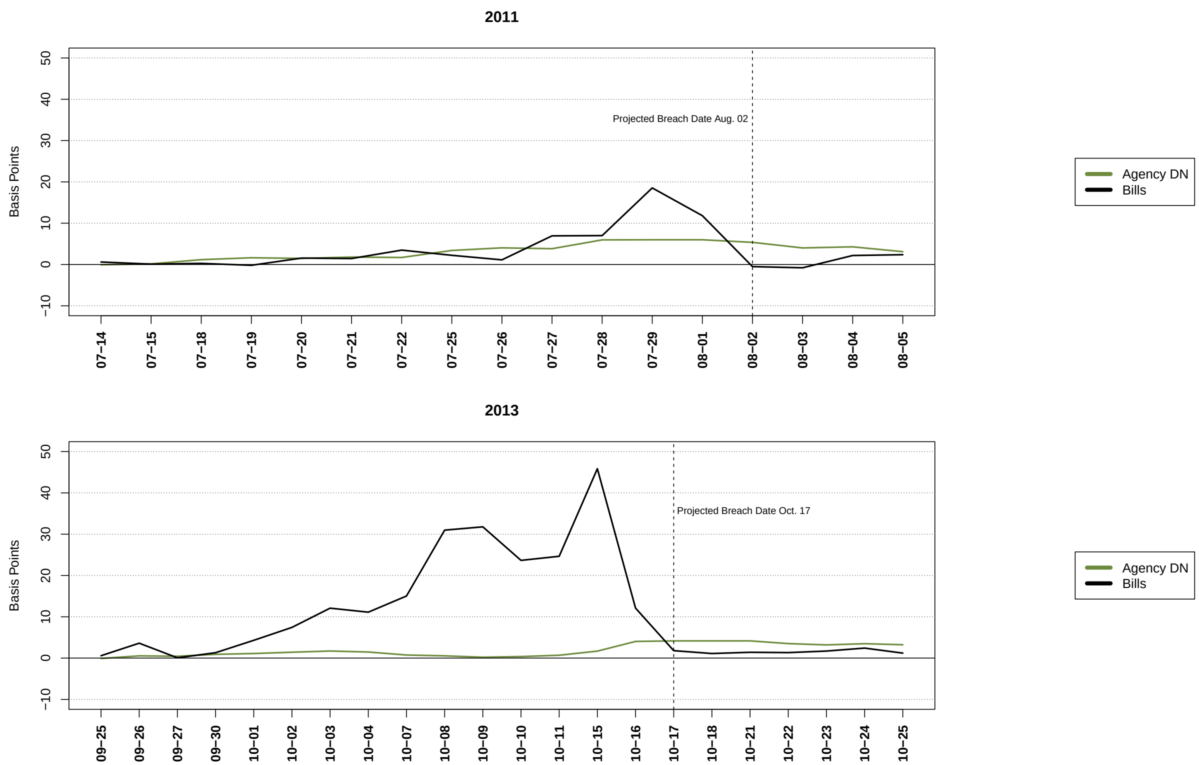
The solid grey line in Figure 7 displays point estimates of the ω_t average money premium erosion coefficients from Equation 2. The solid orange line in Figure 7 displays the yield on the most at-risk T-bill during the impasse. The blue line plots the daily overnight general collateral repo rate.

Figure 8: Agency DN and T-bill average money premium erosion



The green (black) line represents the average money premium erosion in the agency DNs (T-bills), the ω_t in Equation 2, laid out in Section 6.3.

Figure 9: Agency DN and T-bill excess money premium erosion



The green (black) line represents the excess money premium erosion in the agency DNs (T-bills), the $\chi_{c,t}$ in Equation 2, laid out in Section 6.3.

Table 1: Summary statistics

	Count	Average	Std. Dev.	Min	Max
T-Bill yield	24,494	7.4	5.0	-12.2	54.9
2011 Debt Limit	715	5.5	4.8	0.0	26.4
2013 Debt Limit	718	5.6	6.2	-1.5	54.9
Overnight Index Swap (OIS) rate	24,494	12.5	2.8	6.2	26.6
2011 Debt Limit	715	10.6	2.3	6.8	18.1
2013 Debt Limit	718	10.2	1.1	8.5	13.4
U.S. 5-year Credit Default Swap (CDS) spread	750	39.9	9.1	22.1	63.5
2011 Debt Limit	22	56.6	2.9	52.2	63.5
2013 Debt Limit	22	34.6	3.5	29.6	40.4
Spanish CDS spread - U.S. CDS Spread (5-year)	750	285.6	106.3	117.9	583.9
2011 Debt Limit	22	302.8	34.7	252.1	373.7
2013 Debt Limit	22	169.2	14.1	151.6	198.3
T-Bill CUSIP-specific bid-ask spread	24,494	1.30	0.65	0.00	9.65
Pre-structural Break	9,585	1.78	0.69	0.00	6.08
Post-structural Break	14,909	1.00	0.38	0.51	9.65
2011 Debt Limit	715	1.83	0.69	0.00	3.55
2013 Debt Limit	718	1.16	0.79	0.51	9.65
T-Bill norm. CUSIP-specific bid-ask spread	24,494	0.022	1.06	-2.55	25.0
2011 Debt Limit	715	0.092	1.00	-2.55	2.57
2013 Debt Limit	718	0.49	2.27	-1.40	25.0
T-Bill norm. daily average bid-ask spread	750	0.014	0.31	-1.20	3.22
2011 Debt Limit	22	0.047	0.25	-0.46	0.49
2013 Debt Limit	22	0.38	0.81	-0.17	3.22
ON Treasusy General Collateral (GC) Repo Rate	750	10.6	6.5	0.0	28.0
2011 Debt Limit	22	5.9	7.3	0.0	27
2013 Debt Limit	22	7.4	5.6	2.0	19.0
Agency discount note yield	48,644	9.8	4.8	-7.3	42.9
2011 Debt Limit	1,427	9.3	5.3	-4.8	22.8
2013 Debt Limit	1,433	7.2	3.6	0.1	18.5

Notes: Yields, OIS rates, bid-ask spreads, CDS spreads, and GC Repo rates are reported in basis points. Normalized bid-ask spreads are in standard deviations. The normalization process is described in Section 4. Discount note yields include observations for both Fannie Mae and Freddie Mac. The total observations are based on unique observations. Regression observation count lead to similar results. "2011 Debt Limit ("2013 Debt Limit") covers the business days from July 14, 2011 to August 12, 2011 (September 25, 2013 to October 25, 2013). "Pre-structural Break" ("Post-structural Break") covers the business days prior to (following) March 7, 2012, when there was a structural break in bid-ask spread levels and variance.

Table 2: Factor model results – Constrained first stage regression

	US Safety (1)	Both Safety (2)	Liquidity (3)	Combined (4)	2011 At-Risk (5)	2013 At-Risk (6)
(1) OIS	0.579***	0.559***	0.527***	0.515***	1.448**	4.177***
	(0.0244)	(0.0245)	(0.0218)	(0.0217)	(0.678)	(1.312)
(2) US CDS	0.0132***	0.0200***		0.0195***	0.116**	-0.121
	(0.00448)	(0.00468)		(0.00468)	(0.0513)	(0.144)
(3) Spanish CDS - US CDS		-0.00279***		-0.00287***	-0.00443	-0.0495
		(0.000536)		(0.000532)	(0.00905)	(0.0320)
(4) Norm. avg. bid-ask spread			-0.0457**	-0.0409**	-0.202	0.656
			(0.0201)	(0.0200)	(0.242)	(0.820)
(5) Norm. CUSIP bid-ask spread			-0.0134*	-0.0133*	0.138	0.147
			(0.00812)	(0.00809)	(0.0971)	(0.0133)
Debt limit window ($t \in D$)						
(6) US CDS	0.0918***	0.0653**		-0.0348	0.0527	0.0342
	(0.0305)	(0.0306)		(0.0314)	(0.573)	(0.743)
(7) Spanish CDS - US CDS		-0.0212***		-0.00908***	0.00888	0.200
		(0.00294)		(0.00319)	(0.0688)	(0.269)
(8) Norm. avg. bid-ask spread			1.568***	1.507***	1.882	8.051***
			(0.218)	(0.231)	(1.950)	(2.509)
(9) CUSIP bid-ask spread			-0.0240	-0.0238	2.158*	-0.412
			(0.0455)	(0.0456)	(1.270)	(0.412)
(10) Constant	-0.0544***	-0.0550***	-0.0562***	-0.0566***	-0.0625	0.109
	(0.00717)	(0.00714)	(0.00700)	(0.00699)	(0.162)	(0.242)
Observations	24,494	24,494	24,494	24,494	127	127
R-squared	0.052	0.060	0.102	0.106	0.197	0.634

Table 2 presents regression estimates based on Equation 1. Robust standard errors in parentheses. *, **, and *** denote significance at the 1, 5, and 10 percent level, respectively.

Table 3: The effect of market perceptions of safety on T-bill liquidity

	Dep Var: Bid-Ask Spread		
	(1)	(2)	(3)
(1) US CDS	-0.0173**	-0.0151	-0.0162
	(0.00688)	(0.0106)	(0.0106)
(2) Debt Limit Window * US CDS	0.116***		0.117***
	(0.0245)		(0.0248)
(3) Large CDS Change Window * US CDS		0.0290**	-0.00215
		(0.0141)	(0.0137)
(4) Constant	0.00296	0.00193	0.00307
	(0.00888)	(0.00896)	(0.00893)
Observations	24,494	24,494	24,494
R-squared	0.002	0.000	0.002

Table 3 presents estimates of a regression of the business daily first differenced average T-bill bid-ask spread (normalized and adjusted for the 2012 structural break) on our business daily first differenced measure of market perceptions of Treasury safety, U.S. 5-year CDS spreads. We interact the CDS spreads with indicators for the debt limit impasse window and indicators of periods of "large" changes in CDS spreads (i.e. a CDS increase of more than 2 standard deviations over a 10-day period). Robust standard errors in parentheses. *, **, and *** denote significance at the 1, 5, and 10 percent level, respectively.

Table 4: Information model results

	Repo
	(1)
(1) OIS	0.518***
	(0.0231)
(2) Repo	0.0233***
	(0.00258)
(3) 2011 Window * Repo	0.133***
	(0.01701)
(4) 2013 Window * Repo	0.0599
	(0.0397)
(5) Constant	-0.0570***
	(0.00708)
Observations	24,494
R-squared	0.070

Table 4 presents regression estimates based on Equation 5. We include controls for month - and quarter - ends. Robust standard errors in parentheses. *, **, and *** denote significance at the 1, 5, and 10 percent level, respectively.

A Debt Limit Background

The debt limit is an aggregate limit on nearly all federal debt outstanding. This includes debt held by the public in the form of bills, notes, and bonds, as well as debt held in intragovernmental accounts such as the Social Security trust fund, which is invested in nonmarketable Treasury securities. If the debt limit is reached, the Treasury Secretary can declare a Debt Issuance Suspension Period (DISP), which allows the Secretary to invoke "extraordinary measures" that temporarily extend the Treasury's borrowing capacity. Once the extraordinary measures are exhausted (the "breach date"), the Treasury can only meet its obligations with incoming receipts and the cash on hand in the Treasury's checking account at the date of the debt limit breach. If payments due on a given day exceed incoming receipts and the cash balance (the so-called X-date), then the Treasury may be forced to delay interest payments on Treasury securities as well as the principal due on maturing bills, notes, and bonds, triggering a technical default. If the technical default was not resolved in a timely manner, then a more general default on U.S. Treasury debt could occur. For these reasons, failure to increase the debt limit has the potential to drive up yields on Treasury securities as the breach date nears, and likely even more so for the securities that mature soon after the breach date (Johnson [1967]).

Changes in the debt limit require the approval of Congress and the President. From 1962 to 2013, Congress enacted 79 measures to increase, suspend or revise the definition of the debt limit, including 15 measures since 2001. Prior to 1995, these measures passed without much fanfare. Since 1995, however, debate over legislation to increase the debt limit has become increasingly contentious, with DISPs declared as a result.

Treasury Secretaries and market observers noted a change in tone around debt limit negotiations over time. In 2013, Treasury Secretary Jack Lew distinguished the ongoing episode from previous ones. Lew highlighted the Gramm-Rudman-Hollings budget compromises in 1985 and 1986; the Budget Enforcement Act in 1990, and the Balanced Budget Act in 1997. According to Lew, "[in] each of these three instances, the debate was driven by fiscal policy and how to achieve deficit reduction in a responsible, balanced manner. Neither political party thought that defaulting on our debt was a serious, credible option." However, he continued by stating:

> The summer of 2011 was different. Certain Members of Congress argued that default was an acceptable outcome if they were unable to achieve their legislative objectives. Rather than enter into a good-faith compromise on fiscal issues, these Members argued that the United States should voluntarily fail to pay its bills if their position was not accepted. Our economy paid a significant price for these irresponsible and protracted threats.

In both May 2011 and 2013, Congress could not reach an agreement to increase the statutory debt limit, and consequently the Treasury Secretary declared a DISP. Throughout both episodes, the Treasury made several announcements in the form of letters to Congress, official statements, statements to the press, and Congressional testimony. By and large, these announcements informed Congress and the public of extensions to the DISP, and revisions to or affirmations of the projected debt limit breach date, which the Treasury ultimately declared to be August 2, 2011 and October 17, 2013 in the 2011 and 2013 episodes, respectively. During the 2013 episode, the announcements also included projections of the Treasury's cash balance once extraordinary measures were exhausted. Tables A.1 and A.2 lists the date, type, and summary of each announcement, as well as other important dates associated with the debt limit episodes, such as U.S. sovereign credit rating reviews and downgrades.

There have been a few other debt limit episodes from 2013 to the present; the most notable were in 2015 and 2017. Neither of these episodes approached the length and experienced the severity of market dislocations as the 2011 and 2013 episodes. Moreover, some operational features were adjusted so that market participants were better able to identify at-risk securities, dulling the effect of limited information. For these reasons, we focus our analysis on the 2011 and 2013 episodes.

Even though the 2015 and 2017 episodes were less dramatic, they took their toll on sentiment. Reflecting this sentiment, in the lead-up to a potential debt limit debate in October 2015, Secretary Lew wrote the following:

> For these reasons, I respectfully urge Congress to take action as soon as possible, raise the debt limit without delay, and remove an unnecessary threat to our economy. We have learned from the past that failing to act until the last minute can cause serious harm to business and consumer confidence, raise short-term borrowing costs for taxpayers, and negatively impact the credit rating of the United States. And there is no way to predict the irreparable damage that default would have on global financial markets and the American people.

Table A.1: Debt limit announcements from the Treasury and other important events

Episode	Date	Type*	Summary
2011	2-May-11	Letter to Congress (T)	Announcement of Debt Issuance Suspension Period (DISP) lasting through August 2, 2011
	1-Jun-11	Statement (T)	August 2nd breach date projection reaffirmed
	13-Jul-11	Statement	Moody's places U.S. sovereign credit rating of 'Aaa' on review for possible downgrade
	14-Jul-11	Statement	Standard & Poor's places its 'AAA' long-term and 'A-1+' short-term credit rating on the U.S. on Credit Watch negative
	15-Jul-11	Statement (T)	August 2nd breach date projection reaffirmed
	2-Aug-11	Legislation	Budget Control Act of 2011 is passed which immediately increases debt limit by $400 billion; two additional increases of $500 billion and $1.2-1.5 trillion subject to a Congressional motion of disapproval '
	5-Aug-11	Statement	Standard & Poor's lowers long-term sovereign credit rating on U.S. to 'AA+' from 'AAA

Sources:

1. "Debt Limit," U.S. Department of the Treasury, http://www.treasury.gov/initiatives/pages/debtlimit.aspx;

2. Brandimarte, Walter and Daniel Bases (June 13, 2011). "Moody's puts U.S. ratings on review for downgrade," Reuters, www.reuters.com/article/2011/07/13/us-usa-ratings-moodys-idUSTRE76C6PT20110713

3. Research Update: United States of America Long-Term Rating Lowered to 'AA+' on Political Risks and Rising Debt Burden; Outlook Negative (August 5, 2011). Standard & Poor's, http://img.en25.com/Web/StandardandPoors/UnitedStatesofAmericaLongTermRatingLoweredToAA.pdf

4. Budget Control Act of 2011 (August 2, 2011). Government Printing Office, http://www.gpo.gov/fdsys/pkg/PLAW-112publ25/html/PLAW-112publ25.htm

Table A.2: Debt limit announcements from the Treasury and other important events continued

Episode	Date	Type*	Summary
2013	17-May-13	Letter to Congress (T)	Announcement of DISP lasting through August 2, 2013
	2-Aug-13	Letter to Congress (T)	Extension of DISP to October 11, 2013
	26-Aug-13	Letter to Congress (T)	Extraordinary measures projected to be exhausted by mid-October 2013
	25-Sep-13	Letter to Congress (T)	Extraordinary measures projected to be exhausted no later than October 17, 2013
	1-Oct-13	Letter to Congress (T)	Final extraordinary measures being used; reaffirmed exhaustion of extraordinary measures no later than October 17, 2013; "cash balance" (cash on hand) of $30 billion; government shutdown begins
	15-Oct-13	Statement	Fitch places U.S. sovereign credit rating of 'AAA' on negative watch
	16-Oct-13	Legislation	"Continuing Appropriations Act, 2014" is passed, which suspends the debt limit until February 7 , 2014.

*(T) indicates Treasury Department announcement.

Sources:

1. "Debt Limit," U.S. Department of the Treasury, http://www.treasury.gov/initiatives/pages/debtlimit.aspx;

2. H.R. 2775, Continuing Appropriations Act, 2014 (October 17, 2013), Congress.gov,

http://beta.congress.gov/bill/113th-congress/house-bill/2775''

B Appendix tables

Table B.1: Factor model results from second stage regression – Average erosion, 2011

	Baseline (1)	Constrained (2)	Liquidity (3)	US Safety (4)	All Safety (5)	Combined (6)
Jul 18	-0.222	0.139	-0.289	-0.143	1.299***	1.186***
	(0.289)	(0.288)	(0.282)	(0.296)	(0.307)	(0.280)
Jul 19	0.480	0.0685	-0.0114	0.347	1.168***	1.020***
	(0.329)	(0.325)	(0.316)	(0.333)	(0.337)	(0.313)
Jul 20	0.531	0.517	0.395	0.406	0.835**	0.866***
	(0.349)	(0.346)	(0.331)	(0.350)	(0.356)	(0.331)
Jul 21	1.558***	0.553	1.015***	1.399***	1.026***	0.930***
	(0.371)	(0.368)	(0.360)	(0.369)	(0.376)	(0.360)
Jul 22	1.833***	0.555	1.148***	1.634***	1.260***	1.094***
	(0.390)	(0.388)	(0.381)	(0.385)	(0.388)	(0.374)
Jul 25	2.712***	2.798***	2.650***	2.536***	2.675***	2.806***
	(0.411)	(0.409)	(0.400)	(0.405)	(0.404)	(0.390)
Jul 26	3.714***	2.804***	3.137***	3.447***	3.251***	3.260***
	(0.433)	(0.431)	(0.417)	(0.423)	(0.419)	(0.403)
Jul 27	4.954***	3.690***	4.049***	4.582***	4.661***	4.569***
	(0.453)	(0.452)	(0.432)	(0.441)	(0.435)	(0.416)
Jul 28	4.870***	4.544***	4.615***	4.400***	4.620***	5.009***
	(0.471)	(0.469)	(0.445)	(0.457)	(0.448)	(0.427)
Jul 29	7.214***	6.686***	6.355***	6.742***	7.405***	7.254***
	(0.484)	(0.482)	(0.456)	(0.467)	(0.455)	(0.435)
Aug 01	6.515***	6.448***	5.898***	5.902***	7.049***	7.022***
	(0.488)	(0.485)	(0.461)	(0.475)	(0.461)	(0.443)
Aug 02	2.458***	2.705***	1.978***	2.078***	3.538***	3.477***
	(0.484)	(0.482)	(0.456)	(0.475)	(0.457)	(0.439)
Aug 03	0.474	0.945**	0.0612	0.205	2.013***	1.843***
	(0.464)	(0.463)	(0.441)	(0.458)	(0.436)	(0.424)
Constant	-0.0595***	-0.00151	-0.00106	-0.000143	0.000112	-0.000978
	(0.00594)	(0.00593)	(0.00576)	(0.00590)	(0.00586)	(0.00570)
Observations	24,494	24,494	24,494	24,494	24,494	24,494
R-squared	0.373	0.303	0.253	0.320	0.310	0.239

Robust standard error estimates are in parentheses. ***, **, and * denotes significance at the 1, 5, and 10 percent level, respectively.

Table B.2: Factor model results from second stage regression – Average erosion, 2013

	Baseline (1)	Constrained (2)	Liquidity (3)	US Safety (4)	All Safety (5)	Combined (6)
Oct 07	-0.540	-0.612	-0.695	-1.701***	-1.737***	-0.153
	(0.580)	(0.585)	(0.486)	(0.575)	(0.565)	(0.473)
Oct 08	0.849	-0.546	-0.154	-0.499	-0.0496	0.573
	(0.627)	(0.632)	(0.517)	(0.618)	(0.606)	(0.504)
Oct 09	1.018	0.000521	0.208	-0.594	0.0419	1.092**
	(0.669)	(0.675)	(0.543)	(0.657)	(0.642)	(0.529)
Oct 10	2.247***	0.140	0.985*	0.715	0.543	1.630***
	(0.695)	(0.701)	(0.545)	(0.677)	(0.656)	(0.533)
Oct 11	3.795***	3.262***	3.406***	2.882***	2.783***	3.749***
	(0.702)	(0.708)	(0.532)	(0.686)	(0.660)	(0.524)
Oct 15	7.361***	2.285***	3.405***	6.194***	5.136***	3.547***
	(0.575)	(0.582)	(0.498)	(0.568)	(0.559)	(0.493)
Oct 16	3.938***	1.204**	1.763***	2.948***	2.019***	1.888***
	(0.513)	(0.518)	(0.440)	(0.511)	(0.504)	(0.436)
Oct 17	0.555	-0.988**	-0.417	0.178	-0.598	-0.428
	(0.436)	(0.440)	(0.381)	(0.433)	(0.426)	(0.378)
Oct 18	-0.334	-0.939**	-0.655*	-0.457	-0.943**	-0.701**
	(0.383)	(0.385)	(0.343)	(0.384)	(0.381)	(0.340)
Constant	-0.0595***	-0.00151	-0.00106	-0.000143	0.000112	-0.000978
	(0.00594)	(0.00593)	(0.00576)	(0.00590)	(0.00586)	(0.00570)
Observations	24,494	24,494	24,494	24,494	24,494	24,494
R-squared	0.373	0.303	0.253	0.320	0.310	0.239

Robust standard error estimates are in parentheses. ***, **, and * denotes significance at the 1, 5, and 10 percent level, respectively.

Table B.3: Factor model results from second stage regression – Excess erosion, 2011

	Baseline (1)	Constrained (2)	Liquidity (3)	US Safety (4)	All Safety (5)	Combined (6)
Jul 18	0.266	0.281	-0.319	0.331	0.182	-2.376***
	(0.290)	(0.288)	(0.283)	(0.296)	(0.308)	(0.280)
Jul 19	-0.193	-0.107	-2.008***	0.117	0.0789	-3.429***
	(0.330)	(0.326)	(0.316)	(0.333)	(0.338)	(0.314)
Jul 20	1.550***	1.585***	-0.865***	1.877***	1.925***	-1.610***
	(0.350)	(0.346)	(0.332)	(0.351)	(0.357)	(0.332)
Jul 21	1.447***	1.384***	-3.828***	1.736***	1.941***	-3.982***
	(0.371)	(0.369)	(0.361)	(0.369)	(0.377)	(0.361)
Jul 22	3.483***	3.490***	-1.945***	3.991***	4.203***	-2.012***
	(0.391)	(0.388)	(0.382)	(0.385)	(0.389)	(0.375)
Jul 25	2.226***	2.317***	0.245	2.651***	2.796***	-0.354
	(0.412)	(0.410)	(0.401)	(0.405)	(0.405)	(0.391)
Jul 26	1.123***	1.197***	-1.602***	1.551***	1.776***	-2.230***
	(0.433)	(0.431)	(0.418)	(0.424)	(0.420)	(0.405)
Jul 27	6.937***	6.877***	3.655***	7.147***	7.357***	2.386***
	(0.453)	(0.452)	(0.434)	(0.442)	(0.436)	(0.418)
Jul 28	6.993***	6.991***	4.516***	7.254***	7.454***	3.289***
	(0.470)	(0.469)	(0.447)	(0.458)	(0.449)	(0.429)
Jul 29	18.54***	18.34***	13.52***	18.71***	18.85***	11.79***
	(0.484)	(0.483)	(0.458)	(0.469)	(0.458)	(0.438)
Aug 1	11.82***	11.61***	7.027***	12.24***	12.31***	5.583***
	(0.488)	(0.488)	(0.463)	(0.477)	(0.464)	(0.446)
Aug 2	-0.512	-0.817*	-5.405***	-0.257	-0.227	-7.509***
	(0.487)	(0.486)	(0.460)	(0.479)	(0.462)	(0.443)
Aug 3	-0.799*	-1.239***	-3.562***	-0.777*	-0.785*	-6.013***
	(0.471)	(0.470)	(0.448)	(0.464)	(0.444)	(0.431)
Constant	-0.0595***	-0.00151	-0.00106	-0.000143	0.000112	-0.000978
	(0.00594)	(0.00593)	(0.00576)	(0.00590)	(0.00586)	(0.00570)
Observations	24,494	24,494	24,494	24,494	24,494	24,494
R-squared	0.373	0.303	0.253	0.320	0.310	0.239

Robust standard error estimates are in parentheses. ***, **, and * denotes significance at the 1, 5, and 10 percent level, respectively.

Table B.4: Factor model results from second stage regression – Excess erosion, 2013

	Baseline (1)	Constrained (2)	Liquidity (3)	US Safety (4)	All Safety (5)	Combined (6)
Oct 07	15.03***	14.64***	14.02***	4.128***	0.104	21.23***
	(0.574)	(0.579)	(0.484)	(0.570)	(0.560)	(0.471)
Oct 08	30.98***	30.50***	22.82***	19.92***	16.41***	28.11***
	(0.621)	(0.626)	(0.516)	(0.613)	(0.601)	(0.502)
Oct 09	31.78***	31.67***	28.07***	18.27***	14.70***	33.63***
	(0.663)	(0.668)	(0.541)	(0.652)	(0.637)	(0.527)
Oct 10	23.66***	23.51***	13.06***	9.905***	4.327***	21.11***
	(0.691)	(0.697)	(0.549)	(0.675)	(0.656)	(0.536)
Oct 11	24.65***	24.21***	21.24***	16.09***	10.31***	29.37***
	(0.699)	(0.706)	(0.538)	(0.685)	(0.661)	(0.529)
Oct 15	45.85***	45.25***	18.39***	35.88***	28.08***	27.24***
	(0.589)	(0.597)	(0.508)	(0.582)	(0.573)	(0.502)
Oct 16	12.10***	11.59***	-2.974***	2.882***	-5.053***	7.118***
	(0.532)	(0.538)	(0.455)	(0.530)	(0.522)	(0.450)
Oct 17	1.801***	1.304***	-7.435***	-4.132***	-12.11***	2.251***
	(0.462)	(0.466)	(0.403)	(0.458)	(0.451)	(0.398)
Oct 18	1.111***	0.645	-3.168***	-3.314***	-11.10***	6.144***
	(0.413)	(0.415)	(0.367)	(0.413)	(0.408)	(0.364)
Constant	-0.0595***	-0.00151	-0.00106	-0.000143	0.000112	-0.000978
	(0.00594)	(0.00593)	(0.00576)	(0.00590)	(0.00586)	(0.00570)
Observations	24,494	24,494	24,494	24,494	24,494	24,494
R-squared	0.373	0.303	0.253	0.320	0.310	0.239

Robust standard error estimates are in parentheses. ***, **, and * denotes significance at the 1, 5, and 10 percent level, respectively.

Table B.5: T-bill and Agency DN average erosion estimates – 2011 and 2013

	2011			2013	
	Agency DN	Bills		Agency DN	Bills
Jul 21	0.0280	1.558***	Oct 04	-0.175	-0.515
	(0.366)	(0.371)		(0.254)	(0.536)
Jul 22	-0.840**	1.833***	Oct 07	0.519*	-0.540
	(0.403)	(0.390)		(0.279)	(0.580)
Jul 25	0.292	2.712***	Oct 08	1.016***	0.849
	(0.446)	(0.411)		(0.304)	(0.627)
Jul 26	0.0975	3.714***	Oct 09	1.960***	1.018
	(0.480)	(0.433)		(0.322)	(0.669)
Jul 27	3.488***	4.954***	Oct 10	4.240***	2.247***
	(0.517)	(0.453)		(0.328)	(0.695)
Jul 28	4.949***	4.870***	Oct 11	4.750***	3.795***
	(0.550)	(0.471)		(0.324)	(0.702)
Jul 29	4.751***	7.214***	Oct 15	4.222***	7.361***
	(0.576)	(0.484)		(0.317)	(0.575)
Aug 01	5.525***	6.515***	Oct 16	3.052***	3.938***
	(0.598)	(0.488)		(0.269)	(0.513)
Aug 02	5.239***	2.458***	Oct 17	1.941***	0.555
	(0.616)	(0.484)		(0.241)	(0.436)
Aug 03	3.659***	0.474	Oct 18	1.380***	-0.334
	(0.635)	(0.464)		(0.222)	(0.383)
Aug 04	0.891	-0.666	Oct 21	0.618***	-0.441
	(0.646)	(0.434)		(0.194)	(0.338)
Aug 05	-0.442	-0.0615	Oct 22	0.405**	-0.590**
	(0.639)	(0.425)		(0.159)	(0.290)
Observations	48,644	24,494		48,644	24,494
R-squared	0.132	0.373		0.132	0.373

Table B.5 provides point estimates of the ω_t average money premium erosion coefficients based on Equation 2. Robust standard error estimates are in parentheses. ***, **, and * denotes significance at the 1, 5, and 10 percent level, respectively. Red indicates peak T-bills average money premium erosion estimate.

Table B.6: T-bill and Agency DN excess erosion estimates – 2011 and 2013

	2011			2013	
	Agency DN	Bills		Agency DN	Bills
Jul 21	1.798***	1.447***	Oct 04	1.475***	11.12***
	(0.486)	(0.371)		(0.396)	(0.531)
Jul 22	1.695***	3.483***	Oct 07	0.745*	15.03***
	(0.646)	(0.391)		(0.413)	(0.574)
Jul 25	3.403***	2.226***	Oct 08	0.548	30.98***
	(1.085)	(0.412)		(0.581)	(0.621)
Jul 26	4.033***	1.123***	Oct 09	0.211	31.78***
	(1.104)	(0.433)		(0.618)	(0.663)
Jul 27	3.824***	6.937***	Oct 10	0.373	23.66***
	(1.120)	(0.453)		(0.631)	(0.691)
Jul 28	5.960***	6.993***	Oct 11	0.693	24.65***
	(1.136)	(0.470)		(0.630)	(0.699)
Jul 29	5.987***	18.54***	Oct 15	1.6892**	45.85***
	(1.148)	(0.484)		(0.721)	(0.589)
Aug 01	5.986***	11.82***	Oct 16	4.036***	12.10***
	(1.159)	(0.488)		(0.735)	(0.532)
Aug 02	5.365***	-0.512	Oct 17	4.164***	1.801***
	(1.170)	(0.487)		(0.793)	(0.462)
Aug 03	4.011***	-0.799*	Oct 18	4.170***	1.111***
	(1.180)	(0.471)		(0.792)	(0.413)
Aug 04	4.276***	2.181***	Oct 21	4.167***	1.407***
	(1.185)	(0.444)		(0.813)	(0.371)
Aug 05	3.106**	2.373***	Oct 22	3.513***	1.330***
	(1.544)	(0.435)		(0.826)	(0.327)
Observations	48,644	24,494		48,644	24,494
R-squared	0.132	0.373		0.132	0.373

Table B.6 provides point estimates of the $\chi_{c,t}$ excess money premium erosion coefficients based on Equation 2. Robust standard error estimates are in parentheses. ***, **, and * denotes significance at the 1, 5, and 10 percent level, respectively. Red indicates peak T-bills excess money premium erosion estimate.