When Do Treasuries Earn the Convenience Yield? — A Hedging Perspective

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Abstract

We document that the convenience yield of U.S. Treasuries exhibits properties that are consistent with a hedging perspective of safe assets, i.e., Treasuries are valued highly if they appreciate with poor aggregate shocks. In particular, the convenience yield tends to be low when the covariance of Treasury returns with the aggregate stock market returns is high. A decomposition of the aggregate stock-bond covariance into terms corresponding to the convenience yield, the frictionless risk-free rate, and default risk reveals that the covariance between stock returns and the convenience yield itself drives the effect in a substantive capacity.

Keywords: Stock-bond covariance, safety premium, liquidity premium, money premium, exorbitant privilege, safe assets, bubble, inflation, debt ceiling

JEL: G11, G12, G15, E4, E5, F3

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The United States (U.S.) Dollar plays a central role in the international monetary system as a reserve currency for settling financial payments and transactions underlying global trade. Relatedly, and likely consequently, dollar and safe dollar-based fixed-income assets, notably the U.S. Treasuries, command a so-called *exorbitant privilege* in their pricing due to heightened demand from international community (central banks, for instance) looking for ways to park its dollar reserves. Increasingly, however, it is being recognized that the U.S. safe assets – and safe assets, more generally – command such a premium in their pricing due not just to an international demand but also to a domestic demand, driven by the hedging properties of these assets.

Distilled to its essence, this "safe assets" or "hedging" perspective relies on the assumption that markets are effectively incomplete. Households, for example, face consumption shocks which would cause severe disutility if not smoothed across states and over time. Corporations face liquidity shocks in their production and financing needs, potentially leading to costly asset liquidations. Financial investors may face uninsurable background shocks as well due to exposure to illiquid assets such as housing and private equity. Households, corporations, and financial investors, therefore, have a demand for assets that are safe enough to hedge against the impact of these shocks. Similarly, banks prefer to make inter-bank loans collateralized by pristine quality assets rather than take on each others' counterparty credit risk as credit risk shocks may coincide with own funding shocks.

Important early contributions to the literature offering a safe-assets perspective often assume that government bonds have safety and money-like properties and/or there is a built-in preference for such assets in investor or household objective functions.[1] Recent literature, however, has sought to micro-found these outcomes. It emerges from this latter approach that prices of assets whose financial values and/or liquidity covary inversely with aggregate risk should reflect an excess premium as such assets provide hedging value to investors when unspanned shocks materialize. The premium is magnified if assets provide a hedging benefit in a retrading sense: investors value assets whose secondary market prices rise in times of aggregate risk, as in Brunnermeier et al. (2022), or whose liquidity rises in times of aggregate risk, as in Acharya and Pedersen (2005). Such combination of appreciation and liquidity in bad states of the world is dubbed the "good friend" property by Brunnermeier et al. (2022). The U.S. Treasuries are considered a primary candidate for being such assets, and the premium that accrues to their pricing is referred by the literature with a variety of terms such as "convenience yield", "money premium", or "bubble".[2]

In this paper, we establish that this premium, which, for fixing terminology, we refer to as the *convenience yield* of U.S. Treasuries, exhibits time-series properties that are consistent with the hedging perspective of safe assets. Specifically, the Treasury convenience yield is high when the covariance of returns on Treasuries and the aggregate stock market is low. What is more, we find that the convenience yield itself comoves over time with the aggregate equity market returns,

[1] See, e.g., Holmström and Tirole (2001) and Krishnamurthy and Vissing-Jorgensen (2012).

[2] A broad definition of the convenience yield is that it is any value of Treasuries above and beyond the present value their explicit cash-flows could contribute. For instance, extra demand due to regulatory requirements such as the High Quality Liquid Assets (HQLA) requirement under Basel III (see Fuhrer et al. (2017)) could also contribute to the convenience yield.

contributing to the hedging properties of Treasuries, a result suggestive of the service-flow value of ease of retrading safe assets.

We motivate our analysis using a simple intertemporal framework where convenience flows are modeled as (unobservable) time-varying payments accruing to the holder of the bond. The discounting of such convenience flows reflects the potential systematic nature of their variation: if the flows are higher in bad times their present value is commensurately higher. The theoretical framework makes it clear that the effect we seek to document is distinct from a hedging premium that would obtain whenever interest rates are procyclical. We argue that the convenience flows themselves can have a negative beta with respect to stock market returns, contributing to a reduction of expected returns of safe bonds over and above any factors relevant in a frictionless world. Having provided the analytical framework, we document three sets of empirical findings.

In the first set of results, we provide a new decomposition of the aggregate stock-bond covariance, separating out the contribution of the convenience yield. In Panel A of Figure 2 we plot the covariance between the daily returns on 10-year nominal Treasuries and the aggregate stock market in a 30-trading day look-back window. Existing work has found that this covariance exhibits substantial time variation; in particular, note in Figure 2 the periodic large negative spikes in the post-2000 data.[3] To decompose the covariance, we express the 10-year bond yield as the sum of a "frictionless" risk-free rate, the Treasury convenience yield, and a term corresponding to default risk, proxied by the credit default swap (CDS) rate. Our preferred measure of the Treasury convenience yield is the TIPS-Treasury premium which is the yield differential between a synthetic nominal treasury, constructed out of Treasury Inflation Protected Security (TIPS) and traded inflation swaps, and maturity-matched nominal Treasury, and a traded nominal Treasury. This measure is based on the work by Fleckenstein et al. (2014) who document that during 2004 to 2010 nominal Treasuries had almost always been more expensive than the synthetic counterparts.

With this yield decomposition we calculate three covariance terms with stock returns that make up the aggregate stock-bond covariance. We find that both the frictionless risk-free rate component as well as the convenience yield component of the stock-bond covariance contribute in about equal measure to the stock-bond covariance of long maturity bonds. We plot the stock-bond covariance resulting from the convenience yield component of the 10-year yield in Panel B of Figure 2, illustrating the quantitatively large contribution of convenience yield innovations to the aggregate covariance. Further, the large negative spikes in the stock-bond covariance such as those around the Global Financial Crisis, the Eurozone crisis, and most recently, the onset of the Covid pandemic, owe in good measure to the convenience yield component.

In our second and main set of results, we document support for the hedging perspective on safe assets: the convenience yield on Treasuries is high precisely when the covariance between stocks and bonds is low. Employing a set of eight convenience yield proxies (in addition to the TIPS-Treasury premium) spanning short and long maturities, we find that periods of low aggregate stock-bond covariance see larger convenience yields.[4] We illustrate this relationship for the first principal

[3]See Duffee (2022) for a survey.

[4]Specifically, we use the General Collateral Repo rate spread over the 3-month T-bill rate (GC-Tr 3m), the effective

component of the various proxies in Panel A of Figure 4.

Using the stock-bond covariance decomposition (into terms corresponding to the frictionless risk-free rate, the convenience yield, and default risk), we find that the covariance attributable to convenience yield fluctuations is the most robust in explaining the convenience yield of safe fixed income assets, with the covariance attributable to the risk-free rate fluctuations playing a meaningful role too. With respect to magnitudes, a one standard deviation drop in the stock-bond covariance estimated with Treasury convenience yields corresponds to a .6 standard deviation increase in the TIPS-Treasury premium. In contrast, the covariance attributable to the CDS premium fluctuations contributes to the convenience yield only with a quantitatively smaller magnitude.

These results hold for a variety of alternative convenience yield proxies and in samples reaching past 2005 when the TIPS-Treasury measure becomes available. Across the measures, a one standard deviation decrease in the stock-bond covariance corresponds to about a third to two thirds of a standard deviation increase in the convenience yield proxy, despite the differences in maturity and balance sheet treatment of the constituent securities in the proxies. The negative relationship between stock-bond covariance and different convenience yield proxies also extends back to samples starting in 1991 and in 1972. That our baseline results obtain across a set of eight distinct proxies suggests a substantial common component to the convenience yield proxies. While prior work in Siriwardane et al. (2022) has documented low correlations between various arbitrage spreads, our findings are indicative of a common component in Treasury convenience yield proxies.

In the third set of results, we use the first principal component to carry out various robustness analysis. We check that the results are not driven by extreme realizations of convenience yields during the Global Financial Crisis; we document that the results are robust to controlling for the VIX. We also show that expected inflation and default risk in Treasures at different horizons cannot account for our findings. What is more, we use principal component analysis to establish the behavior of the convenience yield across the term structure. We construct principal components separately for the short- and long-term convenience yield proxies, finding that despite a strong commonality across maturities, there are distinct short- and long-term factors. In line with our analytical framework, we find that the short-term stock-bond covariance is particularly strongly related to the first principal component of short-term convenience yields. At the same time, the degree of commonality in the short- and long-maturity proxies indicates that factors operating through the entire yield curve are important drivers of the convenience yield.

We additionally document that our results obtain under a bevy of variations in the construction of the stock-bond covariance. We extend the set of convenience yield proxies to corporate securities such as commercial paper and corporate bonds, as well as to relative measures of U.S. Treasury premium over other hard currency bonds. Across this set of convenience yield proxies we again find that the specialness of Treasuries tends to increase in times of negative stock-bond covariance.

Fed funds rate spread over the 3-month T-bill rate (FF-Tr 3m), the negative of the Z-spread, a measure that compares T-bill rates with yields implied by a fitted yield curve (-1*Z-Spr.), the 30-year LIBOR Swap spread (Libor Spr. 30y), the Agency mortgage-backed security - Treasury spread (FN-Tr 30y), the Treasury Richness measure of Fleckenstein and Longstaff (2024), and the Box rate implied convenience yield as calculated in van Binsbergen et al. (2022).

Finally, we discuss certain underlying drivers of the TIPS-Treasury premium and the Treasury convenience in general: factors specific to the TIPS market, factors specific to the creditworthiness of the U.S., and factors relating to inflation dynamics.[5] Notably, we demonstrate that the resolutions of two debt ceiling stand-offs (in 2011 and in 2023) saw marked increases in the convenience yield.

Overall, the relationship between the level of the convenience yield and the hedging properties of the security lends support to the theoretical models in Acharya and Pedersen (2005) and Brunnermeier et al. (2022) regarding a liquidity premium arising from covariance of a security's liquidity with negative aggregate shocks. Put differently, the convenience yield reflected in the price of a long-maturity security does not only reflect expected convenience flows in future periods, but also a substantial risk adjustment owing to the fact that such flows are elevated in periods of poor aggregate realizations. As mentioned before, the channel we document is thus distinct from the standard negative beta channel of low bond yields.

These results have several implications for theoretical and empirical work on safe assets as well as for policy. Time-series variation in the covariance of U.S. Treasury returns with the aggregate stock market return implies that the moneyness or safe-asset properties of U.S. Treasuries and fixed-income assets are not a given. Instead, these properties are likely tied to macroeconomic and financial developments in the economy. The potentially drastic impact of a drop in the convenience yield is evident in post-Covid asset market data. In Figure 1 we show recent returns on the aggregate equity market, the 7-year nominal Treasury bond (represented by the returns on IEF, an exchange traded fund) and inflation protected Treasury (represented by the returns on TIP, another ETF). While 2021 saw good equity returns in continuation of the recovery from the pandemic-era market trough, the returns in both stocks and bonds were strongly negative in 2022 as higher-than-expected inflation took hold.

Our findings also present a complementary rationale for why the U.S. Treasuries may become "inconvenient" to the one offered by Duffie (2020), He et al. (2022) and Haddad et al. (2021). These papers document that during the peak of the market turmoil during the Covid outbreak of March 2020, U.S. Treasuries—especially the long-term ones—did not benefit from a flight to quality observed during the global financial crisis (GFC) of 2007-09, and, if anything, they appeared to be experiencing fire sales until the Federal Reserve stepped in to provide liquidity to the market. These authors attribute this outcome to the unwinding of leveraged positions in cash-futures basis market, limited intermediation capacity of dealer banks due to post-GFC reforms, and rollover risk faced by non-bank financial intermediaries. In contrast to this episodic and market-function-linked erosion of convenience yield of the U.S. Treasuries (see also Duffie (2023)), the recent erosion we document is linked to a rise in the covariance of Treasury returns with aggregate stock returns and is more slow-moving, and is similar to that observed also in 1970s and 80s, representing possibly a risk to investor ability to hedge aggregate risks.

[5] Inflation dynamics are shown to play an important role in existing literature on convenience yields, for instance, see Cieslak et al. (2023) and Li et al. (2022) among others.

1 Measuring the Stock-Bond Covariance and the Convenience Yield

We begin our analysis by documenting high-frequency dynamics of the aggregate stock-bond covariance. We calculate the covariance between the daily arithmetic CRSP value-weighted stock market return and the daily logarithmic 10-year nominal zero-coupon constant-maturity Treasury bond returns in a rolling 30 trading-day look-back window.[6] One potential concern with measuring the conditional covariance in a short look-back window is that times of market stress might see price pressure in either the stock or the bond market, leading to sharp return reversals. In order to mitigate the potential impact of such market illiquidity, our baseline stock-bond covariance measures uses the sum of three most recent daily returns on both the stock and the bond, divided by the square root of three. This approach dampens the impact of potential return outliers while leaving the scaling of the covariance calculation unchanged.[7] (Note that under i.i.d. returns this covariance calculation would be equivalent to using just daily returns.) We then collapse the covariances to a monthly variable by keeping the last available calculation in each calendar month. Zero-coupon nominal bond prices are from the daily fitted yield curve constructed in Gürkaynak et al. (2007). The use of a fitted yield curve ensures that the bond prices involved always correspond to the exact same maturity and also smooths over the impact of any potential bond-specific demand effects.

The resulting covariances are reported on an annualized basis in percent units. To give an example, if the daily stock return volatility is 2%, daily bond return volatility is .5% and the correlation between the two return series is -.6, the covariance would be reported as $-.6 \times .02 \times .005 \times 252 = -1.512\%$.

We plot the stock-bond covariance using 10-year nominal Treasuries in Panel A of Figure 2. Both low- and high-frequency changes in the stock-bond covariance are evident. Over a long time-frame the stock-bond covariance has seen a marked decline from the 1980s through the 2010s. Over shorter time-frames, the stock-bond covariance exhibits periodic spikes. In the sample since the turn of the century, in particular, the spikes in the stock-bond covariance tend to be on the negative side: during the 2001 recession, notably during the Global Financial Crisis, the Eurozone crisis, and at the onset of the Covid pandemic. The exception to this rule is the most recent, post-Covid pandemic era that saw positive stock-bond covariance during times of unexpectedly high inflation.

The summary statistics of the aggregate covariance between stocks and the 10-year bond are reported in Panels A, D, and E of Table 1, representing different time periods. As shown in Panel A, in the 2005-2023 sample the 10-year nominal bond return covariance with the stock market is on

[6] A calculation with physical bond returns results in identical results. Our short look-back window is in keeping with the approach in Duffee (2022), the rationale being to have each monthly covariance reflect the arrival of recent information. In robustness analysis in Section 3.B we use stock-bond covariance constructed in longer lookback windows.

[7] This approach is similar in spirit to the Dimson (1979) beta but allows for potential illiquidity in both of the constituent assets. An alternative calculation just uses daily returns in the same 30 trading day look-back window. In Appendix Figure OA2 we plot the aggregate stock-bond covariance from both calculations. As the figure shows, the two series overlap tightly for most of the sample. The one exception to this rule is from the early days of the Covid pandemic during which the one-day calculation sees a larger negative spike, consistent with bond market dislocations in this period, as documented in Haddad et al. (2021) and He et al. (2022)

average negative (-.42) and has standard deviation of .90. As suggested by the negative spikes seen in the post-2005 data in Panel A of Figure 2, the aggregate stock-bond covariance in this period is left-skewed with the 10th percentile value of -1.32 and the 90th percentile value of .25.

1.A Convenience Yield Proxy: the TIPS-Treasury Premium

Our main high-frequency proxy for the Treasury convenience yield is based on the relative pricing of nominal and real Treasury bonds. As shown in Fleckenstein et al. (2014), the prices of nominal Treasuries are consistently above the prices of matched maturity TIPS prices, accounting for the variable inflation coupon payment via traded inflation swaps. Specifically, combining TIPS, inflation swaps, and Treasury STRIPS allows these authors to construct "synthetic" nominal Treasury bonds with cash-flows identical to traded nominal Treasuries, but at lower prices than the traded counterparts. Because two such securities—a nominal bond, and a maturity-matched synthetic nominal bond—have identical cash-flows we interpret the gap in their prices as a proxy for the convenience flows afforded by the nominal Treasury. Our interpretation is consistent with the result in Fleckenstein et al. (2014) that this gap increased substantially during the Global Financial Crisis and has a common component with other proxies of Treasury specialness, namely the on-the-run/off-the-run spread, and the Refcorp-Treasury spread.[8]

Relative to the approach in Fleckenstein et al. (2014) we use a simpler method to construct a high-frequency TIPS-Treasury premium. Instead of comparing the prices of matched pairs of nominal and real Treasuries, we employ the continuously compounded fitted nominal and real yield curves from Gürkaynak et al. (2007) and Gürkaynak et al. (2010), respectively. We combine this data with interpolated inflation swap rates to account for the inflation coupon part and calculate the TIPS-Treasury premium for maturity n on date t as:

$$\begin{aligned} \text{Premium}_{n,t} &= \text{TIPS Yield}_{n,t} + \text{Inflation Swap}_{n,t} - \text{Treasury Yield}_{n,t} \quad (1) \\ &= \text{Synthetic Treasury Yield}_{n,t} - \text{Treasury Yield}_{n,t}, \quad (2) \end{aligned}$$

where the second equation emphasizes the terminology of "Synthetic Treasury Yield" to refer to the yield on a nominal bond constructed out of TIPS and inflation swaps.

This method results in a day- and maturity-level proxy of the Treasury convenience yield that is not identical, but highly correlated with the measure documented in Fleckenstein et al. (2014) (the correlation between the two calculations is .91 in the 2004-2014 sample). Relative to that proxy, our construction has the advantage that the yield curve estimation smooths over some of the security-specific pricing factors that could introduce noise to the estimation using matched pairs of actual securities. We use this data both at the daily and monthly frequencies. In order to calculate the covariance between stock returns and convenience yield innovations we use the daily data; when using the TIPS-Treasury Premium as a dependent variable we collapse the data down

[8]See Krishnamurthy (2002) and Longstaff (2004) for more on the on-the-run/off-the-run and Refcorp-Treasury spreads, respectively.

to end-of-month values. We plot the time series of the monthly TIPS-Treasury Premium in Panel A of Figure 3.

Note that changes in realized or expected inflation should not have any directional impact on this measure of the convenience yield: the dependence of TIPS payouts on the inflation rate is hedged away using swap rate data. Indeed, Fleckenstein et al. (2014) provide evidence against the view that the TIPS-Treasury premium reflects mispricing in the inflation swap market by showing that real and nominal corporate bond prices constructed using identical methodology do not exhibit corresponding price disparities. They also discuss the potential impact of credit risk, tax differences, trading costs, and a bevy of other aspects on the dynamics of the TIPS-Treasury premium.[9] Finally, note too that the prices of TIPS themselves might incorporate some degree of convenience which would imply our measure understates the true level of convenience yield.

1.B Other Proxies of the Convenience Yield

In addition to the 10-year TIPS-Treasury premium we employ seven alternative proxies for the Treasury convenience yield, both at shorter and longer maturities. We collect details about variable construction and data sources in Appendix Table A1 and provide a high-level overview here. Most of these variables are constructed on the daily level and collapsed to end-of-month values. We plot all the series described below in Appendix Figure A1.

Our second proxy for Treasury convenience yield is the spread between Treasury yield and the equivalent maturity risk-free interest rate implied by put-call parity on options contracts (the "box rate"). We use the USD convenience yield, labeled "Box USD", as calculated in van Binsbergen et al. (2022) and updated in Diamond and Van Tassel (2021).

Our third proxy for the convenience yield is the spread between three-month General Collateral (GC) repo contract rates and the three-month Treasury bill rate, labeled "GC-Tr 3m". This measure has been widely used in the literature as a proxy for the short-term convenience yield as the GC repo contract is devoid of credit risk but is less liquid than Treasury bills, for instance see Gorton et al. (2022). The fourth proxy for the convenience yield is the spread between the effective Fed funds rate and the three-month Treasury Bill rate, denoted "FF-Tr 3m", again seeking to capture the special value attributed to Treasury Bills over alternative safe short-term investments.

The fifth proxy is the negative of the Z-spread, constructed after Greenwood et al. (2015). These authors measure the yield difference of n month maturity Treasury Bills from the fitted yield curve of Gürkaynak et al. (2007) and call the gap the n-month Z-spread. We follow their methodology by

[9] There is a potential bias on the TIPS-Treasury premium that stems from the contractual features of TIPS: these bonds pay a variable inflation coupon, but in the event of deflation the inflation coupon payment is bounded below at zero. This means that TIPS prices incorporate a put premium if the distribution of the future price level includes deflationary outcomes. For that reason, a shift away of the probability mass from deflationary outcomes, such as that in 2021 and 2022, would have the impact of reducing TIPS prices, hence increasing TIPS yields and, everything else equal, increasing our proxy of the Treasury convenience yield. As discussed in detail below, directionally this effect goes *against* our findings regarding the relationship between the TIPS-Treasury premium and inflation. Note too that recent work in Dittmar et al. (2019) documents a link between U.S. default risk and the TIPS-Treasury premium, a result we discuss further in Section 2.D.

calculating the average Z-spread of Treasury bills with 4 to 26 weeks until maturity. In contrast to Greenwood et al. (2015) we report the negative of the difference between the T-bill rate and the fitted yield curve, so that higher values of the Z-spread correspond to higher levels of convenience. We emphasize this distinction by calling the measure "-1*Z-Spr.". One benefit of the FF-Tr spread and the Z-spread is that they can be constructed going back to the 1970s.

Our sixth proxy for the convenience yield is the 30-year LIBOR Overnight Indexed Swap (OIS) spread, denoted "Libor Spr.". Interest rate swaps are one of the largest derivative markets and the literature has interpreted the swap spread as a proxy for the Treasury convenience yield. In particular, Feldhütter and Lando (2008) decompose swap spreads into a credit risk component, a swap market specific component, and the Treasury convenience yield, with the estimated convenience yield representing the majority of the gap. In recent data swap spreads have been negative, suggesting potential Treasury "inconvenience", for instance see Du et al. (2023). Despite this finding, we include the LIBOR swap spread in our baseline set, noting that the variation in this proxy can reflect convenience yield changes even if its level is negative.

The seventh proxy, "FN-Tr", is the spread between Agency MBS and Treasury yields, established as a Treasury convenience by He and Song (2022). These authors construct an MBS convenience yield with respect to AAA corporates, adjusting for both duration mismatch, as well as the value of the prepayment option in MBS. The eighth and final proxy is the Treasury richness measure from recent work in Fleckenstein and Longstaff (2024). This measure, denoted "Rich.", discounts the promised cash-flows of Treasuries using OIS linked to GC repo rates (and other swap curves prior to the availability of repo swap rates).

All of these proxies are effectively devoid of default risk by employing securities that have implicit or explicit government guarantees or are fully collateralized. Our preferred measure, the TIPS-Treasury premium, stands apart in that it is available at long maturities and both legs of the construction are backed by the U.S. Treasury, hence having the exact same regulatory treatment. In later sections we additionally use measures of the Treasury convenience yield that employ corporate security prices, described in detail in Section 3.C.

1.C Decomposition of the Stock-Bond Covariance

Our first main result is a new decomposition of the aggregate stock-bond covariance. To this end, we break down the nominal Treasury yield into three constituent elements: the convenience yield, proxied by the TIPS-Treasury premium, the default rate, proxied by the CDS rate,[10] and a residual term, which we call the "frictionless" risk-free rate, meaning the part of the yield not owing to default risk or the convenience yield.

Formally, let Treasury $\text{Yield}_{t,n}$ be the time t, maturity n nominal yield, let $\text{CDS}_{t,n}$ denote the corresponding CDS rate, and let $\text{Premium}_{t,n}$ stand for the TIPS-Treasury Premium, a proxy for the convenience yield. We can then back out the Frictionless $\text{Risk-free}_{t,n}$ term from the following

[10]See Chernov et al. (2020) for a quantitative analysis of U.S. CDS rates.

equation

$$\text{Treasury Yield}_{t,n} = \text{Frictionless Risk-free}_{t,n} + \text{CDS}_{t,n} - \text{Premium}_{t,n}. \tag{3}$$

In tables and figures we abbreviate the Treasury Yield as "Tr", the Frictionless Risk-free as "Rf" and the Premium as "Prem." We report the summary statistics of these variables in Panels B and C of Table 1: the average Frictionless rate is within five basis points of the Treasury yield and the standard deviations of the two are similar as well. Decomposing the 10-year nominal yield according to Equation (3), we calculate the stock-bond return covariance with returns implied by each of these constituent parts of the yield. To maintain easy comparability with the benchmark stock-bond covariance calculation, we transform each of these component yield changes into implied returns, assuming a duration of 10:

$$\begin{aligned} R_{t,10}^{\text{Frictionless Risk-free}} &= -\,10 \times \Delta\text{Frictionless Risk-free}_{t,10} \\ R_{t,10}^{\text{CDS}} &= -\,10 \times \Delta\text{CDS}_{t,10} \\ R_{t,10}^{\text{Premium}} &= \quad 10 \times \Delta\text{Premium}_{t,10}. \end{aligned} \tag{4}$$

Note that the change in $\text{Premium}_{t,10}$ is multiplied with 10, rather than -10, as that term enters the yield decomposition in Equation (3) with a negative sign. These three implied bond return components in turn allow us to decompose the aggregate stock-bond return covariance (we drop the time and maturity subscripts for ease of reading):

$$\begin{aligned} \text{Cov}(R^{\text{Bonds}}, R^{\text{Stocks}}) = \text{Cov}(R^{\text{Frictionless Risk-free}}, R^{\text{Stocks}}) &+ \text{Cov}(R^{\text{CDS}}, R^{\text{Stocks}}) \\ &+ \text{Cov}(R^{\text{Premium}}, R^{\text{Stocks}}). \end{aligned} \tag{5}$$

Our convention in constructing these three constituent covariances ensures that negative covariance values always mean that returns stemming from that piece of the yield reflect a hedge with respect to stock market returns. One complication in interpreting this calculation is that the duration of a portfolio of a zero-coupon bond and default protection is stochastic: in the event of a default the terminal cash-flow is paid out early. For that reason, changes in CDS rates always correspond to changes in duration of the CDS payout. In the context of our decomposition in Equation (4), an increase in the CDS rate would bring about a shortening of the duration, hence the multiplication with 10 in the right-hand-side decomposition would tend to somewhat overstate the contribution of CDS rates to bond returns. The magnitude of such an effect is likely to be quite small in the context of U.S. Treasuries where the unconditional default rate is low: assuming a risk-free rate of 2%, a CDS rate of 30bps, and a 30% loss given default (the value used in Chernov et al. (2020)), a two standard deviation daily shock to the 10-year CDS rate starting from the in-sample mean value would see the duration of the CDS contract decrease only by .01 years. Because of the quantitatively small importance of this effect, we ignore stochastic duration calculating our decomposition, though noting it could have a quantitatively important role in contexts with higher default probabilities.[11] A final complication facing this decomposition is potential staleness in CDS quotes. For instance, Boyarchenko and Shachar (2020) find a decreasing amount of "risk-forming" transactions in which participants take change their risk exposures in the CDS market while Klingler and Lando (2018) argue that safe sovereign debt CDS rates are affected by regulatory frictions. Any such staleness relative to the true default risk would tend to attribute the default risk variation to the frictionless risk-free rate instead.

Panel A of Table 1 reports summary statistics for these three constituent terms of the aggregate stock-bond covariance in the monthly sample from 2005 to 2023. We find that both the covariance stemming from the frictionless risk-free rate as well as the Treasury premium contribute to the overall hedging properties of the long bond. The averages of the convenience yield and frictionless risk-free rate parts are both negative with means of -.19 and -.29, respectively, and have similar standard deviations of .91 and .81, respectively. The covariance component stemming from innovations to CDS rate has a mean of .06 and contributes much less to the variation of the stock-bond comovement with a standard deviation of .18. The covariance component corresponding to CDS innovations likewise has the expected sign, to the extent increases in default probability coincide with poor stock market realizations.

The time-series of the stock-bond covariance calculated with innovations to the convenience yield is plotted in Panel B of Figure 2. For comparison we also include the full stock-bond covariance using the 10-year nominal Treasury prices. As the figure shows, a substantial amount of the aggregate variability stems from the convenience yield component: note the substantial spikes during the GFC, during the Eurozone crisis, and most recently, during the onset of the Covid pandemic. Indeed, in November 2008, at the height of the GFC, the hedging properties of the nominal Treasury – summarized in the stock-bond covariance – were entirely accounted for by the convenience yield term, with no contribution from the frictionless risk-free rate.

Nevertheless, for most of the 2005-2023 sample both the covariance terms corresponding to the Treasury convenience yield and the frictionless risk-free rate have contributed to the bond being a hedge to stock market returns. Both components have a positive correlation with the aggregate stock-bond covariance. In Online Appendix Table OA1 Panel A we document that the correlations with the aggregate stock-bond covariance are .64 and .43 respectively for the covariance terms corresponding to the convenience yield and the frictionless risk-free rate, indicating that these two components explain 42% and 20% of the variation in the aggregate covariance. In contrast, the correlation of the term corresponding to CDS innovations with the aggregate covariance is $-.20$. The aggregate covariance and the covariance corresponding to convenience yield show similar amounts of persistence: .65 in the monthly data as reported in Online Appendix Table OA1 Panel B.

In all, the descriptive results in this section document that the convenience yield is an important driver of the aggregate stock-bond covariance. Even though the existence of Treasury convenience yields is well established in the literature, it is not a foregone conclusion that the covariance between

[11] See Fleckenstein and Longstaff (2024) Section II for more on the stochastic duration of Treasury bonds.

stock and bond returns stemming from the convenience yield is substantial, or that it has a negative sign. Indeed, a sizable but stable convenience yield would see no stock-bond covariance emanating from this part of the Treasury yield.

2 Convenience Yield and the Stock-Bond Covariance

In this section we establish our second main result: the level of the convenience yield is high precisely when Treasuries represent a good hedge to stock market returns, as proxied by a low covariance of Treasury and stock market returns. What is more, a good part of this effect stems from the covariance of convenience yield innovations with stock market returns.

2.A Analytical Setup

We first outline the steps to establish this prediction analytically, while relegating the details to Appendix OA.A. Consider a zero-coupon bond with a safe terminal payment at time T that affords its owner a potentially time-varying convenience flow in each period prior to the maturity date. Such convenience flows are not directly observable, but the present value of the bond reflects the terminal payment, as well as the value of the expected future convenience flows. Our claim is that the discounting of such future convenience flows reflects a substantial risk adjustment because the convenience flows tend to be high in states with poor aggregate realizations. In other words, the price of the bond with convenience flows does not just reflect the expectation of such non-pecuniary benefits, but also a premium for a predicted increase of the non-pecuniary benefits in bad states. The effect we are interested in is therefore distinct from a negative bond beta that would arise whenever interest rates are procyclical.

Because any convenience benefits are not observable we cannot directly associate convenience flows with aggregate risk. We can, however, calculate the returns on a bond that conveys such future convenience flows, and associate the returns with stock market returns. Specifically, employing the standard Campbell and Shiller (1988) decomposition, the time $t+1$ return innovation (denoted sr_{t+1} for surprise return) on a bond with convenience flows is given by:

$$sr_{t+1} = (\mathrm{E}_{t+1} - \mathrm{E}_t) \left[\sum_{j=1}^{T-1} \rho^j [(1-\rho) k_{t+j+1} - r_{t+j+1}] \right], \tag{6}$$

where k_t and r_t are the log convenience flow and the log expected return in period t, respectively, and ρ is a constant that depends on the unconditional level of the convenience yield. In words, the surprise return on the bond with convenience flows equals the innovation to the discounted value of the expected convenience flows, minus the innovations to expected returns.

Part of the surprise return in Equation (6) are innovations to the present value of the terminal payment at time T. To isolate the effect of convenience flows, we subtract out returns on a maturity T bond that conveys no such non-pecuniary benefits. Applying a Campbell and Shiller (1988) return decomposition to a bond without convenience flows, and the dividend yield set to equal the expected level of convenience flows, the surprise returns at time $t+1$ are simply:

$$sr_{t+1}^{f,T} = (\mathrm{E}_{t+1} - \mathrm{E}_t)\left[-\sum_{j=1}^{T-1} \rho^j r_{t+j+1}^{f,T}\right], \tag{7}$$

where $r_{t+j+1}^{f,T}$ stands for the return on a safe claim on a time T cash-flow and ρ is the same log-linearization constant than in Equation 6. With these two surprise returns in hand, we can calculate the portion of returns that are not on account of changes to the present value of the terminal payment as

$$\begin{aligned} sr_{t+1} - sr_{t+1}^{f,T} &= (\mathrm{E}_{t+1} - \mathrm{E}_t)\left[\sum_{j=1}^{T-1} \rho^j [(1-\rho)k_{t+j+1} - r_{t+j+1}] - \sum_{j=1}^{T-1} \rho^j r_{t+j+1}^{f,T}\right] \\ &= (\mathrm{E}_{t+1} - \mathrm{E}_t)\left[\sum_{j=1}^{T-1} \rho^j [(1-\rho)k_{t+j+1} - rp_{t+j+1}]\right], \end{aligned} \tag{8}$$

where rp_t stands for risk premium, defined as the gap between returns on the bond with convenience flows minus the return on the bond without such flows.

The formulation in Equation (8) captures the key object we are interested in: the innovations to expected convenience flows, and the associated risk premia. With an empirical proxy of this quantity we are able to estimate the covariance between innovations to convenience flows, inclusive of risk premium innovations, and market returns:

$$\mathrm{Cov}_t\left(sr_{t+1} - sr_{t+1}^{f,T}, r_{t+1}^M\right). \tag{9}$$

Our main prediction is that this conditional covariance explains the time-variation on the level of convenience yields, as it captures the risk adjustment that contributes to the present value of each of the convenience flows:[12]

$$\text{Convenience Yield}_t \cong -\Lambda\,\mathrm{Cov}_t\left(sr_{t+1} - sr_{t+1}^{f,T}, r_{t+1}^M\right). \tag{10}$$

This analysis faces two complications. One, existing literature has documented a strong relationship between the level of the risk-free interest rate and the level of the convenience yield, see Nagel (2016). For that reason, we include the level of the risk-free interest rate as a control variable in our benchmark specifications. Two, we are able to estimate the high-frequency conditional covariance with innovations to the convenience yield only in the post 2005 data. For that reason we use the aggregate stock bond covariance as a stand-in in the longer sample, still finding evidence of the

[12] There are other ways to reach a similar prediction. For instance, within the framework of Acharya and Pedersen (2005) we can conceptualize the return gap between the two bonds–one with convenience flows and the other without–as a liquidity premium. In their setup, the expected level of such liquidity premium would be primarily determined by the covariance of the realized premium with market returns $\mathrm{E}[\text{Premium}] \cong -\lambda\,\mathrm{Cov}(\text{Premium}, R_M)$.

relationship between the hedging properties of Treasuries and the level of the convenience yield. In other words, in the longer sample we use the surprise returns as given in Equation (6) to calculate the covariance.

Finally, we have modeled convenience yield as an unobservable cash-flow accruing to the holder of the bond. Recent literature has frequently captured the convenience yield as a "wedge" in the investor's Euler equation, see Jiang et al. (2021). Such a formulation is essentially identical to the one used in this paper. To see the equivalence, start with the Euler equation for the return r_{t+1} on a bond that earns a convenience yield. The "wedge" formulation of the convenience yield is:

$$\mathrm{E}_t[\exp(m_{t+1} + r_{t+1})] = \exp(-\lambda_t) < 1$$

where m_{t+1} is the SDF and λ_t the convenience yield prevailing at time t. In words, the return on the security with convenience flows is low, such that the Euler equation is below 1 by the amount of $-\lambda_t$. Moving the term λ_t over to the left-hand-side results in

$$\mathrm{E}[\exp(m_{t+1} + r_{t+1} + \lambda_t)] = 1$$

and the quantity $\{r_{t+1} + \lambda_t\}$ can be thought of as the total return (the with-dividend return) on the bond, comprised of the capital gains term, and dividend yield that stems from the unobservable convenience flow.

2.B Baseline results

Our baseline results document a strong association between the level of the Treasury convenience yield and the aggregate stock-bond covariance. In Panel A of Table 2 we report monthly regressions in the 2005 to 2023 sample of eight distinct measures of the convenience yield on the monthly stock-bond covariance using the 10-year zero-coupon nominal Treasury return and controlling for the effective Fed funds rate. (We indicate the time span for convenience yield proxies that are not available for the full period.) We find negative relationships throughout, statistically significant at the 10% level for all, and significant at the 5% level for all but two of the convenience yield proxies.

The estimated effect size is large: a one standard deviation decrease in the aggregate stock-bond covariance (about .90) corresponds to a half standard deviation increase of the 10-year TIPS-Treasury premium. Similar magnitudes obtain for the other convenience yield proxies. We estimate positive coefficients on the effective Fed funds rate, consistent with the findings of Nagel (2016) regarding the positive relationship on convenience yields and the level of the short-term risk-free rate.

Panel B of Table 2 repeats the same analysis but extends the sample beyond 2005. Because of data availability we lose the TIPS-Treasury, Box yield, and Fannie MBS measures in the samples starting before 2005. The LIBOR Spread and Treasury Richness measures go back to 1996 and we find negative relationships with the stock-bond covariance very much in line with the corresponding baseline estimates. The GC Repo - Treasury spread can be constructed starting in May 1991 and in that extended sample it shows a negative correlation with the stock-bond covariance, as do the Fed funds-Treasury spread and the negative of the Z-spread. Finally, pushing the start date back to 1972 we a strong negative relationship for the Fed funds-Treasury spread, but a statistically insignificant one for the Z-spread. Overall, the longer lookback windows reinforce the message from Panel A of Table 2. In the longer lookback windows controlling for the level of the short-term risk-free rate is particularly important and the coefficient is positive for all the convenience yield proxies with the exception of the Z-spread.

Our principal empirical finding is reported in Table 3. Here we decompose the aggregate stock-bond covariance into three constituent parts in keeping with Equation (5). The decomposed stock-bond covariance allows us to directly test our hypothesis: the covariance of stock returns with the convenience yield itself contributes to the level of the convenience yield. We find results exactly in line with the hypothesis: the first column shows that the strong negative relationship between the TIPS-Treasury spread and stock-bond covariance is mostly on account of the covariance between the Treasury premium and the aggregate stock market. In terms of magnitudes, a one standard deviation decrease in the stock-bond covariance estimated from the Treasury premium corresponds to a .6 standard deviation (9 basis points) increase in the 10-year TIPS-Treasury premium. By contrast, the estimated coefficient on the frictionless risk-free rate covariance with the stock market is only .01, while the standard deviations of these two main parts of the stock-bond covariance are of comparable magnitude: .91 and .81 respectively. The impact of the third component, corresponding to the covariance between stock returns and default risk, varies more across specifications. A one standard deviation decrease in the Cov(CDS 10y, St.) term corresponds to a 4 basis point drop in the TIPS-Treasury premium.

Regressions estimated with alternative proxies of the Treasury convenience yield convey the same message and confirm the spirit of Equation (10): the negative relationship between the level of the convenience yield and the stock-bond covariance arises primarily from the covariance component stemming from Treasury convenience yield, an effect that is both economically and statistically significant for all eight proxies of the convenience yield as the dependent variable.

The second row of the table documents that the frictionless risk-free rate has a generally negative relationship with the level of convenience yield proxies, but the statistical strength of these relationships varies greatly across proxies. The third row of the table documents that the relationship between convenience yield proxies and the covariance term owing to default risk innovations is less clear-cut than the other two constituent elements, both in magnitude as well as in sign. We return to the statistical significance and economic interpretation of these last two findings using principal components analysis.

2.C Principal Component Construction

Our baseline results document a negative relationship between the stock-bond covariance and the level of eight different proxies of the convenience yield. These proxies differ in maturity, ranging from 3 months to 30 years, as well as other features such as the issuer and the balance sheet treatment of the securities involved. Despite these differences, the regression results suggest a substantial common component and the correlation matrix of the proxies confirms a strong commonality. As reported in Panel A of Online Appendix Table OA2, nearly all the pairwise correlations are positive as well as statistically significant, with point estimates above .4 for many of the pairs.

Such commonality suggests the use of a combined convenience yield proxy in place of the individual variables, with the hope that in the combined proxy some of the asset-specific variation is diversified away. To this end, we estimate the first principal component of the proxies used in Table 2 and denote it PC1.

We estimate PC1 separately in two samples, starting in May 1991 and starting in January 2005, reflecting availability of the different proxies. In the 2005-2023 sample we use all of the proxies in Panel A of Table 2 except Box USD which is only available until July 2020. The Fleckenstein and Longstaff (2024) 10-year Treasury Richness measure is only available through the end of 2022 and in order to include it in the PC we project its value to 2023 using the 10-year OIS Spread (the two series have an in-sample correlation of 64%). The resulting principal component PC1 is plotted in Panel A of Figure 3. As the figure shows, there is a substantial commonality with the 10-year TIPS-Treasury Premium and in Online Appendix Table OA2 we document the betas of PC1 with respect to the eight convenience yield proxies. We find strong correlations throughout, with the correlation coefficient between the 10-year TIPS-Treasury Premium and PC1 being second-to-lowest, only above the correlation coefficient of the Z-Spread. Notably, the 2-year Box Spread, not included in the PC1 construction due to lack of availability past 2020, is strongly positively correlated with PC1, and the R^2 in the univariate regression is 68%.

In the May 1995-2023 sample we are able to use the three short-term convenience yield proxies: GC-Treasury spread, FF-Treasury spread, and the Z-Spread, to construct PC1, again finding that Z-Spread has the weakest correlation with the estimated first principal component.

In the 2005-2023 sample we also construct two separate principal components for short- and long-maturity convenience yield proxies. The construction of these two series follows that of PC1 in the same period, with the three proxies with under one-year maturity making up "Short PC1", and the other four proxies making up "Long PC1". Online Appendix Table OA3 documents the loadings of these two principal components on all the convenience yield proxies. By construction, Short PC1 sees stronger correlations with its constituent proxies, and ditto for Long PC1. All the while, even the long-term proxies all have statistically significant positive correlations with the short-term PC1, emphasizing a common factor. A graph of these two series in Panel B of Figure 3 further suggests that the two series track one another closely until 2015 and see periods of substantial divergence since then. In subsequent analysis we analyze the convenience yields at different maturities and link them to the corresponding stock-bond covariance measures.

2.D Additional Analysis of Main Results Using PC1

In Table 4 we use the first principal component of convenience yields, PC1, to carry out a variety of robustness checks of the main analysis. In the first column we document a strong negative relationship between the level of PC1 and the aggregate stock-bond covariance. The standard deviation of PC1 is 1.68 so the coefficient of -.72 indicates that a one standard deviation increase in the stock-bond covariance corresponds to about two fifths of a standard deviation decrease in the convenience yield, an estimate in line with the proxy-by-proxy regressions detailed above. The plot of the convenience yields in Figure 3 Panel A suggests an elevated convenience yield during the Global Financial Crisis. To establish that the results do not just reflect dynamics during the crisis, we include a dummy variable for the Global Financial Crisis years 2008-09 as well as an interaction term with the covariance term corresponding to convenience yield innovations. We find that while the crisis dummy absorbs some of the variation in the first principal component, the relationship between stock-bond covariance and the level of the convenience yields is in fact larger than in the baseline and statistically significant at the 5% level. This strong relationship is illustrated in Panel A of Figure 4.

In the third column we include all the constituent elements of the aggregate stock-bond covariance. Consistent with the results employing individual convenience yield proxies, we find that the relationship with the covariance term corresponding to the convenience yield is stronger than in the baseline specification with an estimated coefficient close to -1, indicating that a one standard deviation increase in the covariance term representing convenience yields sees over half a standard deviation drop in PC1. We also find a statistically significant relationship with the covariance term representing the Frictionless risk-free rate. What could underlie this empirical finding? The simplest explanation is that prices of TIPS themselves reflect some measure of convenience flows, and the frictionless risk-free rate covariance hence reflects a similar dynamic as we have outlined in the analytical setup in Section 2.A.

The final three columns of Table 4 carry out further robustness analysis. In the fourth column we re-estimate the main specification controlling for the VIX in order to establish that the relationship between the convenience yield and the stock-bond covariance does not just reflect changes in market-wide volatility.

Columns five and six control for the level of CDS and the level of inflation expectations. These controls are motivated by two strands of recent literature. Firstly, Dittmar et al. (2019) argue that the TIPS-Treasury premium can be accounted for by default risk. To the extent TIPS and nominal Treasuries represent a different default risk—owing to differential recovery rates, relative pricing of real and nominal payoffs in the default state, or dependence of inflation rates on the default event—the TIPS-Treasury spread could be driven by shocks to creditworthiness of the U.S. Motivated by their findings we include the 2- and 10-year CDS rates as control variables to ensure that the documented relationship is not accounted for by the level of default risk. (We separately check that the regressions in Table 2 remain after controlling for CDS rates.) Secondly, recent work in Cieslak et al. (2023) and Li et al. (2022) has established an important role of inflation expectations on convenience yields. To account for the potential direct impact of expected inflation we include the 2- and 10-year expected inflation series produced by the Cleveland Federal Reserve bank.

We find that our results are robust to both sets of control variables: the coefficients on the covariance term representing convenience yield innovations and the frictionless risk-free rate are both larger than in the baseline. In line with the results in Nagel (2016), the coefficients on expected inflation are positive and soak up some of the contribution of the Fed funds rate. More importantly for our purposes, though, the coefficients on the covariance term corresponding to convenience yield innovations are left essentially unchanged.

The structure of Table 5 closely reflects the prior Table 4 but extends the sample back to May 1991. In this longer sample we lose the covariance breakdown into constituent elements as well as the measures of default risk, leading to an abbreviated version of the prior table. In the longer sample we are also limited to the PC1 that uses only short-term convenience yield proxies. Still, we find results in keeping with the most recent sample. The stock-bond covariance has a strong negative association with the level of the convenience yield, and this relationship remains when interacting with the Global Financial Crisis dummy and when controlling for the VIX or expected inflation at different maturities.

2.E Maturity-specific Effects

The plot of Short and Long PC1 in Panel B Figure 3 highlights a divergence in the convenience yield proxies since the second half of 2010s. Such an erosion of longer-term convenience yields has been noted before, for instance see Du et al. (2018) or Du et al. (2023). The analytical framework outlined in Section 2.A provides one potential angle to see this development: our framework suggests that the convenience yield at any given maturity should depend on the convenience flows accruing over the life of the bonds, and the risk-adjustment applied to such flows. Our framework suggests, then, that the difference in short- and long-maturity convenience yields could stem from the associated stock-bond covariance terms.

We study this prediction by constructing stock-bond covariance using shorter maturity zero-coupon bonds. In particular, we follow the construction described in Section 1 and calculate the stock-bond covariance using 2- and 5-year Treasury returns. For ease of interpretability, we multiply the 2-year covariance with 5 and the 5-year covariance with 2, ensuring that these measures have the same scale as the 10-year stock-bond covariance. The summary statistics for these two measures are reported in Panel F of Table 1.

In Table 7 we estimate regressions of both Short and Long PC1 on the different maturity stock-bond covariance measures. The first three columns show that for the short-term convenience yields are particularly exposed to the two-year stock-bond covariance. While we find a statistically significant negative relationship throughout, the two-year stock-bond covariance explains a higher share of the variation in Short PC1 than the ten-year covariance: 27% *versus* 17%.

The pattern for the long-horizon proxy Long PC1 is less clear. Across different maturity stock-bond covariance measures, the five-year stock-bond covariance has the highest explanatory power over this convenience yield proxy, with both the two- and ten-year covariances seeing lower R^2s. Overall, the results in the table emphasize a strong sense of commonality in the three different maturity stock-bond covariance measures, and perhaps a special role for short term convenience yields.

Indeed, the findings in Table 7 suggest that the relationships we document can offer an alternative perspective on the increasing "inconvenience" of longer-term Treasuries. In Table 8 we document the conditional averages of the stock-bond covariance measures. The first three columns report regressions of the 2-, 5-, and 10-year Treasury covariance with stock returns on dummies representing the post-2011 and the post-2021 periods. We find that the increase in stock-bond covariances post-2021 data is particularly pronounced for the 10-year calculation, with the coefficient on the relevant dummy variable being more than twice that of the 5-year calculation and more than five time larger than that of the 2-year calculation. (Note that for level shifts in the yield curve the 10-year covariance measure would be equal to twice the 5-year covariance and 5 times the 2-year covariance.) In this way the link between stock-bond covariance and convenience yields that we document can account for a part of the decrease in long-term convenience yields.

Standard yield curve models would suggest a substantial common element in convenience yields across maturities. To give an extreme example, consider a frictionless yield curve and a time-varying convenience flow that only accrues to, say, the ten-year zero-coupon bond. In this (unrealistic) set-up, one would still expect to see positive convenience yields percolate throughout the term structure. Any investor who does not benefit from the convenience flows directly would look to substitute away from the ten-year to other maturities, in this way ensuring that the yields at other maturities are affected as well. In other words, unless investors have extreme preferences for a given maturity, "local" convenience flows at any given maturity could affect the entire yield curve. Given the strong factor structure in interest rates, a common element in convenience yields is therefore to be expected.

The above simple example also illustrates the difficulty in attributing the drivers of the convenience yield to any specific source. Consider a formulation of the convenience yield of maturity i at time t as a function of maturity-specific supply $Q_{i,t}$, maturity-specific safety demand $X_{i,t}$ and an asset-class level specialness of Treasuries λ_t:[13]

$$\text{Convenience}_{i,t} = \lambda_t v(Q_{i,t}, X_{i,t}).$$

To the extent it is possible to identify supply or demand shifters—for instance around announcements of Quantitative Easing purchases or through different investment mandates—this formulation suggests a potential decomposition of the convenience yield variation into underlying drivers. At the same time, the factor structure of the yield curve complicates any such analysis by inducing a strong response to supply and demand effects of other maturities. With that caveat in mind, we interpret our findings as operating primarily via the common component in convenience yields λ_t. Nevertheless, our finding that there is a distinct short-term convenience yield component with a stronger relation to the short-term bond covariance with the stock market (compared to that of longer-maturity bonds), even as there is a common component of convenience yields across

[13]We thank Arvind Krishnamurthy for suggesting this framework.

short-term and long-term maturities, offers one avenue for future study of the term structure of convenience yields.

2.F Alternative Decompositions of Stock-Bond Covariance

The analysis in this section has used the innovations in the TIPS-Treasury premium to back out the stock-bond covariance stemming from convenience yield innovations. We have shown that this part of the stock-bond covariance is particularly strongly related to the level of the convenience yield. A potential concern, however, is that the decomposition reflects in large part factors idiosyncratic to the TIPS-Treasury premium, such as potential price pressure in the inflation swap market, or illiquidity in the TIPS market.

In order to provide a sense of robustness to such decomposition of the stock-bond covariance we use two alternative proxies of Treasury specialness that have reliable daily data available: the 10-year Treasury Richness form Fleckenstein and Longstaff (2024) and the 10-year OIS Swap spread. With both of these measures of specialness we calculate the stock-bond covariance stemming from convenience yield innovations, following the same procedure than for the baseline Cov(Prem. 10y, St.) measure described in Section 1.C. With these covariance measures in hand, we use the aggregate stock-bond covariance to back out the residual stock-bond covariance.

In Table 6 we document the relationship between these alternative decompositions of the stock-bond covariance and PC1, the first principal component of the convenience yield proxies. The first column reports, for reference, the relationship between the aggregate stock-bond covariance and PC1. In line with the disaggregated results from before, we find a statistically and economically significant link between stock-bond covariance and convenience yields. A one standard deviation increase in the stock-bond covariance sees about a one half standard deviation drop in the convenience yield. The second column shows the breakdown between the part of the stock-bond covariance representing convenience yield innovations, and the residual term, emphasizing that both have a statistically significant negative relationship with the level of the convenience yield.

The third column shows that a close pattern emerges using the Treasury Richness proxy to carry out the covariance decomposition. We again find that the stock-bond covariance term representing convenience yield innovations has a coefficient of -1.4, meaning that a one standard deviation drop in Cov(Rich. 10y, St.) corresponds to about a third of a drop in the convenience yield. The residual stock-bond covariance also sees a substantial effect: a one standard deviation increase corresponds to a little more than a third standard deviation drop in convenience yields.

Finally, in the fourth column we document that the decomposition based on the 10-year OIS Spread sees a similar quantitative effect, with both the convenience yield term and the residual seeing statistically significant negative relationships with the aggregate convenience yield. In all, the results in Table 6 provide a sense of robustness to our baseline decomposition that uses the TIPS-Treasury premium, and suggest that TIPS-specific factors are unlikely to be the main driver of the results.

3 Alternative Stock-Bond Covariance Calculations and Alternative Convenience Yield Proxies

Our focus on the hedging properties of Treasuries requires measuring the conditional covariance between Treasuries and the aggregate stock market. While the theoretical object of interest is made clear in the analytical framework developed in Section 2.A, we face a number of potentially meaningful empirical choices in our implementation. In this section we show that our main results are robust to a variety of permutations of the underlying data construction.

3.A Alternative Stock and Bond Returns

In the first set of robustness checks we explore alternative measures of stock and bond returns. In Panel A of Table 9 we re-estimate the regressions of the first principal component, PC1, on alternative measures of the stock-bond covariance. We carry out the analysis in our two main samples: 2005 to 2023 and 1991/5 to 2023.

In the first alternative covariance calculation we replace the 10-year bond return from Gürkaynak et al. (2007) with the return implied by the fitted yield curve of Liu and Wu (2021) which is designed to better capture various maturity-specific effects, and could thus incorporate important additional variation over and above the curve used in the baseline. We find, however, that for the purposes of the stock-bond covariance these differences matter little both in terms of the implied sensitivity of convenience yields, or the amount of PC1 variation explained.

For the second alternative we go a step further and use actual traded bond returns. We construct a daily return series for the most recently issued ten-year Treasury using the CRSP daily Treasury file. We switch the return series to the new ten-year bond on the first day for which a return is available. Unlike the prior, fitted yield curve based calculations, this return series represents an actual tradeable portfolio. The estimated relationship between PC1 and the stock-bond covariance, however, is again very close to the baseline estimates. For the third alternative we consider a broader stock index: the MSCI World Index return. Again we document a relationship very close to the baseline in both samples, suggesting that the hedging properties of the U.S. Treasury against global equity risk could be driving some of the effect (also note that the returns on the CRSP value-weighted portfolio and the MSCI World Index are highly correlated with a correlation coefficient above .91 in the post 2005 sample).

3.B Alternative Look-back Windows

Another practical choice necessary for our analysis concerns the length of the lookback window in calculating the stock-bond covariance. With shorter lookback windows we are more likely to capture the true conditional covariance in the period at hand which might be particularly important during times of sudden changes in the economic environment, such as around the Global Financial Crisis, or the Covid pandemic. Longer lookback windows, in contrast, might pick up dynamics that are no longer relevant at the end of the period. At the same time, short lookback windows are subject to being unduly influenced by outlier returns, introducing noise into the measure. Similarly, times of market distress might see substantial short-term reversals in stock or bond returns, which motivated our use of three-day returns as described in Section 1.

In the baseline calculations we used a 30 trading day lookback window and we replaced daily returns with the sum of three most recent daily returns, divided by the square root of three. In Panel B of Table 9 we establish robustness with respect to these choices. In the first and fourth column we instead use single daily returns for the stock-bond covariance calculation. We estimate convenience yield sensitivities very close to the baseline in both samples.

In the second and third columns of both sets we use 60 and 252 trading day lookback windows. To ease interpretation these covariance calculations are annualized just like the baseline measure. We again find robust negative relationships with the level of the first principal component of convenience yield proxies. For instance, in the sample since 2005, the 252-day lookback window stock-bond covariance is -2 with a volatility of .5, indicating about two thirds of a standard deviation decrease in the convenience yield with a one standard deviation drop in the covariance. Overall, the results in Panel B of Table 9 suggest that the choice of a specific lookback window is not driving our results.

3.C Convenience Yields Employing Corporate and Foreign Securities

Our main analysis focused on convenience yield proxies that either directly or indirectly benefit from a government backstop. In this section we establish that relative convenience yields on corporate securities, as well as foreign safe bonds are similarly affected.

In the first four columns of Table 10 we document the dependence of various corporate spreads over Treasuries as a function of the stock-bond covariance. Our first measure is the 90-day P2-rated commercial paper spread to Treasury bills, as used in Krishnamurthy and Li (forthcoming). The second and third measures are the long-term AAA-rated corporate bond spread over long-term Treasuries and the BAA-AAA spread, both studied as a function of total Treasury supply in Krishnamurthy and Vissing-Jorgensen (2012). Finally, we use the Excess Bond Premium (EBP) first constructed in Gilchrist and Zakrajšek (2012) and updated in Gilchrist et al. (2021). The EBP is a measure of corporate bond yield premium that is cleansed of duration mismatch, and that controls for, among other features, prepayment optionality and default risk. This measure, then, seeks to capture the corporate bond yield premium that is not due to default risk. The other proxies, however, do reflect some degree of default spread.

We find that when the Treasury convenience yield covariance with stock returns is low, the gap between corporate and Treasury yields opens up. Both the covariance terms corresponding to the convenience yield and the frictionless risk-free rate contribute to this relationship, with the convenience yield part being the dominant channel. A one standard deviation increase in the convenience yield covariance term corresponds to about 85% standard deviation decrease in the P2 spread, and a 40% standard deviation decrease in the AAA-Treasury spread.

In the final column we document the impact of the stock-bond covariance on the spread between U.S. Treasuries and foreign safe assets. We follow Du et al. (2018) and construct measures of foreign currency sovereign bond convenience yields with respect to U.S. Treasuries. This measure is a close analogue to the convenience yield approximated as the TIPS-Treasury premium: it measures the yield on foreign safe bonds, with the cash-flows swapped into USD, relative to the yield on U.S. Treasuries. Specifically, Du et al. (2018) show that in frictionless markets the relative convenience yield on U.S. Treasuries with respect to a foreign sovereign bond is equal to the foreign yield minus the U.S. yield, minus the forward premium for hedging the foreign currency against the U.S. Dollar.[14] The resulting measure, USD premium, is an equal-weighted average of the U.S. convenience yield over a basket of ten foreign currencies (AUD, CAD, CHF, DKK, EUR, GBP, JPY, NOK, NZD, SEK).

The last column of Table 10 documents a strong negative relationship between the stock-bond covariance term corresponding to the convenience yield, and the U.S. premium over foreign currencies. A one standard deviation increase in the convenience yield covariance term corresponds to about a fifth of a standard deviation decrease in the U.S. premium.

3.D Other Robustness

We relegate the two remaining robustness checks to the Online Appendix. In Table OA4 we re-estimate the baseline Table 2 but lag the covariance measure by one month. The motivation behind this table is to show that the strong relationship between convenience yields and stock-bond covariance is not dependent on measuring both in the same month (recall that our convenience yield proxies are all end-of-month values so there is no mechanical relationship in our baseline estimates). In both panels we find that the negative relationship between the covariance and convenience yield remains quantitatively similar, with some reduction in statistical significance, particularly in the longer samples. This result is to be expected given the persistence of the covariance measures documented in Section 1.C.

On the main analysis we use the stock-bond covariance as the main right-hand-side variable. We motivate this choice in the analytical setup by noting that if the SDF is an affine function of the stock market return, the expected return is proportional to a measure of risk aversion times the covariance between stocks and bonds. In Appendix Table OA6 we instead use the stock-bond correlation, the stock beta of bonds, as well as the associated decompositions into terms representing shocks to the convenience yield, frictionless risk-free, and CDS rates.

We find that the negative relationship between the stock-bond comovements and the level of the convenience yield holds when employing correlation or stock market betas as the right-hand-side variable. In the first two columns of Table OA6 we use the Treasury beta with respect to the stock market, again separating out three terms corresponding to the convenience yield, the frictionless risk-free rate, and the CDS innovations. We find a strong negative relationship between PC1 and the beta corresponding to the convenience yield innovations, as well as the beta corresponding to the frictionless risk-free rate. In the third and fourth column we repeat the analysis with correlation

[14] Du et al. (2018) consider a number of alternative calculations. We follow their calculation that estimates the forward premium using interest rate swaps and basis swaps, see Equation (9) in that paper.

coefficient between stock and bond returns, as well as the correlation coefficients corresponding to the three constituent parts of the 10-year yield. We again find that the correlation coefficients are negatively related to the level of PC1, both for the aggregate bond return, as well as the correlation coefficients corresponding to convenience yield and frictionless risk-free rate innovations. Finally, in the last two columns we show that the negative relationship with betas and correlations obtains in the longer sample starting in May 1991.

4 Discussion

Our main result establishes a connection between the covariance between stock and bond returns and the level of the convenience yield. The theoretical framework sketched in Section 2.A motivates this relationship by capturing the convenience flows in a given period as functions of state variables that also drive equity returns. In this section we briefly discuss various underlying economic forces potentially underlying such time variation in convenience flows.

4.A Potential TIPS-specific Factors

Our preferred decomposition of the stock-bond covariance uses the TIPS-Treasury premium, a measure of relative convenience between two securities issued by the U.S. Treasury. Because these two securities differ little in their balance sheet treatment, and in their default risk we have argued that the price gap between the two is most likely a reflection of the higher convenience yield on the nominal Treasuries.

Another potential driver of the TIPS-Treasury premium could be variation in the relative supply of the two types of securities. In Appendix Figure OA1 we plot the total amount of nominal and real Treasuries outstanding. Two aspects are worth noting: one, the TIPS supply is an order of magnitude smaller than nominal supply, with yearly issuance representing about 5-10% of the total Treasury supply; two, the TIPS supply grows at a steady rate. These two observations suggest to us that fluctuations in TIPS supply are not major drivers of the TIPS-Treasury premium.

There is a possibility that TIPS prices themselves reflect some amount of convenience, which would make our proxy an underestimate of the total convenience afforded by nominal Treasuries. For one look at this question, we compare the "synthetic" nominal Treasury yield, constructed from TIPS and inflation swaps, with the AAA-rated corporate bond yield. We find that in the 2005-2023 sample, the 10-year "synthetic" nominal Treasury yield is 13 bps lower than the Bank of America AAA-rated corporate bond index yield, consistent with a convenience yield on TIPS itself (for reference, the level of the 10-year TIPS-Treasury premium in this period is 25 bps.) That said, there are prolonged periods during which either of the rates is higher: for instance, from 2010 to 2015 the AAA yield was lower than the 10-year "synthetic" nominal rate. We conclude that there is some evidence for the convenience yield of TIPS but it is not as robust as the TIPS-Treasury premium which is positive in every month of the sample.

4.B Debt Ceiling Standoffs

Next, we seek to provide evidence regarding the convenience yield and the stock-bond covariance around two debt ceiling standoffs in the U.S., one in Summer 2011 and the other in Spring 2023. These events are unique in that they represent substantial potential disruptions to the near-term cash-flows and liquidity of Treasuries, while not necessarily calling into question the long-term creditworthiness of the U.S. government. To the extent the convenience yield of Treasuries depends on the ease of re-trading, such events could see substantial increases in the stock-bond covariance and decreases in the convenience yield.

The two panels of Table 11 document the behavior of both short- and long-term convenience yield proxies around these events. We use the 2- and 10-year TIPS-Treasury Premium as well as three versions of a daily first Principal Component of the convenience yield proxies. The three daily PCs are constructed analogously to the monthly PCs described in Section 2.C, with the exception that we do not use the adjusted spread between Agency and Treasury yields as it is only available at the monthly frequency.

In Panel A of Table 11 we document that the 10-year TIPS-Treasury premium, as well as the aggregate and maturity-specific PCs, increased with the resolution of the 2011 standoff on August 1, 2011, when the House of Representatives passed a debt ceiling bill. We use 20 trading days of data before and after the event day in these regressions, resulting in an event window that starts on July 1. Our choice of look-back window length is motivated by the sharp increase in 2-year CDS rates in the first week of July, indicating a material increase about debt ceiling worries. In terms of magnitudes, we see a nearly 9 basis point increase in the 10-year TIPS-Treasury premium, a sizeable amount relative to the unconditional mean of 26 basis points. Similarly, both the short and long PCs increase, with similar economic magnitudes. Only the 2-year TIPS-Treasury premium shows no response in this specification.

Panel B of Table 11 reports the corresponding analysis for the 2023 debt ceiling standoff that was resolved with congressional action on May 31, 2023. We again use 20 trading days before the resolution day as the pre-event window, coinciding with a run-up in the CDS rates at the 1- and 2-year horizons. In these regressions we find that both the 2- and 10-year TIPS-Treasury premium increase on announcement with the 2-year spread increasing by 6 basis points. We also document a positive effect of debt ceiling resolution on the three PCs, though only the long PC1 shows a statistically significant increase.

Overall, these two event studies highlight the importance of sovereign default risk on convenience yields. Further, that both short-and long-term proxies are positively affected—even though the debt ceiling standoff primarily affects the short-term securities—highlights the importance of asset-class level variation (i.e., the presence of a common convenience yield factor in Treasuries) relative to maturity-specific effects.

Finally, in Figure 5, we show a link of these convenience yield results to the constituent elements of the stock-bond covariance. The aggregate stock-bond covariance dropped after the debt ceiling resolution on August 1, 2011, with both the convenience yield component and especially the frictionless risk-free rate component dropping after the event day. As also shown in Figure 5, despite a rise in the U.S. CDS premium in build-up to the crisis date, its covariance with aggregate stock returns is quantitatively too small to explain the pre-resolution fall in the convenience yield.[15]

4.C The Role of Inflation Expectations

Our finding that the time-variation in the convenience yield can materially contribute to the hedging properties of Treasuries additionally suggests a novel channel via which inflation can affect the stock-bond covariance. Prior literature has extensively studied the link between realized and expected inflation shocks and the stock-bond covariance and has attributed the long-term shift from positive to negative stock-bond covariance to changes in inflation dynamics, for instance, see Campbell et al. (2017). Our results open the possibility, however, that inflation also affects the stock-bond covariance via its impact on the convenience yield, particularly the convenience yield component that is driven by hedging properties of bonds. Prior work in Duffee (2018) has argued that inflation volatility can explain only a small part of long-term nominal yield volatility and, more recently, Duffee (2022) has shown that inflation news have historically not been volatile enough to justify the role inflation has been given in accounting for the stock-bond covariance. To the extent inflation news also affect convenience yields, such a channel could offer an additional channel via which inflation affects excess returns of long bonds.

Specifically, our analytic framework emphasizes that the variation in convenience flows is a function of various systematic factors. With respect to inflation, recent literature in Cieslak et al. (2023) has emphasized the tension between two forces in the link between expected inflation and convenience yields. On the one hand, high expected inflation tends to increase convenience yields by virtue of increasing the opportunity cost of holding cash, suggesting a "money" channel positive relationship between expected inflation and Treasury convenience. On the other hand, a "New Keynesian" channel sees positive shocks to demand of liquid stores of wealth as drivers of lower aggregate demand, and hence lower inflation.

Our empirical findings suggest some of the relationship between inflation on convenience yields could stem from forward-looking inflation dynamics. For instance, with a shift to the regime where the "money" channel dominates, expected future convenience flows depend positively on expected future short rates. To the extent short rates are procyclical, such regime would see a positive beta on convenience flows, reducing the convenience yield today. Market dynamics in response to the post-Covid surge in inflation are broadly in line with this mechanism. In Panel B of Figure 4 we document a strong negative relationship between PC1 and the stock-bond covariance in the 2020-2023 sample, in keeping with the full sample evidence presented in Panel A of the same figure. As shown in Panel A of Figure 3, 2011 and 2022 saw a dip in the TIPS-Treasury premium as well as other convenience yields as captured by PC1. This was precisely the time when poor inflation news started materializing: note the low returns on nominal bonds, relative to real bonds, in both

[15]The pattern in stock-bond covariances is less stark around the 2023 event date with small post-event increases in the different covariance terms.

2021 and 2022 shown in Figure 1. This dip in convenience yields corresponds to an increase in the stock-bond covariance, as well as the stock-bond covariance stemming from convenience yield innovations, as seen in Panel B of Figure 2. We leave a full analysis of this relationship on inflation and convenience yields to future work as it requires the modeling of expected and realized inflation dynamics.

5 Related Literature

Our paper brings together two large literatures: one on the stock-bond comovement and the other on the convenience yield on Treasury securities. The literature on the aggregate stock-bond comovement extends back to the work in Shiller and Beltratti (1992) and Campbell and Ammer (1993). An important part of this literature has studied stock and bond returns jointly in affine economies, for instance Bekaert and Grenadier (1999), Bekaert et al. (2010), and Lettau and Wachter (2011). Recent work in Cieslak and Pang (2021) uses sign-restriction identification to decompose stock and bond returns. Further work studying stock-bond comovements, including nonlinearities and the term structure, includes Connolly et al. (2005), Baele et al. (2010), Adrian et al. (2015), Koijen et al. (2017), Xu (2017), Backus et al. (2018), Chang et al. (2021), and Ermolov (2022).

Many papers in the recent literature have focused on the sign shift in the aggregate stock-bond comovement in the early 2000s. Campbell et al. (2017) study the risk exposures of nominal bonds and attribute the changing covariance to a shift in the covariance between nominal interest rate and the real economy while Campbell et al. (2018) study the impact of monetary policy rules. Other recent work such as Laarits (2021), Choi et al. (2022), Jones and Pyun (2022), Kozak (2022), and Chernov et al. (2023) explore non-inflation accounts of stock-bond comovement, in line with the argument in Duffee (2022) that inflation innovations have not been the main driver of the time-varying stock-bond comovement.

Quantitatively, Laarits (2021) shows that the variability of the aggregate stock-bond covariance can be captured using a price of risk process calibrated to match moments of the equity market. In particular, he finds that the real bond-stock covariance is well captured by a frictionless model of price of risk, while the nominal bond-stock covariance exhibits additional volatility, a finding in line with the argument here on the important role of convenience yields. On the empirical side, Laarits (2021) documents that the stock-bond covariance co-moves with credit spreads, predicts returns on corporate bonds, and captures risk-neutral moments of Treasury returns as well as aggregate issuance of safe assets. Hu et al. (2023) use intraday data to measure the conditional correlation between stocks and bonds. They show that days with substantial negative stock-bond correlations see poor equity market returns, appreciation of Treasuries, appreciation of the Yen with respect to USD, spikes in implied volatility, and widening of Treasury specialness, in line with the findings here. Also part of this literature has studied the relationship between aggregate stock-bond covariance and the cross-section of stock and bond returns, for instance see Baker and Wurgler (2012).

The literature on Treasury convenience yields goes back to Duffee (1996) and Longstaff (2004).

Fleckenstein and Longstaff (2024) provide a recent overview and re-evaluation of absolute Treasury convenience using the term structure of repo swap rates. Krishnamurthy and Vissing-Jorgensen (2012) document a strong relationship between the aggregate supply of Treasuries and the spread between safe corporate bonds and Treasury yields while He et al. (2019) model the determination of the safe asset in a model of two sovereigns. The relationship between Treasury supply and the convenience yield is explored in Greenwood et al. (2015) while Sunderam (2015) studies private market response to Treasury scarcity. Di Tella et al. (2023) estimate zero-beta rates from risky asset returns and interpret the difference between zero-beta and risk-free assets as the convenience yield. Krishnamurthy and Li (forthcoming) study the substitutability between different types of money and money-like claims, while Eren et al. (2023) estimate a demand system for Treasury securities. d'Avernas and Vandeweyer (2021), Stein and Wallen (2023), and Doerr et al. (2023) study intermediation frictions pertaining to the near end of the yield curve.

Two other recent papers study the relationship between convenience yields and inflation. Li et al. (2022) study this link using a model of fiscal policy in which deficit shocks lead to both higher expected inflation, as well as lower convenience yields from additional future issuance. Cieslak et al. (2023) document two specific regimes in the inflation-convenience yield relationship: a "money channel" regime in which high inflation corresponds to high convenience yields, and a "New Keynesian" regime in which shocks to liquid stores of wealth drive aggregate demand and inflation, resulting in a negative stock-bond covariance. Relative to these two papers we emphasize the importance of the covariance of Treasury convenience with aggregate shocks as an important driver of the level of the convenience yield and emphasize that one channel via which inflation affects the convenience yield is through its impact on this covariance.

Finally, the convenience yield of Treasuries also relies on the proper functioning of the associated markets, for instance see Amihud and Mendelson (1991). Adrian et al. (2017) construct a daily measure of Treasury market liquidity and contrast with existing measures of market liquidity, such as Hu et al. (2013). In contrast to existing measures, they find higher illiquidity at the onset of the Covid pandemic in March 2020. A recent literature has studied these dislocations in the Treasury market in that tumultuous period, see He et al. (2022), Haddad et al. (2021), as well as Duffie (2020). Other market microstructure issues can be important, such as specific Treasury securities being cheapest-to-deliver into futures contracts, or going on special in the repo market, as illustrated and analyzed in Duffie (1996), and Jappelli et al. (2022). Relative to the existing literature on the convenience yield, our novelty lies in the focus on the dynamics of this part of Treasury yields, particularly with respect to aggregate equity market movements.

6 Conclusion

We argue—and empirically establish—that the hedging perspective for safe assets is a quantitatively important channel to capture the time-variation in the Treasury convenience yield: we document that times when the aggregate stock-bond covariance is large and negative see a widening of

Treasury convenience yields. In a decomposition of the aggregate stock-bond covariance into terms corresponding to the frictionless risk-free rate, default risk, and the convenience yield, we find that the convenience yield component contributes most robustly to the aggregate hedging properties of the Treasury, particularly during times of market stress. We estimate convenience yield separately at short and long maturities and find a strong common component, though also some evidence of recent reduction in long-term convenience yields. We additionally show that debt ceiling standoffs also erode the convenience yield, again both at the short and long maturities. In all, our results lend strong support to the view that investors pay for the convenience yield they enjoy from holding safe assets in a service-flow or an ease-of-retrading sense.

These results also imply that that the safe asset properties of U.S. Treasuries are not to be taken as given but need to be ensured via prudent macroeconomic outcomes. In other words, the convenience yield of government bonds must be "earned" by the central bank and the government by ensuring bonds retain their hedging properties for unspanned shocks faced by households, investors, financial firms, and corporations. Finally, our results can be used to test various theories of the convenience yield. The systematic time variation documented here is evidence that models beyond the money-in-the-utility framework are likely needed, while the observation that the covariance of convenience yield itself with the stock market accounts for the level of the convenience yield is suggestive of theories of coordination, such as in He et al. (2019). More research is warranted to better understand this time variation.

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7 Tables

Panel A. 2005-2023.

	mean	p1	p10	p50	p90	p99	sd	count
Cov(Tr 10y, St.)	-0.42	-4.23	-1.28	-0.23	0.26	1.27	0.89	228
Cov(Prem. 10y, St.)	-0.19	-4.63	-0.31	-0.05	0.08	0.44	0.90	228
Cov(Rf 10y, St.)	-0.29	-3.26	-0.95	-0.18	0.29	2.20	0.80	228
Cov(CDS 10y, St.)	0.06	-0.12	-0.02	0.00	0.18	0.94	0.18	228

Panel B. 2005-2023.

	mean	p1	p10	p50	p90	p99	sd	count
Prem. 10y	0.26	-0.01	0.12	0.25	0.35	1.13	0.15	228
GC-Tr 3m	0.13	-0.13	0.01	0.10	0.30	0.62	0.13	228
FF-Tr 3m	0.08	-0.50	-0.13	0.03	0.39	1.20	0.28	228
-1*Z-Spr.	0.14	-0.23	-0.01	0.13	0.27	0.78	0.15	228
Libor Spr. 30y	-0.14	-0.68	-0.55	-0.25	0.52	0.68	0.37	228
FN-Tr 30y	0.48	0.09	0.21	0.42	0.84	1.42	0.27	228
Rich. 10y [2005-2022]	0.09	-0.26	-0.16	0.08	0.37	0.53	0.21	216
Box USD 2y [2005/9-2020/7]	0.36	0.12	0.18	0.30	0.62	1.33	0.22	179
PC1	-0.00	-2.83	-1.58	-0.44	2.35	4.96	1.68	228
Short PC1	0.00	-2.89	-1.08	-0.22	1.28	5.37	1.30	228
Long PC1	-0.00	-2.09	-1.50	-0.45	2.20	4.20	1.45	228
Eff. Fed Funds	1.50	0.05	0.07	0.29	5.05	5.33	1.85	228

Panel C. 2005-2023.

	mean	p1	p10	p50	p90	p99	sd	count
Tr 10y	2.94	0.68	1.59	2.76	4.61	5.11	1.15	228
Rf 10y	2.89	0.69	1.44	2.68	4.82	5.40	1.24	228
CDS 2y	0.16	0.01	0.01	0.12	0.30	0.71	0.14	228
CDS 10y	0.32	0.02	0.03	0.31	0.58	0.71	0.19	228
E[Inflation] 2y	1.85	0.56	1.28	1.75	2.62	2.93	0.52	228
E[Inflation] 10y	1.93	1.23	1.53	1.88	2.46	2.67	0.35	228
P2 CP-Tr 3m	0.57	0.07	0.17	0.39	1.06	4.74	0.72	228
AAA-Tr	0.80	0.44	0.53	0.65	1.04	3.82	0.55	228
BBB-AAA	1.25	0.57	0.65	1.11	1.91	4.17	0.66	228
EBP	0.02	-0.79	-0.48	-0.14	0.66	3.33	0.68	228
US Prem. 10y [2005-2022/6]	-0.16	-0.53	-0.34	-0.17	0.06	0.14	0.15	222

Table continues...

Table 1: Summary Statistics. Monthly data 2005-2023. Panel A: the stock-bond covariance calculated using 10-year constant maturity Treasury returns and the CRSP value-weighted stock market return in a 30 trading-day look-back window, collapsed to a monthly variable by keeping the last available calculation in each month. Stock-bond covariance calculated separately using the TIPS-Treasury premium, the frictionless risk-free rate, and the CDS rate. Panel B: various proxies of the Treasury convenience yield (described in Section 1.B) as well as the first Principal Component (PC1) of the convenience yield proxies, jointly and separately across maturity categories. Panel C: Treasury CDS rates, expected inflation, measures of convenience yield using corporate securities, and U.S. Treasury convenience yield relative to other government bonds. Data span indicated in brackets if series not available for the full period indicated in the panel title.

...table continued.
Panel D. 1991/5-2023.

	mean	p1	p10	p50	p90	p99	sd	count
Cov(Tr 10y, St.)	-0.22	-3.57	-1.02	-0.11	0.62	1.48	0.87	392
GC-Tr 3m	0.14	-0.11	0.01	0.11	0.31	0.68	0.14	392
FF-Tr 3m	0.23	-0.54	-0.09	0.07	0.76	1.81	0.41	392
-1*Z-Spr.	0.08	-0.35	-0.08	0.08	0.23	0.65	0.15	392
Libor Spr. 30y [1996-2023]	0.04	-0.63	-0.51	-0.03	0.59	1.13	0.44	331
Rich. 10y [1996-2022]	0.18	-0.25	-0.13	0.17	0.52	0.92	0.26	312
PC1, Long Sample	-0.00	-2.10	-1.05	-0.33	1.50	4.46	1.22	392
Eff. Fed Funds	2.65	0.05	0.08	2.16	5.81	6.86	2.28	392

Panel E. 1971-2023.

	mean	p1	p10	p50	p90	p99	sd	count
Cov(Tr 10y, St.)	0.07	-2.83	-0.79	0.09	1.02	2.60	0.91	624
FF-Tr 3m	0.62	-0.50	-0.05	0.33	1.71	4.55	1.01	624
-1*Z-Spr.	-0.01	-0.85	-0.27	0.03	0.21	0.58	0.30	624
Eff. Fed Funds	5.01	0.06	0.09	5.04	10.44	17.46	4.12	624

Panel F. 2005-2023.

	mean	p1	p10	p50	p90	p99	sd	count
Cov(Tr - Prem. 10y, St.)	-0.23	-2.28	-0.89	-0.17	0.30	2.19	0.76	228
Cov(Rich. 10y, St.) [2005-2022]	-0.07	-1.56	-0.23	-0.01	0.14	0.55	0.39	216
Cov(OIS Spr. 10y, St.)	-0.02	-1.04	-0.15	0.01	0.14	0.61	0.26	228
Cov(Tr - Rich. 10y, St.) [2005-2022]	-0.39	-3.04	-1.21	-0.24	0.18	1.57	0.82	216
Cov(Tr - OIS Spr. 10y, St.)	-0.40	-4.46	-1.15	-0.24	0.30	1.55	0.93	228
5 x Cov(Tr 2y, St.)	-0.26	-2.70	-0.85	-0.12	0.12	1.66	0.67	228
2 x Cov(Tr 5y, St.)	-0.37	-3.33	-1.23	-0.21	0.19	1.34	0.76	228
Cov(Tr 10y, St.), Single ret.	-0.55	-6.18	-1.36	-0.31	0.21	0.93	1.12	228
Cov(Tr 10y LW, St.)	-0.45	-4.72	-1.39	-0.24	0.23	1.23	0.99	228
Cov(Raw Tr 10y, St.)	-0.37	-3.49	-1.13	-0.21	0.19	1.06	0.75	228
Cov(Tr 10y, MSCI)	-0.38	-3.86	-1.14	-0.22	0.25	1.29	0.85	228
Cov(Tr 10y, St.), 60 days	-0.40	-3.12	-1.21	-0.26	0.19	1.11	0.72	228
Cov(Tr 10y, St.), 252 days	-0.43	-1.85	-1.31	-0.30	0.02	0.61	0.54	228

Table 1, continued: Summary Statistics. Monthly data in the indicated period. Panels D and E: longer samples of the stock-bond covariance and different convenience yield proxies (described in Section 1.B). Panel F: alternative stock-bond covariance calculations—different proxies of the frictionless risk-free rate, different bond maturities, and different lookback windows, as described in Section 3.B. Data span indicated in brackets if series not available for the full period indicated in the panel title.

Panel A.

	2005-2023						2005-2022	2005/9-2020/7
	Prem. 10y	GC-Tr 3m	FF-Tr 3m	-1*Z-Spr.	Libor Spr. 30y	FN-Tr 30y	Rich. 10y	Box USD 2y
Cov(Tr 10y, St.)	-0.080**	-0.039**	-0.106***	-0.046	-0.070*	-0.143***	-0.062***	-0.119***
	(-2.23)	(-2.45)	(-2.67)	(-1.64)	(-1.89)	(-4.02)	(-3.48)	(-2.76)
Eff. Fed Funds	0.011*	0.015	0.071***	0.003	0.106***	0.043***	0.055***	0.059***
	(1.71)	(1.20)	(3.13)	(0.32)	(2.65)	(3.15)	(4.32)	(5.83)
Constant	0.206***	0.091***	-0.068**	0.120***	-0.323***	0.356***	-0.011	0.213***
	(9.37)	(4.51)	(-2.28)	(6.80)	(-6.17)	(8.60)	(-0.28)	(11.59)
Observations	228	228	228	228	228	228	216	179
R^2	0.198	0.091	0.257	0.067	0.257	0.235	0.221	0.374

Panel B.

	1996-2023	1996-2022	1991/5-2023			1972-2023	
	Libor Spr. 30y	Rich. 10y	GC-Tr 3m	FF-Tr 3m	-1*Z-Spr.	FF-Tr 3m	-1*Z-Spr.
Cov(Tr 10y, St.)	-0.062*	-0.058***	-0.034**	-0.091***	-0.043*	-0.123***	-0.016
	(-1.91)	(-3.41)	(-2.22)	(-2.97)	(-1.92)	(-2.72)	(-0.71)
Eff. Fed Funds	0.138***	0.079***	0.027***	0.094***	-0.018***	0.199***	-0.035***
	(6.31)	(5.51)	(4.06)	(6.30)	(-4.02)	(11.47)	(-6.87)
Constant	-0.290***	-0.007	0.063***	-0.107***	0.117***	-0.373***	0.170***
	(-5.53)	(-0.19)	(3.41)	(-3.10)	(7.06)	(-5.28)	(8.15)
Observations	324	312	392	392	392	624	624
R^2	0.438	0.393	0.157	0.247	0.182	0.572	0.264

Table 2: Stock-Bond Covariance and Proxies of the Treasury Convenience Yield. Left-hand-side variables are proxies of the convenience yield. Right-hand-side variables are the monthly stock-bond covariance and the effective Fed Funds rate. Monthly data for the indicated time periods. The selection of left-hand-side variables in Panel B reflects their availability in the indicated time periods. Heteroskedasticity and autocorrelation robust t statistics in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. The regression specification is

$$\text{CONV}_t = a + b \times \text{Cov(Tr 10y, St.)} + c \times \text{Eff. Fed Funds} + \epsilon_t$$

where CONV_t stands for the indicated convenience yield proxy.

	2005-2023						2005-2022	2005/9-2020/7
	Prem. 10y	GC-Tr 3m	FF-Tr 3m	-1*Z-Spr.	Libor Spr. 30y	FN-Tr 30y	Rich. 10y	Box USD 2y
Cov(Prem. 10y, St.)	-0.106***	-0.051***	-0.095***	-0.074***	-0.068**	-0.168***	-0.052***	-0.142***
	(-6.60)	(-4.87)	(-3.11)	(-5.77)	(-2.34)	(-8.49)	(-3.59)	(-7.72)
Cov(Rf 10y, St.)	-0.008	-0.022	-0.146**	0.005	-0.095*	-0.082**	-0.064***	-0.049
	(-0.41)	(-1.12)	(-2.35)	(0.32)	(-1.74)	(-2.39)	(-3.07)	(-1.61)
Cov(CDS 10y, St.)	0.231*	-0.118*	-0.269*	-0.018	-0.310*	0.061	0.115	0.004
	(1.89)	(-1.86)	(-1.77)	(-0.43)	(-1.72)	(0.78)	(1.35)	(0.08)
Eff. Fed Funds	0.013**	0.014	0.041*	0.002	0.103***	0.044***	0.057***	0.061***
	(2.50)	(1.09)	(1.66)	(0.26)	(2.60)	(3.27)	(4.72)	(5.78)
Constant	0.201***	0.100***	-0.059*	0.128***	-0.313***	0.356***	-0.023	0.224***
	(10.68)	(4.82)	(-1.86)	(8.08)	(-5.85)	(8.55)	(-0.63)	(12.40)
Observations	228	228	228	228	228	228	216	179
R^2	0.449	0.132	0.177	0.191	0.270	0.286	0.247	0.475

Table 3: Components of the Stock-Bond Covariance and Proxies of the Treasury Convenience Yield. Left-hand-side variables are proxies of the convenience yield. The right-hand-side variables are components of the aggregate stock-bond covariance, corresponding to the convenience yield, the frictionless risk-free rate, and the CDS rate according to Equation (5). Monthly data 2005-2023 except as indicated in the column header. Heteroskedasticity and autocorrelation robust t statistics in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. The regression specification is

$$\mathrm{CONV}_t = a + b_1 \times \mathrm{Cov(Prem.\ 10y,\ St.)} + b_2 \times \mathrm{Cov(Rf\ 10y,\ St.)} + b_3 \times \mathrm{Cov(CDS\ 10y,\ St.)} + c \times \mathrm{Eff.\ Fed\ Funds} + \epsilon_t$$

where CONV_t stands for the indicated convenience yield proxy.

	PC1, 2005-2023					
Cov(Prem. 10y, St.)	-0.730***	-0.806**	-1.002***	-0.897***	-1.102***	-1.030***
	(-10.43)	(-2.08)	(-6.93)	(-5.13)	(-6.59)	(-6.69)
Crisis		2.335***				
		(2.62)				
Crisis x Cov(Prem. 10y, St.)		0.398				
		(0.96)				
Cov(Rf 10y, St.)			-0.704**	-0.663**	-0.744***	-0.744***
			(-2.52)	(-2.47)	(-2.73)	(-2.78)
Cov(CDS 10y, St.)			-0.595	-0.795	-0.048	-0.197
			(-0.56)	(-0.76)	(-0.06)	(-0.23)
VIX				1.861		
				(0.75)		
CDS 2y					-2.959**	
					(-2.37)	
E[Inflation] 2y					0.178	
					(0.35)	
CDS 10y						-1.510
						(-1.08)
E[Inflation] 10y						1.179*
						(1.74)
Eff. Fed Funds	0.342**	0.368**	0.394**	0.403**	0.349**	0.150
	(2.09)	(2.25)	(2.50)	(2.48)	(2.09)	(0.74)
Constant	-0.650***	-0.901***	-0.949***	-1.284**	-0.811	-2.410**
	(-3.39)	(-4.62)	(-4.68)	(-2.57)	(-1.07)	(-2.23)
Observations	228	228	228	228	228	228
R^2	0.246	0.396	0.326	0.331	0.386	0.378

Table 4: Stock-Bond Covariance and 1st Principal Component the Convenience Yield Proxies. The left-hand-side variable is the first principal component of the convenience yield proxies available in the entire indicated period. The right-hand-side variables are components of the aggregate stock-bond covariance, corresponding to the convenience yield, the frictionless risk-free rate, and the CDS rate, as well as the effective Fed funds rate, an indicator variable for the Global Financial Crisis, and the VIX. Monthly data 2005-2023. Heteroskedasticity and autocorrelation robust t statistics in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. The regression specification is

$$\text{PC1}_t = a + b_1 \times \text{Cov} + b_2 \times \text{Interaction} + b_3 \times \text{Controls} + c \times \text{Eff. Fed Funds} + \epsilon_t,$$

where the selection of variables in the groups

$$\begin{aligned} &\text{Cov} \in \{\text{Cov(Prem. 10y, St.)}, \text{Cov(Rf 10y, St.)}, \text{Cov(CDS 10y, St.)}\} \\ &\text{Interaction} \in \{\text{Crisis}, \text{Crisis} \times \text{Cov(Prem. 10y, St.)}\} \\ &\text{Controls} \in \{\text{VIX}, \text{CDS}, \text{E[Inflation]}\} \end{aligned}$$

is indicated in the table.

	PC1, 1991/5-2023				
Cov(Tr 10y, St.)	-0.368***	-0.254**	-0.254**	-0.307**	-0.334***
	(-2.91)	(-1.98)	(-2.09)	(-2.41)	(-2.67)
Crisis		0.537			
		(1.22)			
Crisis x Cov(Tr 10y, St.)		-0.220			
		(-1.47)			
VIX			2.388**		
			(2.06)		
E[Inflation] 2y				-0.486	
				(-1.53)	
E[Inflation] 10y					-0.444
					(-1.15)
Eff. Fed Funds	0.283***	0.281***	0.276***	0.404***	0.382***
	(5.07)	(4.77)	(5.17)	(3.45)	(3.06)
Constant	-0.830***	-0.851***	-1.252***	-0.028	-0.035
	(-6.46)	(-5.87)	(-4.46)	(-0.05)	(-0.05)
Observations	392	392	392	392	392
R^2	0.232	0.256	0.248	0.254	0.250

Table 5: Stock-Bond Covariance and 1st Principal Component the Convenience Yield Proxies. The left-hand-side variable is the first principal component of the convenience yield proxies available in the entire indicated period. The right-hand-side variables are components of the aggregate stock-bond covariance, corresponding to the convenience yield, the frictionless risk-free rate, and the CDS rate, as well as the effective Fed funds rate, an indicator variable for the Global Financial Crisis; the VIX, and expected inflation and CDS rate at two different maturities. Monthly data 1991/5-2023. Heteroskedasticity and autocorrelation robust t statistics in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. The regression specification is

$$\text{PC1}_t = a + b_1 \times \text{Cov(Tr 10y, St.)} + b_2 \times \text{Interaction} + b_3 \times \text{Controls} + c \times \text{Eff. Fed Funds} + \epsilon_t,$$

where the selection of variables in the groups

$$\text{Interaction} \in \{\text{Crisis}, \text{Crisis} \times \text{Cov(Tr. 10y, St.)}\}$$
$$\text{Controls} \in \{\text{VIX}, \text{E[Inflation]}\}$$

is indicated in the table.

	2005-2023		2005-2022	2005-2023
	PC1	PC1	PC1	PC1
Cov(Tr 10y, St.)	-0.904***			
	(-4.27)			
Cov(Prem. 10y, St.)		-1.006***		
		(-7.08)		
Cov(Tr - Prem. 10y, St.)		-0.717***		
		(-2.59)		
Cov(Rich. 10y, St.)			-1.390***	
			(-4.35)	
Cov(Tr - Rich. 10y, St.)			-0.754***	
			(-3.46)	
Cov(OIS Spr. 10y, St.)				-1.185**
				(-2.04)
Cov(Tr - OIS Spr. 10y, St.)				-0.906***
				(-4.52)
Eff. Fed Funds	0.395**	0.394**	0.592***	0.399***
	(2.57)	(2.52)	(5.50)	(2.60)
Constant	-0.973***	-0.947***	-1.055***	-0.985***
	(-5.00)	(-4.63)	(-5.66)	(-5.18)
Observations	228	228	216	228
R^2	0.313	0.327	0.483	0.315

Table 6: Stock-Bond Covariance and the 1st Principal Component of the Convenience Yield Proxies. The left-hand-side variable is the first principal component of the convenience yield proxies available in the entire indicated period. The right hand side variables are stock-bond covariance, and a decomposition of the aggregate stock-bond covariance into terms corresponding to the convenience yield and the residual term. We use three different proxies for the convenience yield: the TIPS-Treasury premium; the 10-year Treasury Richness from Fleckenstein and Longstaff (2024); the 10-year OIS Spread. Monthly data for the indicated time period. Heteroskedasticity and autocorrelation robust t statistics in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. The regression specification is

$$\text{PC1}_t = a + b_1 \times \text{Cov(Conv. 10y, St.)} + b_2 \times \text{Cov(Tr - Conv. 10y, St.)} + c \times \text{Eff. Fed Funds} + \epsilon_t \ ,$$

where Conv. 10y stands for the convenience yield proxy indicated in the table. The first column is included for reference and does not include the term with a frictionless rate proxy.

	2005-2023					
	Short PC1	Short PC1	Short PC1	Long PC1	Long PC1	Long PC1
5 x Cov(Tr 2y, St.)	-0.952***			-0.910***		
	(-3.72)			(-3.62)		
2 x Cov(Tr 5y, St.)		-0.799***			-0.884***	
		(-3.70)			(-4.21)	
Cov(Tr 10y, St.)			-0.568***			-0.709***
			(-3.00)			(-4.92)
Eff. Fed Funds	0.115	0.167	0.179	0.267**	0.325***	0.349***
	(1.04)	(1.43)	(1.44)	(2.34)	(2.96)	(3.12)
Constant	-0.422***	-0.544***	-0.508***	-0.640***	-0.814***	-0.822***
	(-2.78)	(-3.28)	(-3.20)	(-3.04)	(-3.85)	(-3.80)
Observations	228	228	228	228	228	228
R^2	0.269	0.238	0.167	0.290	0.320	0.289

Table 7: Short and Long Maturity Convenience Yield Measures. The left-hand-side variables are the first principal components of the short- and long-term convenience yield proxies. The right-hand-side variables are the aggregate stock-bond covariance, calculated with the indicated maturity bond return, as described in Section 3.B. Monthly data for the indicated time period. Heteroskedasticity and autocorrelation robust t statistics in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. The regression specification is

$$\mathrm{PC1}_t = a + b \times \mathrm{Cov} + c \times \mathrm{Eff.\ Fed\ Funds} + \epsilon_t,$$

where PC1 and Cov stand for the indicated principal component and stock-bond covariance calculation.

	Cov(..., St.)					
	Tr 2y	Tr 5y	Tr 10y	Prem. 10y	Rf 10y	CDS 10y
Crisis	-0.200***	-0.489***	-0.737	-1.046	0.269	0.048
	(-3.38)	(-2.86)	(-1.56)	(-1.51)	(0.71)	(0.50)
Post 2011	0.021	0.101	0.284	0.038	0.316	-0.058
	(1.02)	(1.29)	(1.12)	(0.46)	(1.40)	(-1.30)
Post 2021	0.078	0.275**	0.587***	0.114	0.456**	0.015
	(1.44)	(2.31)	(3.31)	(1.64)	(2.40)	(0.79)
Constant	-0.053***	-0.225***	-0.583**	-0.112	-0.566***	0.086**
	(-2.69)	(-3.03)	(-2.34)	(-1.36)	(-2.59)	(2.03)
Observations	228	228	228	228	228	228
R^2	0.304	0.304	0.193	0.141	0.072	0.040

Table 8: Conditional Averages of Stock-Bond Covariance Measures. The left-hand-side variables are the indicated stock-bond covariance measures. The right-hand-side variables are dummies indicating the Global Financial Crisis, and periods after 2011, and after 2021. Monthly data 2005-2023. Heteroskedasticity and autocorrelation robust t statistics in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. The regression specification is

$$\text{Cov}_t = a + b_1 \times \text{Crisis} + b_2 \times \text{Post 2011} + b_3 \times \text{Post 2021} + \epsilon_t$$

where Cov_t stands for the indicated component of the stock-bond covariance.

Panel A.

	PC1, 2005-2023			PC1, 1991/5-2023		
Cov(Tr 10y LW, St.)	-0.839***			-0.367***		
	(-5.11)			(-3.43)		
Cov(Raw Tr 10y, St.)		-1.103***			-0.458***	
		(-3.92)			(-2.98)	
Cov(Tr 10y, MSCI)			-0.917***			-0.441***
			(-3.61)			(-3.09)
Eff. Fed Funds	0.394**	0.400***	0.392**	0.284***	0.282***	0.282***
	(2.57)	(2.62)	(2.57)	(5.20)	(5.17)	(5.27)
Constant	-0.969***	-1.014***	-0.936***	-0.842***	-0.849***	-0.845***
	(-5.01)	(-5.15)	(-4.71)	(-6.61)	(-6.53)	(-6.63)
Observations	228	228	228	392	392	392
R^2	0.326	0.325	0.299	0.241	0.237	0.244

Panel B.

	PC1, 2005-2023			PC1, 1991/5-2023		
Cov(Tr 10y, St.), Single ret.	-0.744***			-0.346***		
	(-3.19)			(-3.14)		
Cov(Tr 10y, St.), 60 days		-1.141***			-0.411**	
		(-3.19)			(-2.45)	
Cov(Tr 10y, St.), 252 days			-1.955***			-0.629**
			(-3.11)			(-2.28)
Eff. Fed Funds	0.395**	0.435***	0.600***	0.283***	0.293***	0.350***
	(2.51)	(2.75)	(3.03)	(5.18)	(4.84)	(4.09)
Constant	-1.004***	-1.113***	-1.746***	-0.863***	-0.860***	-1.055***
	(-5.07)	(-4.85)	(-4.17)	(-6.56)	(-5.94)	(-4.21)
Observations	228	228	228	392	392	392
R^2	0.329	0.306	0.368	0.247	0.222	0.226

Table 9: Alternative Stock and Bond Returns. Various Lookback Windows of the Covariance Calculation. In Panel A the left-hand-side variable is PC1. The right-hand-side variables are alternative measures of the stock-bond covariance, described in Section 3.A. In Panel B the left-hand-side variables are the first principal components of the short- and long-term convenience yield proxies. The right-hand-side variables are the aggregate stock-bond covariance, calculated over the indicated length look-back window. Monthly data for the indicated time period. Heteroskedasticity and autocorrelation robust t statistics in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. The regression specification is

$$\text{PC1}_t = a + b \times \text{Cov} + c \times \text{Eff. Fed Funds} + \epsilon_t,$$

where PC1 and Cov stand for the indicated principal component and stock-bond covariance calculation.

Panel A.

	2005-2023				2005-2022/6
	P2 CP-Tr 3m	AAA-Tr	BBB-AAA	EBP	US Prem. 10y
Cov(Tr 10y, St.)	-0.469**	-0.350**	-0.326***	-0.391***	-0.029
	(-2.23)	(-2.45)	(-4.22)	(-2.61)	(-1.50)
Eff. Fed Funds	0.050*	0.002	-0.103***	-0.005	0.016
	(1.68)	(0.13)	(-3.11)	(-0.18)	(1.03)
Constant	0.296***	0.652***	1.269***	-0.135	-0.194***
	(4.42)	(13.06)	(11.15)	(-1.57)	(-7.60)
Observations	228	228	228	228	222
R^2	0.316	0.320	0.335	0.268	0.049

Panel B.

	2005-2023				2005-2022/6
	P2 CP-Tr 3m	AAA-Tr	BBB-AAA	EBP	US Prem. 10y
Cov(Prem. 10y, St.)	-0.627***	-0.455***	-0.375***	-0.501***	-0.033**
	(-7.57)	(-8.30)	(-8.02)	(-8.10)	(-2.40)
Cov(Rf 10y, St.)	-0.171	-0.122	-0.105*	-0.104	-0.015
	(-1.31)	(-1.43)	(-1.69)	(-1.06)	(-0.52)
Cov(CDS 10y, St.)	-0.106	0.240	1.309***	0.766***	0.052
	(-0.27)	(0.97)	(4.53)	(2.59)	(0.68)
Eff. Fed Funds	0.050	0.005	-0.088***	0.004	0.017
	(1.61)	(0.34)	(-3.41)	(0.15)	(1.08)
Constant	0.333***	0.660***	1.209***	-0.151**	-0.197***
	(6.99)	(17.12)	(13.27)	(-2.07)	(-7.69)
Observations	228	228	228	228	222
R^2	0.504	0.502	0.541	0.469	0.062

Table 10: Corporate Spreads and the Stock-Bond Covariance. Left-hand-side variables are proxies of the Treasury convenience yield employing corporate security prices. Right-hand-side variables in Panel A are the aggregate stock-bond covariance and the effective Fed funds rate. Right-hand-side variables in Panel B are the components of the aggregate stock-bond covariance corresponding to the convenience yield, the frictionless risk-free rate, and the CDS rate, as well as the effective Fed funds rate. Monthly data 2005-2023 Heteroskedasticity and autocorrelation robust t statistics in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. The regression specification is

$$\mathrm{CONV}_t = a + b \times \mathrm{Cov} + c \times \text{Eff. Fed Funds} + \epsilon_t$$

where the selection of variables $\mathrm{Cov} \in \{\text{Cov(Prem. 10y, St.)}, \text{Cov(Rf 10y, St.)}, \text{Cov(CDS 10y, St.)}\}$ is indicated in the table.

Panel A. 2011 debt crisis. Cutoff August 1, 2011

	Prem. 2y	Prem. 10y	PC1	Short PC1	Long PC1
After Cutoff Date	0.004	0.087***	0.231***	0.174***	0.116*
	(0.13)	(3.91)	(3.09)	(2.61)	(1.79)
Constant	0.200***	0.201***	-0.130*	-0.179***	0.057
	(18.34)	(12.78)	(-1.80)	(-5.44)	(0.93)
Observations	41	41	41	41	41
R^2	0.001	0.406	0.316	0.237	0.088

Panel B. 2023 debt crisis. Cutoff May 31, 2023

	Prem. 2y	Prem. 10y	PC1	Short PC1	Long PC1
After Cutoff Date	0.060***	0.040**	0.155	0.115	0.170***
	(3.42)	(2.36)	(1.49)	(0.77)	(3.13)
Constant	0.170***	0.270***	-1.818***	-1.371***	-1.041***
	(14.76)	(17.58)	(-28.27)	(-12.30)	(-31.52)
Observations	41	41	41	41	41
R^2	0.310	0.295	0.066	0.021	0.357

Table 11: Convenience Yields and Stock-Bond Covariances Around Two Debt Ceiling Deals. Daily data around the indicated event window. 2011 debt ceiling standoff sample from June to September 2011; 2023 debt ceiling sample from April to June 2023. Heteroskedasticity and autocorrelation robust t statistics. ***, **, and * denote significance at the 1%, 5%, and 10% levels. The regression specification is

$$\text{LHS}_t = a + b \times \text{Event} + \epsilon_t$$

where Event is a dummy variable that indicates days starting with the event day listed in the table header and

$\text{LHS}_t \in \{\text{Prem. 2y},\ \text{Prem. 10y},\ \text{PC1},\ \text{Short PC1},\ \text{Long PC1}\}$
as indicated in the table.

8 Figures

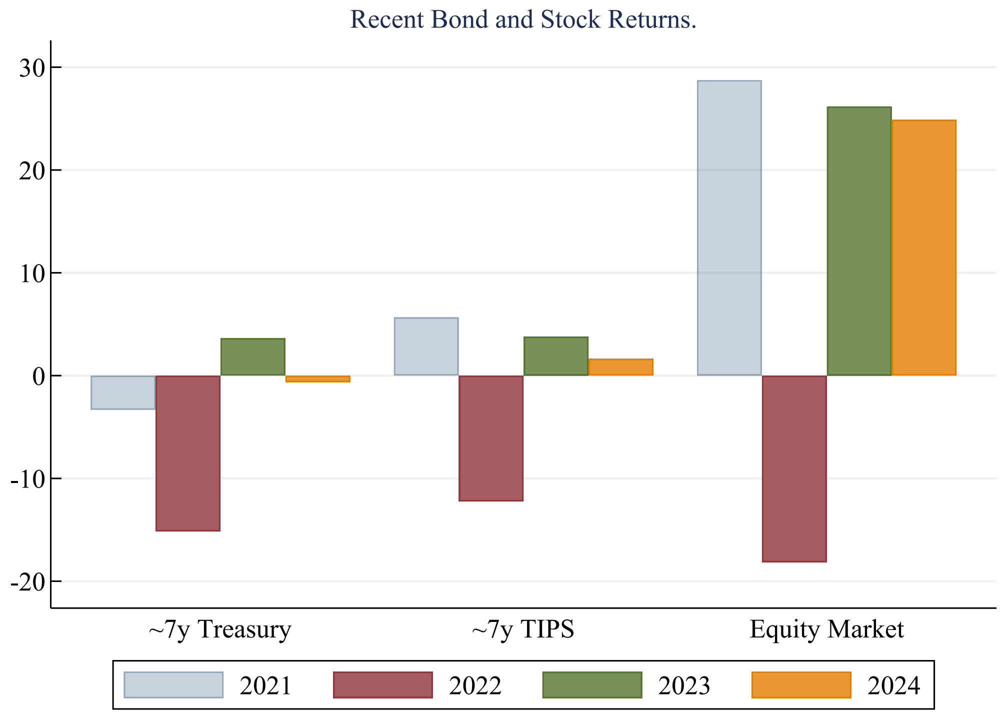


Figure 1: Returns in 2021-2024. Nominal Bonds, Real Bonds, and Stocks. Returns on nominal and real bonds proxied by IEF and TIP, respectively, bond ETFs with duration of approximately 7 years each. Returns on stocks proxied by SPY, an SP500 ETF.

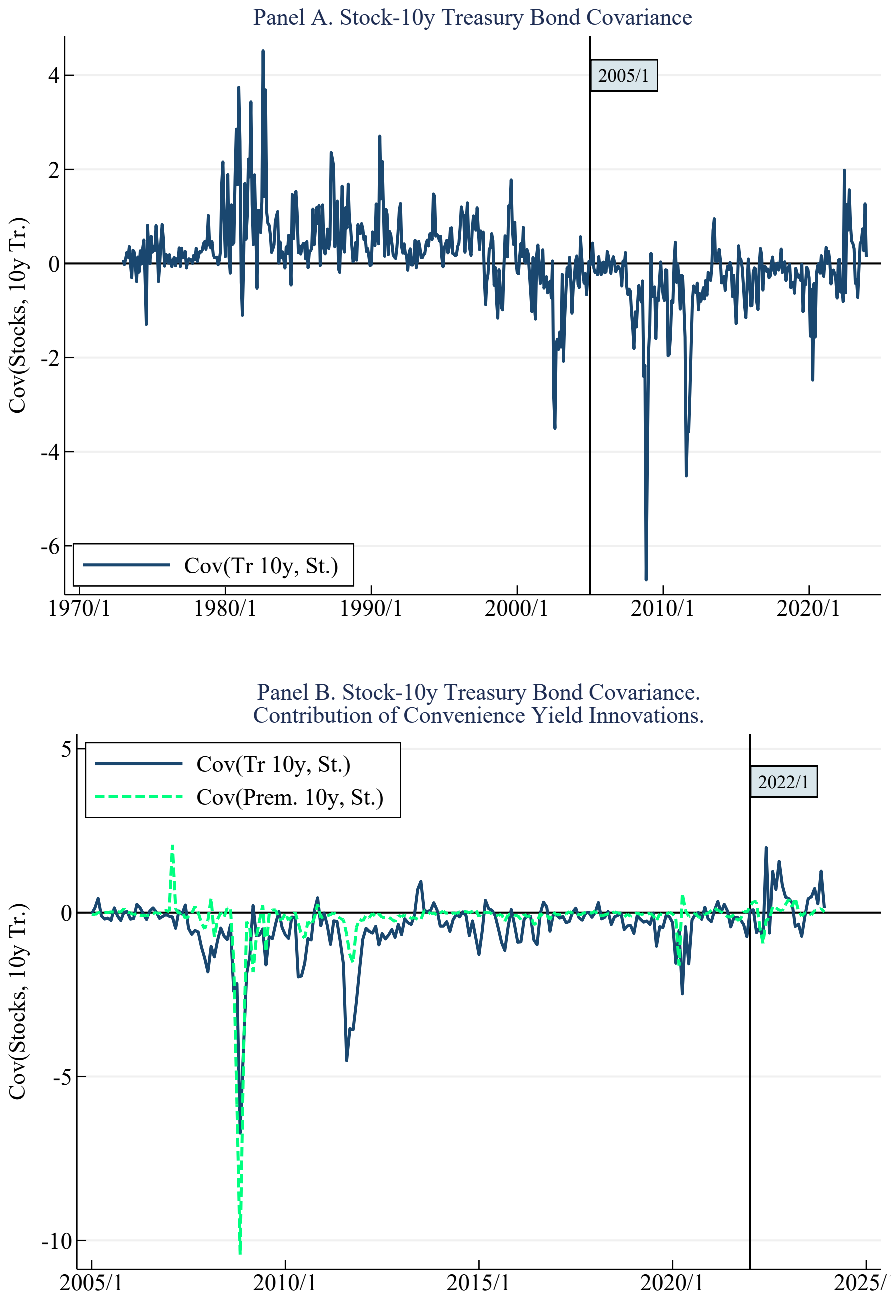


Figure 2: The Stock-Bond Covariance. Panel A shows the covariance between a nominal 10-year constant maturity bond and the aggregate stock market in a 30 trading-day lookback window. The bond return is calculated based on the yield from the Gürkaynak et al. (2007) fitted yield curve and the stock return is the CRSP value-weighted market return. Plot shows end of month values. Monthly data 1973-2023. Panel B repeats the aggregate stock-bond covariance and plots separately the contribution of convenience yield innovations as described in Section 1.C. Monthly data 2005-2023.

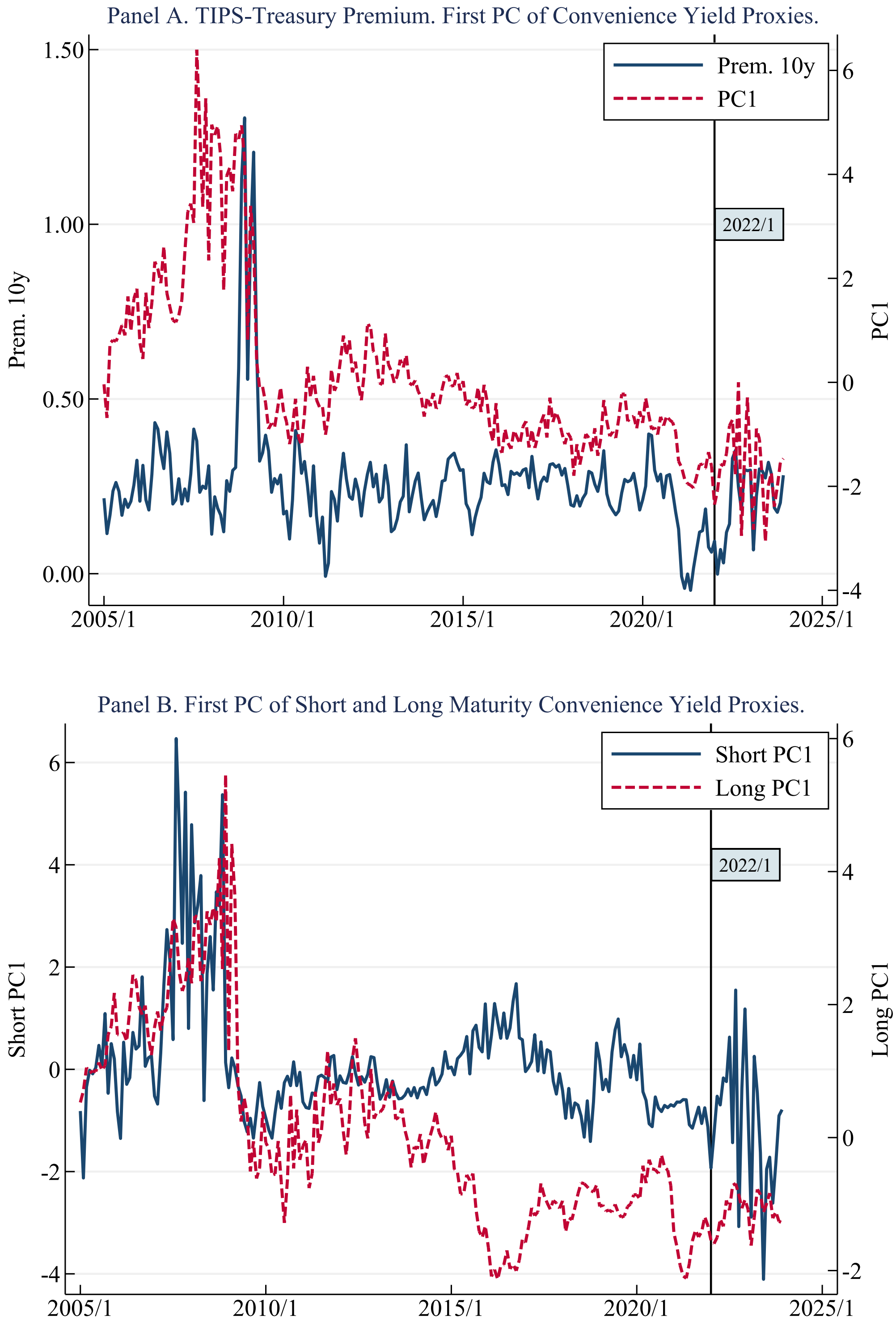
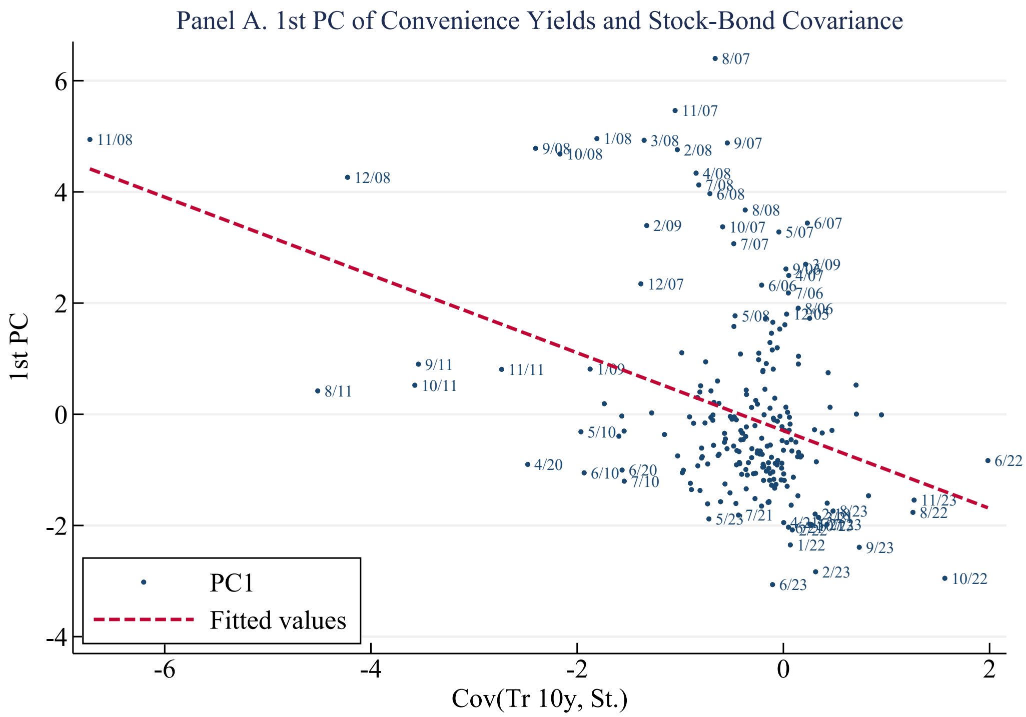


Figure 3: Time Series of Convenience Yield Proxies. Panel A plots the 10-year TIPS-Treasury premium and the first Principal Component (PC1) of the convenience yield proxies. The construction of PC1 is described in Section 2.C. Panel B plots the first Principal Component of the short- and long-maturity convenience yield proxies, as described in Section 2.E.



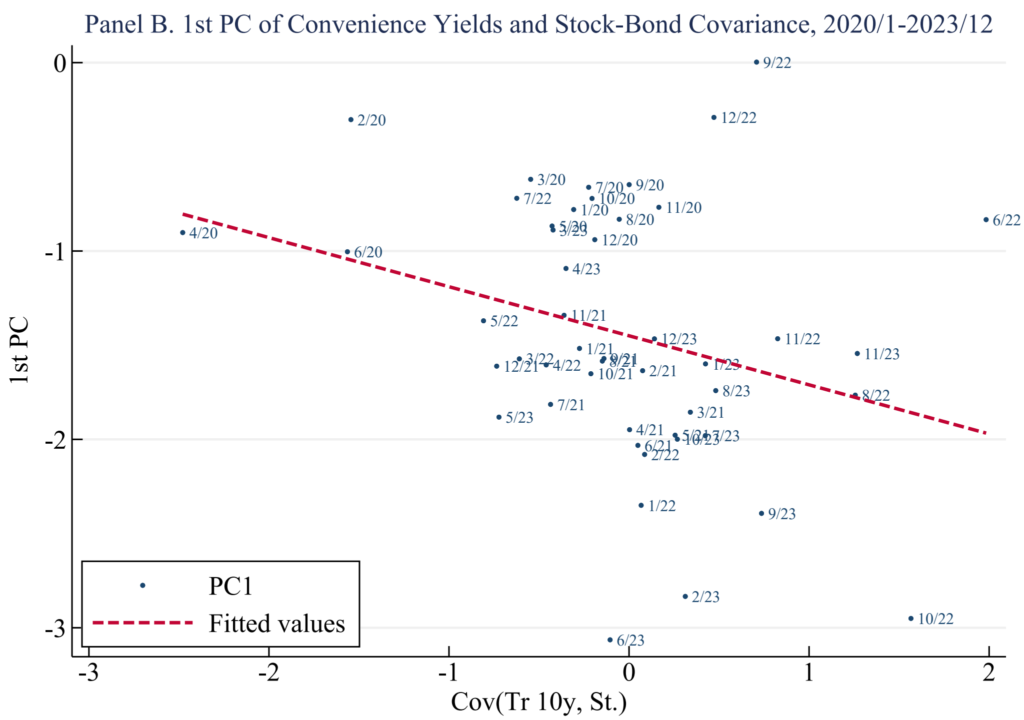


Figure 4: Treasury Convenience Yields and the Stock-Bond Covariance. Panel A is a scatterplot of the first principal component of the convenience yield proxies against the aggregate stock-bond covariance. Monthly data 2005-2023. Panel B plots the same data, restricted to the 2020-2023 subsample.

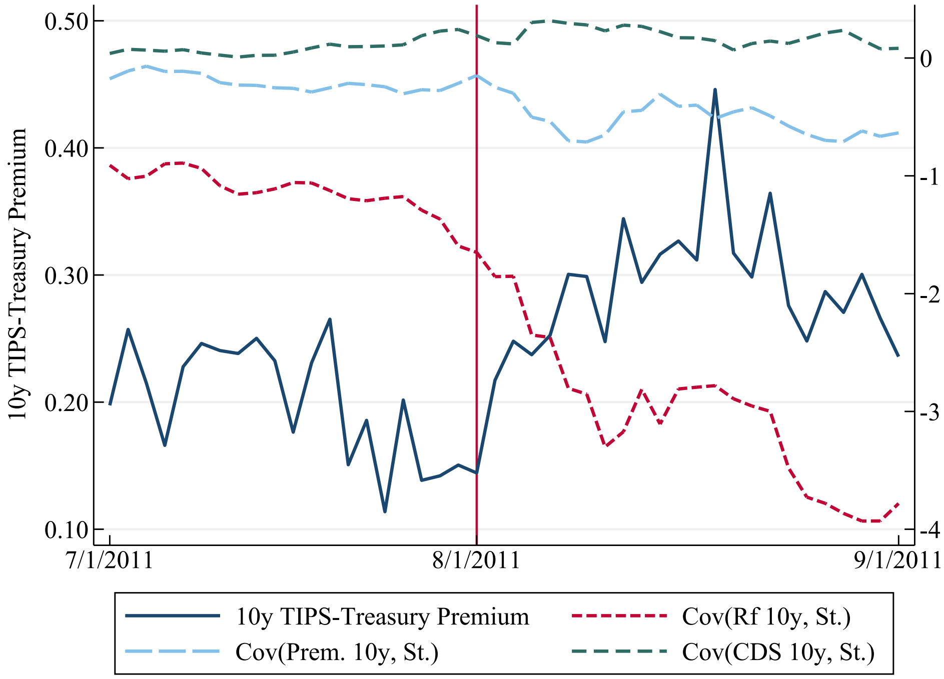


Figure 5: TIPS-Treasury Premium and the Stock-Bond Covariance around the 2011 Debt Ceiling Standoff. The 10-year TIPS-Treasury premium and the aggregate stock-bond covariance, as well as the components of the stock-bond covariance corresponding to the convenience yield, the frictionless risk-free rate, and the CDS rate. Red vertical line indicates August 1, 2011, the date of the debt ceiling standoff resolution.

A Appendix

Abbrev.	Full Label	Description
Prem.	TIPS - Treasury Premium	The yield spread between a synthetic nominal Treasury, constructed out of Treasury Inflation Protected Security (TIPS) plus inflation swap of the same maturity and a nominal Treasury. The yields on TIPS and nominal Treasuries are from the fitted yield curves constructed in Gürkaynak et al. (2007) and Gürkaynak et al. (2010) with identifiers SVENYxx and TIPSYxx, respectively. The inflation swap data is from the Bloomberg system, ticker stem USSWITxx Curncy and the maturities available on any given day are smoothed using a cubic spline with knots at 0 and 25 years. We carry out a daily calculation of the TIPS-Treasury Premium at the 2-, 5, and 10-year maturities.
GC-Tr	General Collateral - Treasury Bill Spread	The yield spread between the three-month General Collateral (GC) repo rate, and the three-month Treasury Bill rate. The GC repo rate is from the Bloomberg system, ticker USRGCGC ICUS Curncy, and the Treasury Bill rate is from the St. Louis Fed FRED database, ticker DGS3MO. In calculating the end-of-month values we drop the December 31, 2018 observation because of a repo market specific spike. Similarly we exclude the spike at the end of April 1993. All our results are robust to including these spikes in the GC-Tr spread.
FF-Tr	Fed Funds - Treasury Bill Spread	The yield spread between the overnight Fed funds rate and the three-month Treasury Bill rate. Both data series are from the St. Louis Fed FRED database, tickers are DFF and DGS3MO, respectively.
-1*Z-Spr.	Negative of the Z-Spread	A measure of the "richness" of the short end of the yield curve, constructed after Greenwood et al. (2015). These authors calculate the average yield difference of n-month maturity Treasury Bills and the fitted yield curve of Gürkaynak et al. (2007) and label it the n-month Z-spread. This measure is typically negative, reflecting lower yields on T-bills relative to those implied by the fitted yield curve. We follow their methodology by calculating the average Z-spread of T-bills with 4 to 26 weeks until maturity. In our empirical analysis we use the negative of the Z-spread to ensure that higher values correspond to high convenience yield of Treasury, consistent with other proxies of the convenience yield.
Libor Spr.	LIBOR Swap Spread	The LIBOR Swap rate data is from the Bloomberg system, ticker stem USSWxx. The swap spread is calculated by comparing the quoted swap rate with the swap rate implied by the Gürkaynak et al. (2007) nominal risk-free yield curve, recognizing that LIBOR swaps are on a biannual schedule.
FN-Tr	Fannie MBS - Treasury Spread	The option-adjusted spread between Agency MBS and Treasury yields, as suggested as a convenience yield proxy by recent work in He and Song (2022). Data from the Bloomberg system, the ticker is I00098US and option-adjusted spread is available in the analytics menu.
Rich.	Treasury Richness	Treasury Richness as constructed in Fleckenstein and Longstaff (2024) and available in the replication package on the *Journal of Finance* website. Treasury Richness measures the value of a given Treasury bond relative to the value from discounting the promised cash-flows with a risk-free curve implied by fixed-to-floating repo swap rates (and OIS swap rates in the earlier sample). For this measure we use the Richness, quoted as a yield spread, of the most recently issued 10-year Treasury Note.
Box USD	USD Box Rate	The yield spread between two-year Treasury yield and the risk-free interest rate implied by put-call parity on options contracts (the "box rate") as calculated in van Binsbergen et al. (2022) and available on Will Diamond's website.

Table continues on next page...

Table A1: Labeling and Construction of the Main Variables. Abbreviated label, full label, and description with data sources. Tables and figures use the abbreviated label and indicate the maturity, in either months ("m") or years ("y").

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Abbrev.	**Full Label**	**Description**
CDS	U.S. Credit Default Swap Rate	The data on CDS rates is from Markit and reflects quotes provided by different brokers. We use daily data for the 2-, 5-, and 10-year tenors. On any given day, both EUR and USD denominated contracts are available, as are up to four contracts with different contract clauses. These different contract clauses differ in what constitutes a restructuring event. We use the contracts corresponding to Full Restructuring (CR). With the introduction of the 2014 ISDA Credit Derivatives Definitions we use the CR14 designation, whenever available, CR otherwise. For compatibility with the pre-2008 data we use the Par Spread throughout.
E[Inflation]	Expected Inflation	Expected inflation series constructed by the Cleveland Fed. Data from the St. Louis Fed FRED database, ticker stem EXPINF.
Rf	Frictionless Risk-free Rate	The frictionless risk-free rate implied by the decomposition in Equation (3). Data sources for the constituent parts of the decomposition are listed in this table.
Rf FL	Frictionless Risk-free Rate, Fleckenstein-Longstaff	The "frictionless" risk-free rate implied by the Treasury richness measure in Fleckenstein and Longstaff (Forthcoming). Data from the replication package of that paper on the *Journal of Finance* website.
Rf OIS	Frictionless Risk-free Rate, OIS	The frictionless risk-free rate implied by the Fed Funds overnight indexed swap curve. Data from the Bloomberg system, ticker stem USSOxx.
P2-Tr	P2-rated Commercial Paper - Treasury Bill Spread	The yield spread between 90-day P2-rated Commercial paper and three-month Treasury Bills, following Krishnamurthy and Li (forthcoming). Data from the St. Louis Fed FRED database, tickers RIFSPPNA2P2D90NB and DGS3MO, respectively.
US Prem.	US Treasury Premium	The premium of US Treasuries over foreign safe bonds, as constructed in Du et al. (2018). This measure compares the yield on foreign safe bonds, with the cash-flows swapped into USD, relative to the yield on U.S. Treasuries. Du et al. (2018) consider a number of alternative calculations. We follow their calculation that estimates the forward premium using interest rate swaps and basis swaps, see Equation (9) in that paper. The resulting measure, US Premium, is an equal-weighted average of the U.S. convenience yield over a basket of ten foreign currencies (AUD, CAD, CHF, DKK, EUR, GBP, JPY, NOK, NZD, SEK).
EBP	Excess Bond Premium	The Excess Bond Premium, a measure of the corporate yield spread not accounted for by default risk, as first constructed in Gilchrist and Zakrajšek (2012) and updated continuously by the Federal Reserve Board at `https://www.federalreserve.gov/econres/notes/feds-notes/ebp_csv.csv`.
AAA-Tr	AAA - Treasury Spread	The option-adjusted yield spread of the ICE BofA AAA US Corporate Index. Data from the St. Louis Fed FRED database, ticker BAMLC0A1CAAA.
BBB-AAA	BBB - AAA Spread	The difference between the option-adjusted yield spread of the ICE BofA BBB US Corporate Index and the option-adjusted yield spread of the ICE BofA AAA US Corporate Index. Data from the St. Louis Fed FRED database, tickers BAMLC0A4CBBB and BAMLC0A1CAAA, respectively.

Table A1, continued: Labeling and Construction of the Main Variables. Abbreviated label, full label, and description with data sources. Tables and figures use the abbreviated label and indicate the maturity, in either months ("m") or years ("y")

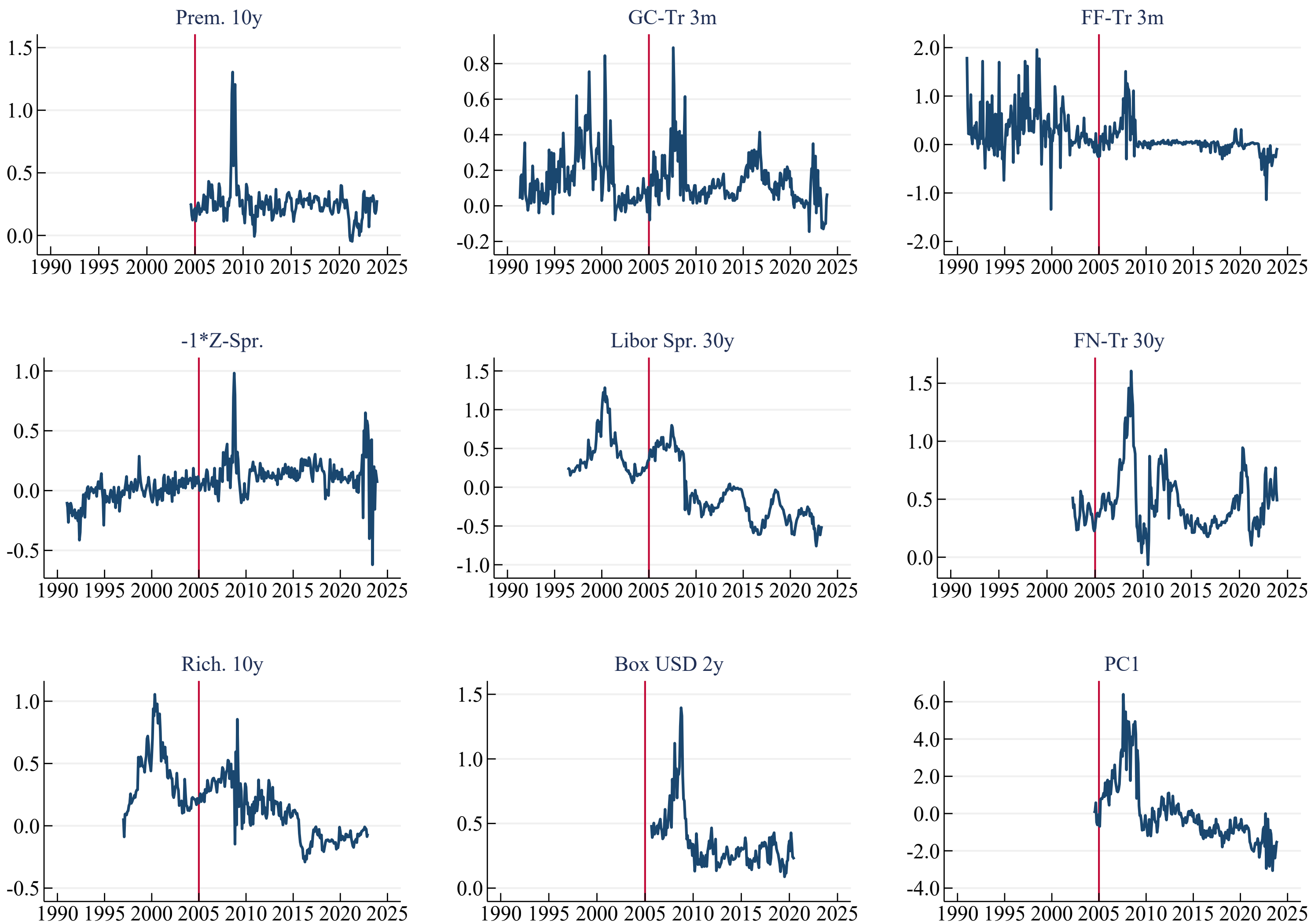

Figure A1: Convenience Yield Proxies. Monthly data from 1991 to 2023. The vertical lines indicate 2005/1.

OA Online Appendix

OA.A Analytical Setup Details

Consider a zero-coupon safe bond with face value 1 and maturity T. In periods $t < T$, the holder of the bond accrues a non-pecuniary and potentially time-varying convenience flow $K_t = b + f(X_t)$, where X_t captures market conditions at time t: the demand for safety, supply of safe assets and so on. The present value of the bond is given by:

$$P_0 = \frac{\mathrm{E}_0[K_1]}{1 + \mathrm{E}_0[R_{0,1}]} + \frac{\mathrm{E}_0[K_2]}{1 + \mathrm{E}_0[R_{0,2}]} + ... + \frac{\mathrm{E}_0[K_{T-1}]}{1 + \mathrm{E}_0[R_{0,T-1}]} + \frac{1}{1 + \mathrm{E}_0[R_{0,T}]} \tag{OA1}$$

where $\mathrm{E}_0[R_{0,t}]$ is the fair discount rate for the time t flows, made up of explicit cash payments, if any, and the non-pecuniary convenience benefits. Consequently, the discount rate at each maturity captures both a pure risk-free discount, as well as a potential risk adjustment on account of the time-variation in convenience flows. To see explicitly how the expected returns are determined, consider a hypothetical security that only earns the time $t < T$ convenience flow with time 0 price $P_{0,t}$. The hold-to-maturity return is a function of the state variable X_t:

$$1 + R_{0,t} = \frac{b + f(X_t)}{P_{0,t}}. \tag{OA2}$$

Suppose the aggregate market return $R^M_{0,t}$ prices assets and is itself a function of the same state variable. In that case, the expected hold-to-maturity returns are given by:

$$\mathrm{E}_0[R_{0,t}] = R^f_{0,t} + \Lambda \,\mathrm{Cov}_0\left(R_{0,t}, R^M_{0,t}\right), \tag{OA3}$$

where Λ captures risk aversion.

If the convenience service flow is good precisely when the market return is poor, the covariance term is negative and the expected return on the hypothetical single convenience flow paying bond will be below the frictionless risk-free rate. As a result, the price of the bond as calculated in Equation (OA1) depends on such covariance terms as well.

By contrast, consider a zero-coupon bond with maturity date t but with no associated convenience services. The present value of this bond is just

$$P^f_{0,t} = \frac{1}{1 + \mathrm{E}_0[R^f_{0,t}]}, \tag{OA4}$$

where the superscript f indicates the frictionless risk-free rate. Because the single cash-flow is fixed, the hold-to-maturity expected returns do not reflect any risk adjustment and are known with certainty at time $t = 0$

$$\mathrm{E}_0[R^f_{0,t}] = R^f_{0,t}. \tag{OA5}$$

The gap, then, between the two expected returns at any maturity t is given by

$$\mathrm{E}_0\left[R^f_{0,t}\right] - \mathrm{E}_0\left[R_{0,t}\right] = -\Lambda\,\mathrm{Cov}_0(R_{0,t}, R^M_{0,t}), \tag{OA6}$$

This simple setup illustrates that in the presence of convenience flows, the hold-to-maturity returns on safe zero-coupon bonds are risky, and the expected returns can therefore reflect a risk adjustment. Our empirical analysis is motivated by Equation (OA6): the gap in hold-to-maturity returns (or, equivalently, yields) is proportional to the covariance of hold-to-maturity returns—inclusive of the convenience flows—with the market return.

In practice, we do not observe the value of the non-pecuniary flows accruing to the bondholder, making it impossible to estimate Equation (OA6) directly. We do, however, observe a proxy for the present value of such convenience flows. Our empirical analysis, therefore, proceeds by calculating the single-period returns on bonds with convenience flows and estimating their covariance with market returns.

Let r_t with a single subscript denote the single-period log returns and let k_t denote the log convenience flow in period t. By the Campbell and Shiller (1988) decomposition, the log price of the bond described in Equation (OA1) follows[16]

$$p_t \approx \frac{c}{1-\rho} + \mathrm{E}_t\left[\sum_{j=0}^{T-1} \rho^j[(1-\rho)k_{t+j+1} - r_{t+j+1}]\right], \tag{OA7}$$

where $\rho = 1/\left(1+\exp(\overline{k-p})\right)$ is a constant depending on the unconditional level of the convenience yield and $c = -\ln(\rho) - (1-\rho)\ln(1/\rho - 1)$.

The time $t+1$ return on the bond exclusive of the convenience flows is just $p_{t+1} - p_t$ (recall we do not observe the convenience flows so we cannot calculate a with-dividend return):

$$xr_{t+1} = p_{t+1} - p_t = (\mathrm{E}_{t+1} - \mathrm{E}_t)\left[\sum_{j=1}^{T-1} \rho^j[(1-\rho)k_{t+j+1} - r_{t+j+1}]\right] - \mathrm{E}_t[(1-\rho)k_{t+1} - r_{t+1}], \tag{OA8}$$

and the surprise returns at time $t+1$ are given by

$$sr_{t+1} = (\mathrm{E}_{t+1} - \mathrm{E}_t)\,(xr_{t+1}) = (\mathrm{E}_{t+1} - \mathrm{E}_t)\left[\sum_{j=1}^{T-1} \rho^j[(1-\rho)k_{t+j+1} - r_{t+j+1}]\right]. \tag{OA9}$$

In words, the surprise return on the bond with convenience flows equals the innovation to the discounted value of the expected convenience flows, minus the innovations to expected returns.

The surprise return on the bond without convenience flows can be calculated in a similar manner. Let $r^{f,T}_t$ denote the single-period return on the safe bond with maturity T and a coupon rate set to

[16] See Campbell (2017) Section 5.3 for derivation.

equal the unconditional level of the convenience yield. The surprise return on the bond is given by:

$$sr_{t+1}^{f,T} = (\mathrm{E}_{t+1} - \mathrm{E}_t)\left[-\sum_{j=1}^{T-1} \rho^j r_{t+j+1}^{f,T}\right]. \tag{OA10}$$

With these two return innovations in hand we are in position to calculate the exposure of convenience flows to market returns. The difference in the surprise return in Equation (OA9) and Equation (OA10) captures the return due to changes in expected convenience flows, as well as changes in the risk premium:

$$sr_{t+1} - sr_{t+1}^{f,T} = (\mathrm{E}_{t+1} - \mathrm{E}_t)\left[\sum_{j=1}^{T-1} \rho^j [(1-\rho)k_{t+j+1} - r_{t+j+1} - r_{t+j+1}^{f,T}]\right] \tag{OA11}$$

$$= (\mathrm{E}_{t+1} - \mathrm{E}_t)\left[\sum_{j=1}^{T-1} \rho^j [(1-\rho)k_{t+j+1} - rp_{t+j+1}]\right], \tag{OA12}$$

where in the second equation rp stands for the risk premium: the gap between returns on the bond with convenience yield minus the return on the bond without such convenience flows. With the surprise returns in hand we are able to estimate the covariance between innovations to convenience flows (inclusive of risk premium innovations) and market returns:

$$\mathrm{Cov}\left(sr_{t+1} - sr_{t+1}^{f,T}, r^M\right). \tag{OA13}$$

In our empirical work we estimate Equation (OA13) with rolling lookback windows and then show that it accounts for the level of the convenience yield, as described in Equation (OA6). Namely, we regress proxies of the Treasury convenience yield on the conditional covariance between the stock market and the Premium component of nominal Treasury returns.

OA.B Appendix Tables

Panel A. Correlation matrix.

	Cov(Tr 10y, St.)	Cov(Prem. 10y, St.)	Cov(Rf 10y, St.)	Cov(CDS 10y, St.)
Cov(Tr 10y, St.)	1.000			
Cov(Prem. 10y, St.)	0.644***	1.000		
Cov(Rf 10y, St.)	0.431***	-0.391***	1.000	
Cov(CDS 10y, St.)	-0.192***	-0.074	-0.354***	1.000

Panel B. Autocorrelations.

	2005-2022			
	Cov(Tr 10y, St.)	Cov(Prem. 10y, St.)	Cov(Rf 10y, St.)	Cov(CDS 10y, St.)
L.Cov(Tr 10y, St.)	0.664***			
	(9.05)			
L.Cov(Prem. 10y, St.)		0.656***		
		(2.60)		
L.Cov(Rf 10y, St.)			0.516***	
			(5.34)	
L.Cov(CDS 10y, St.)				0.427***
				(3.64)
Constant	-0.141***	-0.064**	-0.141***	0.032***
	(-3.60)	(-2.03)	(-2.70)	(3.57)
Observations	227	227	227	227
R^2	0.441	0.430	0.266	0.182

Table OA1: Correlation Coefficients. Autocorrelation Coefficients of the Stock-Bond Covariance Components. Panel A shows the correlation matrix of the aggregate stock-bond covariance and its components corresponding to the convenience yield, the risk-free rate, and the CDS rate. Panel B reports the autocorrelation coefficients of the four stock-bond covariance measures. Monthly data 2005-2023. Heteroskedasticity and autocorrelation robust t statistics in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. The regression specification is

$$\mathrm{Cov}_t = a + b \times \mathrm{Cov}_{t-1} + \epsilon_t$$

where Cov_t stands for the indicated component of the stock-bond covariance.

Panel A. Correlation matrix.

	Prem. 10y	GC-Tr 3m	FF-Tr 3m	-1*Z-Spr.	Libor Spr. 30y	FN-Tr 30y	Rich. 10y	Box USD 2y
Prem. 10y	1.000							
GC-Tr 3m	0.223***	1.000						
FF-Tr 3m	0.041	0.542***	1.000					
-1*Z-Spr.	0.304***	0.356***	0.076	1.000				
Libor Spr. 30y	0.033	0.256***	0.541***	-0.152**	1.000			
FN-Tr 30y	0.371***	0.248***	0.338***	0.351***	0.268***	1.000		
Rich. 10y	0.262***	0.160**	0.463***	-0.025	0.737***	0.475***	1.000	
Box USD 2y	0.417***	0.421***	0.573***	0.472***	0.563***	0.709***	0.551***	1.000

Panel B. First PC Loadings.

	2005-2023						2005-2022	2005/9-2020/7
	Prem. 10y	GC-Tr 3m	FF-Tr 3m	-1*Z-Spr.	Libor Spr. 30y	FN-Tr 30y	Rich. 10y	Box USD 2y
PC1	0.037*	0.048***	0.128***	0.028**	0.163***	0.108***	0.098***	0.107***
	(1.85)	(5.32)	(5.43)	(2.05)	(6.69)	(4.54)	(9.06)	(5.71)
Constant	0.256***	0.130***	0.084***	0.143***	-0.136***	0.481***	0.080***	0.323***
	(13.62)	(9.93)	(4.25)	(8.75)	(-3.50)	(15.72)	(4.45)	(20.00)
Observations	228	228	228	228	228	228	216	179
R^2	0.166	0.393	0.596	0.093	0.537	0.440	0.615	0.677

Table OA2: Convenience Yield Proxy Variation Explained by the First Principal Component. Panel A shows the correlation matrix of the eight main proxies of the convenience yield. Panel B reports regressions of the convenience yield proxies on the first principal component (PC1). Monthly data 2005-2023. Heteroskedasticity and autocorrelation robust t statistics in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. The regression specification is

$$\text{CONV}_t = a + b \times \text{PC1} + \epsilon_t$$

where CONV_t stands for the indicated convenience yield proxy.

Panel A. First PC Loadings. Short maturity principal component.

	2005-2023						2005-2022	2005/9-2020/7
	Prem. 10y	GC-Tr 3m	FF-Tr 3m	-1*Z-Spr.	Libor Spr. 30y	FN-Tr 30y	Rich. 10y	Box USD 2y
Short PC1	0.028*	0.088***	0.160***	0.066***	0.108***	0.084***	0.050***	0.105***
	(1.71)	(12.29)	(5.65)	(3.60)	(4.11)	(2.58)	(2.90)	(3.65)
Constant	0.256***	0.130***	0.084***	0.143***	-0.136**	0.481***	0.085***	0.332***
	(12.86)	(22.12)	(3.50)	(9.75)	(-2.41)	(12.76)	(2.71)	(13.29)
Observations	228	228	228	228	228	228	216	179
R^2	0.056	0.796	0.552	0.301	0.141	0.160	0.087	0.372

Panel B. First PC Loadings. Long maturity principal component.

	2005-2023						2005-2022	2005/9-2020/7
	Prem. 10y	GC-Tr 3m	FF-Tr 3m	-1*Z-Spr.	Libor Spr. 30y	FN-Tr 30y	Rich. 10y	Box USD 2y
Long PC1	0.049**	0.029**	0.108***	0.015	0.200***	0.129***	0.128***	0.112***
	(2.06)	(2.14)	(3.52)	(0.93)	(5.50)	(5.17)	(13.95)	(5.68)
Constant	0.256***	0.130***	0.084***	0.143***	-0.136***	0.481***	0.081***	0.331***
	(13.89)	(8.27)	(3.16)	(8.57)	(-3.76)	(15.79)	(6.65)	(16.97)
Observations	228	228	228	228	228	228	216	179
R^2	0.215	0.110	0.316	0.020	0.608	0.468	0.817	0.586

Table OA3: Convenience Yield Proxy Variation Explained by the First Principal Component. Short and long maturity Principal Components. The regression specification is

$$\text{CONV}_t = a + b \times \text{PC1} + \epsilon_t$$

where CONV_t stands for the indicated convenience yield proxy and

$\text{PC1} \in \{\text{Short PC1}, \text{Long PC1}\}$

as indicated in the table.

Panel A.

	2005-2023						2005-2022	2005/9-2020/7
	F.Prem. 10y	F.GC-Tr 3m	F.FF-Tr 3m	F.-1*Z-Spr.	F.Libor Spr. 30y	F.FN-Tr 30y	F.Rich. 10y	F.Box USD 2y
Cov(Tr 10y, St.)	-0.080**	-0.024**	-0.059*	-0.010	-0.068*	-0.147***	-0.073***	-0.095***
	(-2.12)	(-2.02)	(-1.67)	(-0.42)	(-1.94)	(-4.98)	(-5.33)	(-3.21)
Eff. Fed Funds	0.012**	0.015	0.068***	-0.000	0.110***	0.050***	0.060***	0.062***
	(2.12)	(1.12)	(2.92)	(-0.06)	(2.80)	(3.51)	(4.96)	(5.35)
Constant	0.204***	0.098***	-0.041	0.140***	-0.330***	0.345***	-0.022	0.222***
	(10.27)	(4.77)	(-1.42)	(7.08)	(-6.32)	(8.95)	(-0.62)	(12.86)
Observations	227	227	227	227	227	227	215	179
R^2	0.204	0.058	0.191	0.004	0.278	0.267	0.272	0.322

Panel B.

	1996-2023	1996-2022	1991/5-2023			1972-2023	
	F.Libor Spr. 30y	F.Rich. 10y	F.GC-Tr 3m	F.FF-Tr 3m	F.-1*Z-Spr.	F.FF-Tr 3m	F.-1*Z-Spr.
Cov(Tr 10y, St.)	-0.057*	-0.065***	-0.021*	-0.041	-0.016	-0.067	-0.013
	(-1.82)	(-4.39)	(-1.78)	(-1.46)	(-0.84)	(-1.27)	(-0.73)
Eff. Fed Funds	0.140***	0.082***	0.026***	0.074***	-0.022***	0.171***	-0.035***
	(6.64)	(5.98)	(3.89)	(5.82)	(-4.67)	(9.92)	(-6.95)
Constant	-0.292***	-0.016	0.070***	-0.043	0.135***	-0.234***	0.165***
	(-5.59)	(-0.45)	(3.81)	(-1.47)	(7.10)	(-3.48)	(7.82)
Observations	323	311	391	391	391	623	623
R^2	0.452	0.427	0.145	0.161	0.139	0.442	0.247

Table OA4: Stock-Bond Covariance and Proxies of the Treasury Convenience Yield. Left-hand-side variables are proxies of the convenience yield. The right-hand-side variables are the aggregate stock-bond covariance and the effective Fed funds rate. Right-hand-side variables lagged by one month. Monthly data 2005-2023. Heteroskedasticity and autocorrelation robust t statistics in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. The regression specification is

$$\mathrm{CONV}_t = a + b \times \mathrm{Cov(Tr\ 10y,\ St.)} + c \times \mathrm{Eff.\ Fed\ Funds} + \epsilon_t$$

where CONV_t stands for the indicated convenience yield proxy.

Panel A. 2005-2023.

	mean	p1	p10	p50	p90	p99	sd	count
Cov(Tr 10y LW, St.)	-0.45	-4.72	-1.39	-0.24	0.23	1.23	0.99	228
Cov(Tr 10y, MSCI)	-0.38	-3.86	-1.14	-0.22	0.25	1.29	0.85	228
Cov(Raw Tr 10y, St.)	-0.37	-3.49	-1.13	-0.21	0.19	1.06	0.75	228
Corr(Tr 10y, St.)	-0.27	-0.85	-0.72	-0.31	0.32	0.65	0.38	228
Corr(Prem. 10y, St.)	-0.14	-0.65	-0.48	-0.15	0.19	0.38	0.25	228
Corr(Rf 10y, St.)	-0.21	-0.79	-0.66	-0.29	0.35	0.68	0.36	228
Corr(CDS 10y, St.)	0.10	-0.62	-0.24	0.09	0.45	0.68	0.28	228
St. Beta Tr 10y	-0.15	-0.72	-0.45	-0.17	0.20	0.55	0.26	228
St. Beta Prem. 10y	-0.04	-0.25	-0.16	-0.04	0.05	0.15	0.14	228
St. Beta Rf 10y	-0.13	-0.69	-0.41	-0.17	0.22	0.60	0.29	228
St. Beta CDS 10y	0.02	-0.08	-0.02	0.00	0.08	0.18	0.04	228

Panel B. 1991/5-2023.

	mean	p1	p10	p50	p90	p99	sd	count
Cov(Tr 10y LW, St.)	-0.25	-3.63	-1.14	-0.12	0.60	1.48	0.93	392
Cov(Tr 10y, MSCI)	-0.22	-3.42	-0.98	-0.11	0.51	1.29	0.79	392
Cov(Raw Tr 10y, St.)	-0.22	-3.22	-0.99	-0.10	0.44	1.06	0.72	392

Table OA5: Additional Summary Statistics. Panel A: alternative measures of the stock-bond covariance. Correlation with the stock market and stock market beta of the 10-year Treasury bond, separated into terms corresponding to the three constituent elements of the 10-year yield. Monthly data 2005-2023. Panel B: alternative measures of the stock-bond covariance. Monthly data 1991-2023. Data span indicated in brackets if series not available for the full period noted in the panel title.

	PC1, 2005-2023				PC1, 1991/5-2023	
St. Beta Tr 10y	-1.497**				-0.681**	
	(-2.31)				(-2.51)	
St. Beta Prem. 10y		-2.802**				
		(-2.29)				
St. Beta Rf 10y		-1.530**				
		(-2.30)				
St. Beta CDS 10y		-4.945				
		(-1.34)				
Corr(Tr 10y, St.)			-1.309***			-0.598**
			(-2.61)			(-2.31)
Corr(Prem. 10y, St.)				-1.359**		
				(-2.41)		
Corr(Rf 10y, St.)				-0.937*		
				(-1.93)		
Corr(CDS 10y, St.)				-0.574		
				(-1.34)		
Eff. Fed Funds	0.340**	0.359**	0.362**	0.373**	0.279***	0.291***
	(2.15)	(2.26)	(2.32)	(2.36)	(4.52)	(4.52)
Constant	-0.737***	-0.757***	-0.898***	-0.892***	-0.748***	-0.825***
	(-2.83)	(-2.84)	(-3.39)	(-3.36)	(-5.57)	(-5.37)
Observations	228	228	228	228	392	392
R^2	0.147	0.165	0.180	0.172	0.204	0.213

Table OA6: Stock-Bond Correlation, Stock Beta of Bonds, and the 1st Principal Component of Convenience Yield Proxies. The first Principal Component of convenience yield proxies available in the indicated period. The right-hand-side variables are stock betas of the bond returns, separately corresponding to the convenience yield, the frictionless risk-free rate, and the CDS rate, and the stock-bond correlation coefficients, corresponding to the convenience yield, the frictionless risk-free rate, and the CDS rate, as well as the effective Fed funds rate. Heteroskedasticity and autocorrelation robust t statistics in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. Monthly data in the indicated period. The regression specification is

$$\mathrm{PC1}_t = a + b_1 \times \mathrm{Corr} + b_2 \times \mathrm{St.\ Beta} + c \times \mathrm{Eff.\ Fed\ Funds} + \epsilon_t,$$

where the selection of variables in the groups

$$\mathrm{Corr} \in \{\mathrm{Corr(Prem.\ 10y,\ St.)}, \mathrm{Corr(Rf\ 10y,\ St.)}, \mathrm{Corr(CDS\ 10y,\ St.)}\}$$
$$\mathrm{St.\ Beta} \in \{\mathrm{St.\ Beta\ Prem.\ 10y}, \mathrm{St.\ Beta\ Rf\ 10y}, \mathrm{St.\ Beta\ CDS\ 10y}\}$$

is indicated in the table.

OA Online Appendix Figures

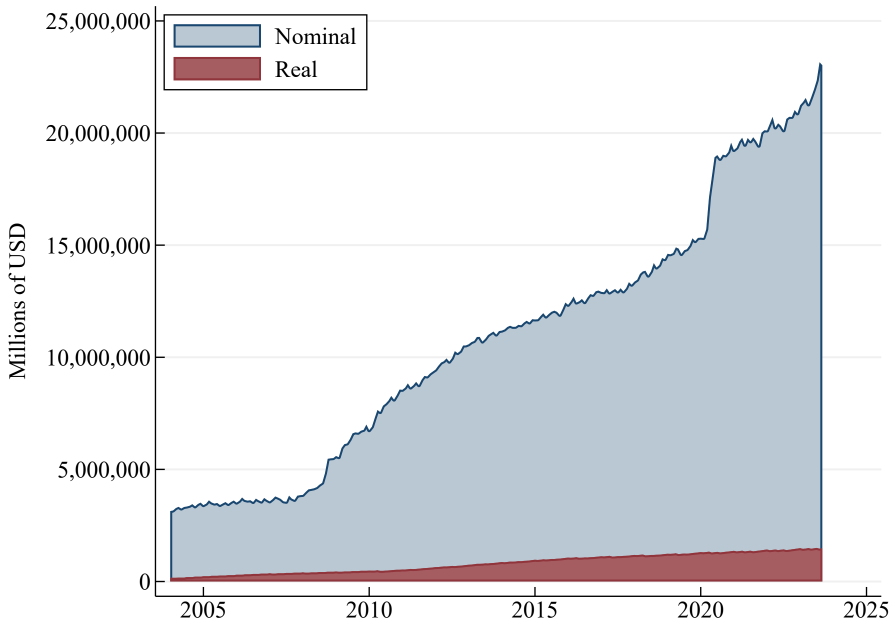

Figure OA1: Nominal and Real Treasuries Outstanding. Dollar value of Treasuries held by the private sector. Monthly calculation.

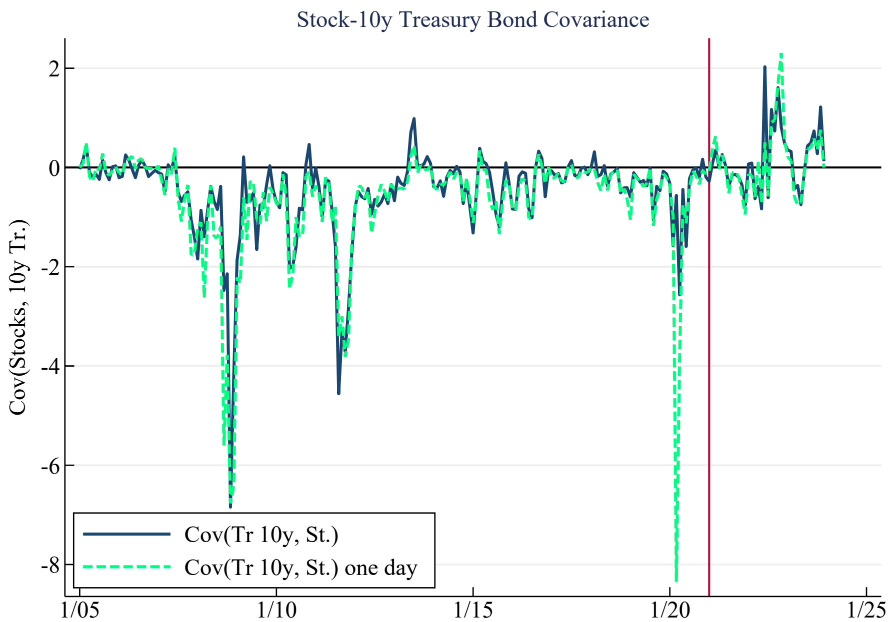

Figure OA2: Stock-bond Covariance. Calculation with three daily returns in blue, calculation with single daily returns in dashed neon green. Monthly data from 2005 to 2023. Vertical line indicates 2021/1.