Unconventional Monetary Policy Spillovers and the (In)convenience of Treasuries*

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February 27, 2026

ABSTRACT

Foreign monetary policy shocks increasingly influence U.S. yields, particularly since the Global Financial Crisis. We show that this heightened sensitivity reflects both the adoption of unconventional monetary policy tools and a decline in the convenience of Treasuries. Using high-frequency identification, we find that when Treasuries command a low convenience premium—behaving more like other assets—they respond more to ECB monetary policy, consistent with increased sensitivity to portfolio rebalancing. A two-country preferred-habitat model with time-varying demand elasticity rationalizes these results: when Treasuries are less convenient, investors' demand for them becomes more elastic on aggregate, amplifying cross-border transmission of policy shocks.

Keywords: Treasuries, convenience yield, monetary policy, international spillovers, quantitative easing, quantitative tightening, preferred habitat investors.

JEL Codes: E44, E52, F42, G12.

*We thank seminar and conference participants at the 2026 ASSA annual meetings, the 2025 Fed System Conference on Financial Institutions, Regulations and Markets, the 2025 West Coast Workshop on International Finance, Women in International Economics 2025, Midwest Macro 2025, the 2025 Meeting of the International Finance and Banking Society, the 2025 Fed System Committee on International Economic Analysis, the 2025 Conference of the International Journal of Central Banking, the Federal Reserve Bank of Kansas City, University of Tennessee, Knoxville, University of Indiana Bloomington, and Midwest Economics 2025 for helpful comments and suggestions. We further thank Galina Hale, Amy Huber, Sebastian Infante, Maria Jose Carreras, and Jenny Tang for providing thoughtful discussion and comments.

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1 Introduction

Since the end of the Second World War, US Treasury securities have occupied a singular role in the international financial system as the world's unrivaled safe asset. Their privileged status derives not only from cash flows free of default risk, but also from their unmatched "convenience." Deep and liquid markets, broad regulatory compatibility, and the ability to serve as high-quality collateral for a diverse set of financial institutions combine with the US dollar's reserve currency status to grease the wheels of the global financial system. As a consequence of the dollar's ubiquity in international trade and finance, safe dollar-based fixed income assets—Treasuries in particular—command a persistent premium in their pricing, reflecting structural demand from domestic and international investors. This premium, often termed the "convenience yield," captures the value that investors derive from the non-pecuniary benefits of holding Treasuries relative to other instruments with comparable credit risk.

Due to their non-remunerative properties, demand for Treasuries has come to be treated as relatively inelastic ((Krishnamurthy & Vissing-Jorgensen, 2012)). However, developments since the Global Financial Crisis (GFC) strongly suggest that these characteristics, and therefore the elasticity of Treasury demand, can vary with time. Seismic shifts in the market for Treasuries since the GFC have engendered explosive growth in the literature on the changing uniqueness or convenience thereof. Growing net supply of Treasuries[1], falling intermediation capacity of dealer banks due to post-GFC regulatory reforms[2], and persistently under- and then over-target inflation[3] have all seemingly contributed to a diminution in the convenience of Treasuries.

Against this backdrop, we provide new evidence that variation in the Treasury convenience yield is not merely an empirical artifact, but a powerful latent amplifier of international shock transmission to the US Treasury market, and by extension to US financial markets more broadly. In particular, we highlight how fluctuations in Treasury convenience influence both the magnitude and persistence of spillovers from unconventional monetary pol-

[1](Greenwood, Hanson, & Stein, 2015); (Krishnamurthy & Vissing-Jorgensen, 2012); (Nagel, 2016)
[2](Du, Hébert, & Li, 2023), (Du, Hébert, & Huber, 2023), (Duffie, 2023); (Klingler & Sundaresan, 2023)
[3](Campbell, Sunderam, Viceira, et al., 2017); (Acharya & Laarits, in press)

icy (UMP) in other advanced economies, with specific attention to post-GFC behavior of the US term premium. Prior to the GFC, spillovers from foreign central banks to the US financial system were thought to be limited, owing largely to the outsized role of the United States in global capital markets. Pre-GFC, international transmission of conventional monetary policy was muted by the dominant position of the United States in international finance[4].

Prolonged periods at the effective lower bound (ELB) on interest rates and the consequent expansion of unconventional monetary tools have profoundly altered this landscape. A growing body of work documents that unconventional monetary policy in major advanced economies has substantial cross-border effects (see, e.g., (Fratzscher, Lo Duca, & Straub, 2018); (Dedola, Georgiadis, Gräb, & Mehl, 2021); (Neely, 2015)). A much smaller group of papers shows that these unconventional spillovers extend even to the US. For eaxample, (Rogers, Scotti, & Wright, 2018) and (Rogers et al., 2014) show that ECB asset purchases lowered yields not only in the euro area but also in global bond markets, including the United States. In addition, (Miranda-Agrippino & Nenova, 2022) compare the bilateral spillovers from Fed and ECB actions, finding broadly similar patterns across the two central banks.

Theoretical and empirical studies suggest that the critical difference between conventional and unconventional policy lies in UMP's unique reliance on portfolio rebalancing to loosen domestic financial conditions, and that this same force intensifies international spillovers ((Gourinchas, Ray, & Vayanos, 2025), (Kearns, Schrimpf, & Xia, 2023)). However, while the mechanisms and import of the portfolio rebalancing channel are well-appreciated theoretically, empirical estimates quantifying its import for the propagation of international shocks remain scarce. While previous empirical work establishes that foreign UMP can generate spillovers to the US, they do not explain how or why the magnitude of spillovers varies over time.

Our work fills these gaps by providing robust empirical evidence that portfolio rebalancing is the dominant channel for foreign spillovers to the US Treasury market, and that the degree to which Treasuries are subject to portfolio rebalancing hinges on Treasuries' "specialness". When the convenience yield declines, Treasuries resemble other safe assets more closely, becoming subject to heightened rebalancing flows and increased US vulnerability to

[4](Ehrmann & Fratzscher, 2005); (Rogers, Scotti, & Wright, 2014)

external shocks. In this sense, the time spent at the effective lower bound offers a laboratory in which to explore the potential consequences of "convenience lost".

Thus, our paper also advances the convenience yield literature by moving beyond understanding the determinants and drivers of the convenience yield — a focus of much prior theoretical work[5] — to studying the macroeconomic consequences of its time variation. While convenience yields have been modeled extensively (particularly for US Treasuries), the implications of their variation for other macroeconomic aggregates and for the transmission of monetary policy are far less explored. We provide both theoretical reasoning and empirical validation that changes in convenience premia materially affect domestic financial market conditions and the effectiveness of monetary policy.

Along those lines, our work most closely resembles (Kekre & Lenel, 2024). Although predominantly interested in the risk-bearing properties of international financial investors and the possibility of a safety trap, the authors are very clear in noting that "all of the paper's insights only rely on time variation in the convenience yield".[6] Our approach explores additional facets of unconventional monetary policy, most notably the differential impact of time-varying Treasury substitutability across the yield curve, which can alter the efficacy of conventional monetary policy.

Finally, we situate our contribution within the growing literature on "exorbitant privilege" ((Gourinchas & Rey, 2007), (Caballero, Farhi, & Gourinchas, 2008), (Chen, Jiang, Lustig, Van Nieuwerburgh, & Xiaolan, 2025)), a concept capturing the benefits accrued to the United States from the global dominance of its sovereign debt and currency. Conceptually, exorbitant privilege can be understood to insulate the US economy from foreign monetary policy shocks by virtue of structural demand for Treasuries and their unique safe-asset status. However, our paper demonstrates that erosion of this privilege — closely associated with a declining convenience yield — substantially increases the susceptibility of US Treasury yields to foreign monetary shocks and reduces the effectiveness of countervailing US monetary policy. This erosion

[5] see e.g., (Hassan, 2013), (Gopinath et al., 2020), (Mukhin, 2022), (Koijen & Yogo, 2025)

[6] (Kekre & Lenel, 2024) solve and calibrate a standard open economy New Keynesian model, adding heterogeneity of country-level risk bearing capacity and non-pecuniary utility derived from holding domestic bonds. The latter introduces a time-varying wedge in the Euler equations of the domestic investors which the authors label as the convenience yield. Shocks to this wedge ("safety shocks") propagate throughout macroaggregates proportionally.

has broad implications for policymakers and financial market participants, calling into question longstanding assumptions regarding the resilience of US financial markets in a changing global environment.

Our approach is three-fold. First, we use high frequency identification to extract intraday monetary policy surprises from the European Central Bank (ECB) as in (Altavilla, Brugnolini, Gürkaynak, Motto, & Ragusa, 2019). While much of the existing spillover literature focuses on the Federal Reserve, we emphasize the ECB as a source of international monetary shocks, especially at the effective lower bound. Our analysis reveals that ECB-induced spillovers to the US Treasury market have grown substantially over time, particularly at the long end of the yield curve through changes in the term premium. We find that the intensity and persistence of these spillovers are especially pronounced at intermediate and long maturities, where investor segmentation and duration risk exposure are strongest.

Second, we empirically link heightened spillovers directly to observable measures of Treasury specialness, using the maturity-matched swap spread. Having established that spillovers rise when the convenience premium falls, we document that "inconvenience" is strongly linked to other proxies of Treasury substitutability, like the return correlation between Treasuries and German Bunds.

Third, we motivate our findings with the two-country preferred-habitat model of (Gourinchas et al., 2025), in which segmented clienteles exhibit stable demand for bonds of particular maturities and currencies while global arbitrageurs reallocate under capital constraints. We highlight how the expected change in US yields following foreign UMP directly depends on the covariance between US and foreign bond yields. This approach captures how the marginal valuation of Treasuries and their substitutability vary over time, resulting in state-dependent spillover effects. Critically, the model predicts the empirical pattern that foreign asset purchases have more pronounced effects on US yields during periods of waning Treasury convenience.

The model yields testable implications that are consistent with our empirical findings. Primarily, when Treasury convenience is high, Treasuries are an "expensive" substitute for EU sovereign bonds, limiting the responsiveness of US term premia to foreign net bond supply shocks and providing insulation against spillovers. Conversely, low convenience entails

increased substitutability across sovereign bonds, intensifying co-movement in international long-term yields.

Time-varying substitutability of Treasuries has important implications for both fiscal and monetary policy. For instance, our results suggest that the persistently low long-term interest rates and yield curve inversion observed between the GFC and the Covid-19 pandemic were driven in part by international spillovers fueled by the combination of US quantitative tightening and large-scale asset purchases by other advanced economies. By removing expectations for the Federal Reserve to absorb Treasury issuance, quantitative tightening increased net Treasury supply and reduced private demand. Simultaneously, the tightening of US monetary policy dampened expected returns on long-term Treasuries. Dealers and leveraged investors, constrained by balance sheet costs, struggled to intermediate increased supply, resulting in diminished Treasury convenience. In this environment, ongoing large-scale asset purchases in the Euro Area further depressed long-term US Treasury yields, while US policy tightening raised short-term rates, reshaping the yield curve in a manner consistent with the predictions of our model. Our conclusions suggest that policy asynchronicity contributes to, and interacts with, a declining convenience yield to hamper the effectiveness of US conventional monetary policy in enacting its goals.

2 Motivation and Background: Spillovers at the Effective Lower Bound

Over long stretches of history, central banks have largely conducted monetary policy by buying and selling short-term debt and, in most circumstances, target short-term interest rates. However, at the effective lower bound, the availability of cash as an asset prevents stimulus from decreasing the short-term policy rate indefinitely below zero. Beyond the effective lower bound of interest rates, central banks have enacted a suite of policies such as direct lending, liquidity provision to key credit markets, and large-scale asset purchases in pursuit of their mandates. While directed lending and liquidity provision featured prominently in the crisis phase of the last two recessions, large-scale asset purchases (LSAPs) became a key part of central banks' strategy to aid the recovery of aggregate demand. These large-scale asset

purchases, coupled with forward guidance regarding the path of policy, aim specifically to lower long-term interest rates through heavier management of expectations and adjustments to term premia.

To distinguish between conventional and unconventional monetary policy channels, it is convenient and common to consider the yield on an n-period risk-free bond as the average level of short-term interest rates over the maturity of the bond and a term premium:

$$Y_t^{(n)} = \mathbb{E}[\bar{Y}_{t,t+n}|I_t] + YTP_t^{(n)} \tag{1}$$

where $\mathbb{E}[\bar{Y}_{t,t+n}|I_t]$ is the average short-term rate expected to prevail over the period t to $t+n$ (that is, the component of the yield that would drive its variation if the expectations hypothesis were to hold exactly), and $YTP_t^{(n)}$ is a maturity-specific term premium. The expected path of interest rates reflects beliefs about the likely path of short rate policy, which in turn is influenced by beliefs about the monetary policy rule, coupled with the likely path of growth and inflation. As the maturity of the bond lengthens, expectations about the path of interest rates give way to risk, as individuals' perceptions of the path become less certain. The price and quantity of that risk is reflected in the term premium, which captures the additional required compensation for holding a long-term bond.

Conventional monetary policy enacted through policy rates operates chiefly via the expected path of short rates, as both the policy decision and forward guidance alter agents' perceptions of future interest rates ((Hamilton, 2009)). The spillover effects from changes in the expected path of interest rates abroad primarily transmit through foreign growth rates, exchange rate adjustments, and risk taking by financial intermediaries. Due to its size and centrality, the United States is comparatively insulated (although not immune) from these types of spillovers. Although conventional monetary policy can also move the domestic term premium by altering interest rate risk, there is little theoretical or empirical evidence to suggest that these changes generate international spillovers to the US.

Unconventional monetary policy also influences both terms of equation (1). On the expected path of short rates ($\mathbb{E}[\bar{Y}_{t,t+n}|I_t]$) in the first term, expansionary forward guidance lowers the expected path of interest rates by communicating the central bank's intention to keep interest rates low (or to pursue ongoing asset purchases), committing often to a specific time

horizon or state of fundamentals. This signaling channel of unconventional monetary policy carries the same potential to generate international spillovers as conventional means—international bank balance sheets, exchange rates, the current account.

Because the role of the expected path of short interest rates shrinks with maturity, monetary policy at the effective lower bound also aims to decrease longer term rates by decreasing term premia. They do so by purchasing long duration assets, reducing their effective supply and in turn raising their prices and lowering their yields. In so doing, LSAPs remove duration risk from the market along the lines laid out by preferred-habitat models like (Greenwood & Vayanos, 2014) and (Vayanos & Vila, 2021). As investors rebalance their portfolios in response to LSAPs, the prices of the assets they acquire rise as well, decreasing their respective yields and term premia.

From the central bank's perspective, the ideal investor reaction to LSAPs entails substituting the purchased asset with another domestic asset, like a corporate bond. However, LSAPs also operate through additional channels that shape their passthrough, such as the liquidity, interest rate uncertainty and prepayment risk channels emphasized by (Krishnamurthy & Vissing-Jorgensen, 2011) and ((2013)). These same authors also emphasize what they label a safety channel: because not all default-risk-free assets meet the safety demands of "displaced" clientele, a reduction in the effective supply of safe sovereign assets does not uniformly affect all assets of a similar maturity. In particular, the safety channel attenuates the total response in assets that price some risk absent from the domestic sovereign bonds (like prepayment risk in the case of US mortgage-backed securities), and amplifies the response of assets that are most similar. Therefore, in some circumstances and for some investors, foreign sovereign bonds are among the best substitutes. In this case, investors displaced from their target allocation by home LSAPs may restore their balance sheet by purchasing safe, long duration sovereign bonds elsewhere, raising their price and lowering their yield. In this way, unconventional monetary policy uniquely potentiates spillovers because expansionary policy with strong portfolio balance effects has the potential to decrease *international* term premia at the long end of the yield curve.[7]

[7] Although the other channels of QE, like liquidity, prepayment, and fragmentation risk have been found influential in driving passthrough *within* the US and European economies, we focus on the duration and safety channels because within the advanced economy safe-asset complex, credit risk is negligible and assets are close

2.1 Time-varying spillovers

Thus we should expect, and previous research has shown, that spillovers rise with the global adoption of unconventional monetary policy due to its unique reliance on long-duration assets (portfolio rebalancing). However, the literature on unconventional monetary policy transmission suggests that the strength of the portfolio balance channel can vary over time. For example, (Droste, Ray, & Gorodnichenko, 2023) show that local supply effects of Treasury demand shocks are most obvious during periods of elevated risk. That is, LSAPs are less likely to be "spot" effective at a particular tenor when the risk bearing capacity of arbitrageurs is high. Given that preferred-habitat investors become less willing to substitute to other maturities of the same broad asset when risk bearing capacity is low, we surmise that willingness to substitute between international markets could be suppressed under these conditions. Alternatively, investors may require a deeper discount to substitute their holdings, amplifying the change in price.

For initial evidence of time variation in monetary policy spillovers, consider a series of rolling regressions using zero coupon bond yields from (Gürkaynak, Sack, & Wright, 2007).[8] From January 2000, through December 2022, we regress n-year Treasury yields on intraday ECB monetary policy surprises over windows covering 24 - 25 ECB announcement dates (i.e., dates on which the ECB made a monetary policy announcement).[9] Because t indexes days on which the ECB made an announcement, the window corresponds to 700 calendar days.

$$\Delta Y_t^{(n)} = \alpha + \beta MP_t^{eu} + \epsilon_t$$

Throughout our paper, monetary policy surprises (MP_t^{eu}) comprise the first principal component of intraday changes in the yields on a number of assets, measured from 10-20 minutes pre-decision release to 10 - 20 minutes post-press conference, from (Altavilla et al., 2019). These include 1-, 3-, 6-, 12-, and 24-month OIS rates, along with 5- and 10-year German and French bond yields. We favor this configuration of assets because monetary policy surprises derived from the cross-section of yields have the advantage of subsuming policies aimed

substitutes along maturity and safety dimensions. To the extent that foreign LSAPs affect liquidity, they would *raise* Treasury yields as LSAPs shrink the liquidity premium.

[8] https://www.federalreserve.gov/pubs/feds/2006/200628/200628abs.html

[9] The timescale begins in March 2003 because January 2000 - March 2003 is the first full estimation window.

at different maturities in the yield curve. Such compound measures summarize shocks to the overall stance of monetary policy both at and away from the effective lower bound. Our choice to use a mix of the French and German bond yields to fill the long end of the yield curve reflects institutional features of ECB policy during much of the ELB period. For much of the sample where LSAPs are relevant, accommodative actions of the ECB were clearly aimed at lowering government bond yields of countries whose sovereign bond markets were coming under significant pressure, rather than German bond yields. We use French yields as the foil because its sovereign assets possess fewer non-pecuniary "safe asset" benefits relative to German bonds, while avoiding the influence of credit risk and crisis-specific dynamics from countries like Spain and Italy. For ease of interpretation, we normalize monetary policy surprises such that a one unit tightening raises two year Euro OIS by 10 basis points (BP).[10]

Figure 1a depicts rolling estimates of ECB spillovers to 1-, 5-, and 10-year US zero coupon bond yields. Several patterns stand out. First, as previous work has shown, spillovers within the period of conventional monetary policy are not statistically different from zero, while the period of unconventional monetary policy is marked by growing spillovers at the longer end of the yield curve. Second, the time period in which spillovers become significant (i.e., when the rolling regressions integrate observations that pull the window's estimate away from zero) varies substantially from the time when the ECB began to engage in quantitative easing (QE).[11] In particular, spillovers from the ECB become statistically significant when rolling regressions integrate observations starting in 2010, well before the start of the Expanded Asset Purchase Program in 2015 (and even before the "whatever it takes" speech in the summer of 2012). Moreover, while spillovers from the ECB last through most of the policy response to Covid, they began to dissipate not when the Pandemic Emergency Purchase Program ended in March of 2022, but when the Fed announced a start to LSAP tapering in November 2021. It seems, therefore, that the prevalence of spillovers to the US emanates from more than the mere fact of ECB LSAPs.

[10] Supplementary appendix Figure 1 displays the time series of monetary policy surprises.

[11] We follow (Bernanke, 2009) in defining QE as a central bank balance sheet expansion focused on the mix of assets that the central bank holds, with explicit consideration for the effect this composition has on credit conditions. This definition distinguishes early ECB policy from the Fed, the Bank of England, and the Bank of Japan. While other central banks orchestrated the growth of their balance sheets as part of their policies of QE, the ECB allowed the discretion of commercial banks and their need for refinancing to drive balance sheet expansion until 2015.

To begin to see why, we return to the decomposition from Equation 1 and repeat rolling regressions with elements of the 10-year yield decomposition as the dependent variable. We utilize the shadow rate term structure model of (Wu & Xia, 2016) to achieve the decomposition.[12] Figure 1b plots the estimated impact of ECB monetary policy shocks on the 10-year term premium and expected path of short rates. Two features emerge that both validate the importance of the portfolio balance channel and suggest its explanatory power varies. First, during intervals marked by the largest spillovers, term premium effects surpass the expected path of short rates. Second, while early spillovers from unconventional monetary policy comprise a more even mix of expected path and term premium spillovers, later spillovers (roughly post-2014) feature larger term premium spillovers. This latter result stands out because the timing overlaps with the announced cessation of US LSAPs; that is, term premium spillovers to the United States featured most prominently when the Federal Reserve was out of sync with other advanced economy central banks, working to withdraw stimulus while other central banks were stepping on the gas.

Taken together, these results suggest that international spillovers evolve not only between conventional and unconventional monetary policy regimes, but also within periods of UMP. While spillovers increase during periods of heavy multilateral large-scale asset purchases, the size of spillovers is clearly changing over time. Importantly, if we ignored the time-varying nature of spillovers, we might conclude there are no spillovers to be found.

The natural question arising from this collection of estimates is: why? The US Treasury market is the world's deepest, most liquid asset market, standing at the center of the US and global financial systems. As a consequence of the dollar's ubiquity in trade and finance, safe dollar-based fixed income assets (and Treasuries in particular) command a premium in their pricing due to structural demand from both domestic and international actors. This premium is reflected in the spread between sovereign bond yields and other risk-free assets of the same maturity and domicile. While the convenience yield has many representations, convenience is ultimately in the eye of the beholder. Throughout this paper, we use the spread between sovereign bond yields and maturity matched overnight index swaps (the swap spread) because the relative convenience it prices matches the incentives of the types of investors we ex-

[12] A high level description of the methodology is provided in Supplementary Appendix (SA) Section 1.

pect to generate spillovers in our model (i.e., those with a preference for sovereign-level credit quality and global arbitrageurs).

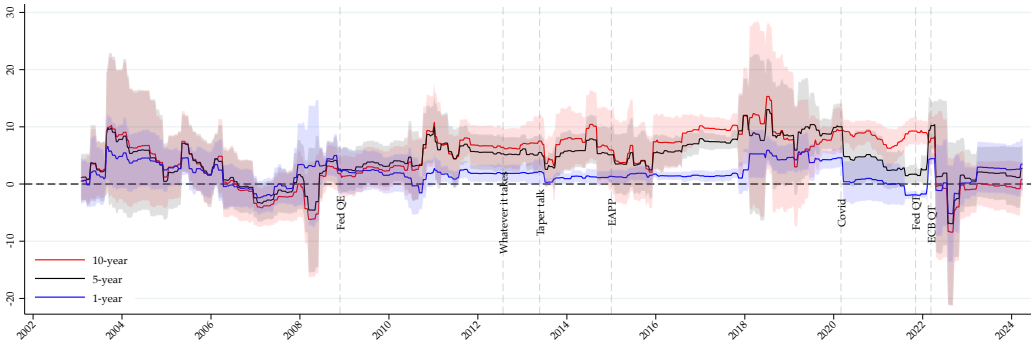
Prior to the Global Financial Crisis, yields on Treasuries ran below the fixed interest rates on swaps of the same maturity. However, the years following the GFC brought about seismic shifts in the global financial and regulatory landscape, and contemporaneous to those changes emerged a diminution and even reversal of this relationship. This attenuation in the convenience yield on Treasuries reflects a degradation in their special status. In the context of international portfolio rebalancing, the less special are long term Treasuries, the more directly substitutable they are for other risk-free long-duration assets, including other safe sovereign bonds.

As a first step to explore the relationship between spillovers to the US term structure and Treasury (in)convenience, we plot in Figure 1c the rolling parameters associated with 10 year yields and term premium ($\beta^{Y}_{(10)}$ and $\beta^{TP}_{(10)}$) against the reverse swap spread ($Y^{(10)}_{US} - OIS^{(10)}_{US}$), which reflects the increasing *inconvenience* of Treasuries since the GFC. We adopt this sign convention throughout our empirical applications for ease of interpretation because Treasury *inconvenience* amplifies the spillover. Estimated spillovers to the 10 year yield and the swap spread are correlated throughout the sample ($\rho = 0.4$), but particularly during the period from 2008 to 2022 ($\rho = 0.7$).

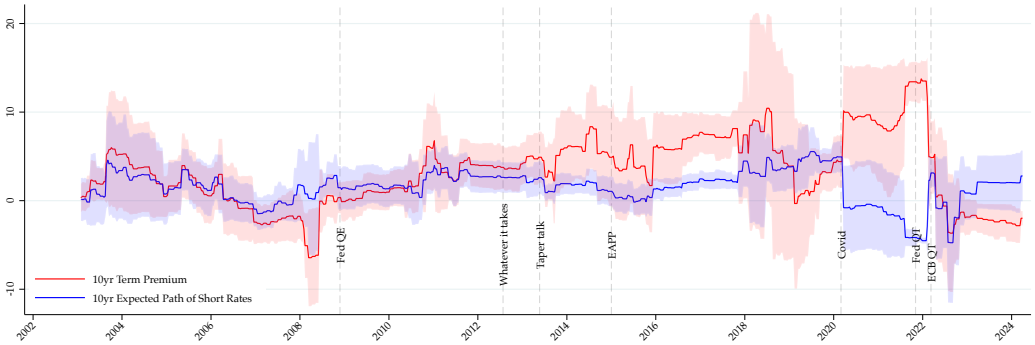
We postulate that time variation in the sensitivity of the US yield curve to unconventional monetary policy spillovers emanates from the increased substitutability associated with diminishing non-pecuniary benefits. Specifically, when Treasuries command a large premium in their price, price-sensitive individuals nudged away from their pre-announcement allocation by the yield compression wrought by LSAPs (or the expectation of LSAPs) are unwilling to pay the premium because it prices characteristics not shared by the assets they seek to replace. The more price-sensitive the marginal investor, the lower would be their willingness to accept the premium associated with the nonpecuniary benefits of Treasuries, and thus the lower would be spillovers from foreign monetary policy. We formalize these and related hypotheses in the following section with a model of time-varying portfolio rebalancing.

Figure 1: Time-varying ECB spillovers to the US yield curve

(a) 1, 5, 10-year Treasury yields



(b) 10-year yield decomposition



(c) Spillovers and Treasury (In)convenience

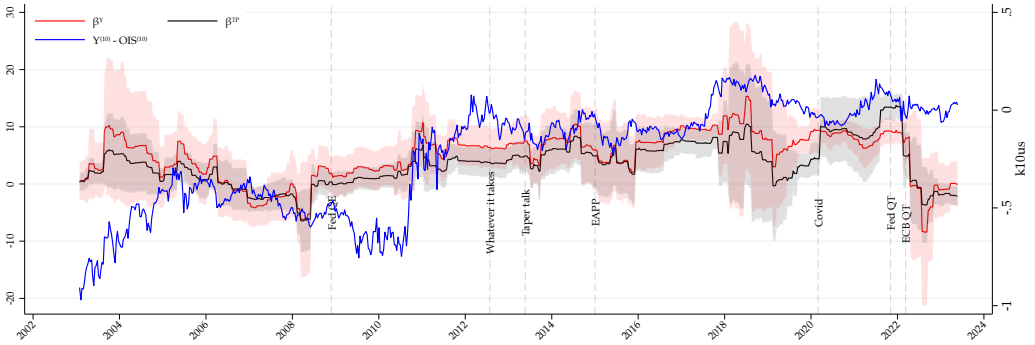


Figure 1 depicts estimates from a 700 business day (24 - 25 announcement) rolling regression of changes in Treasury yields and its decomposition on ECB monetary policy shocks. The timescale begins in March 2003 because January 2000 - March 2003 is the first full estimation window. Figure 1a shows the spillover coefficients to 1-, 5-, and 10-year zero coupon bond yields, while Figure 1b shows spillovers to the 10-year US term premium and expected path of short rates. ECB surprises comprise the first principal component of intradaily changes in the following: 1-, 3-, 6-, 12-, and 24-month OIS rates, plus 5-, 10-year German and French bond yields. Surprises are normalized to raise two year OIS by 10BP. Shaded areas denote 90% robust confidence intervals. Figure 1c plots the parameters corresponding to the term premium and yield at a maturity of 10 years alongside the 10 year reverse swap spread (Y - OIS)

3 A Model of Time-Varying Portfolio Rebalancing

We explore the "specialness" of Treasuries as a key buffer of international spillovers to the United States through the lens of the portfolio rebalancing channel. Pointedly, when the ECB announced the public sector purchase program in March of 2015, policy makers explicitly referenced the accompanying fall in yields in terms not only of a reduction of duration risk, but also the creation of scarcity. In the face of increased scarcity, the preferences of habitat investors for the relative safety, liquidity, and duration of advanced economy sovereign bonds causes these assets' prices (and those of their closest substitutes) to rise because they cannot easily be replaced ((Vayanos & Vila, 2021)). Empirical evidence on inelastic asset markets shows that net supply of debt can indeed explain domestic yields (e.g., (Krishnamurthy & Vissing-Jorgensen, 2011); (Hamilton & Wu, 2012); (Greenwood & Vayanos, 2014); (Wolcott, 2020); (Blattner & Joyce, 2020)).

The existence of a portfolio balance channel relies on the notion of partially segmented asset markets. If investors care only about risk-adjusted returns and view assets as otherwise perfect substitutes, then LSAPs would not affect yields at all, including those of domestic sovereign bonds ((Curdia & Woodford, 2011)). On the other extreme, if global markets are completely segmented, then LSAPs might pass through to domestic assets, but would not generate international spillovers. In practice, investors likely fall between these two extremes. In partially segmented markets, investors view assets in different markets as imperfect substitutes, in which case asset purchases affect yields in both the domestic sovereign bond market and other markets (home and foreign).

Assuming markets are partially segmented, we should expect spillovers among safe sovereign bonds with similar maturities. In such an environment, portfolio rebalancing would direct funds toward the closest substitutes. The greater the dissimilarity between the substitute and the original asset, the larger the discount buyers require to hold the substitute. The degree of substitutability among assets depends both on the extent to which they offer comparable benefits and on the price sensitivity of investors who do not value the differing attributes.

To explore the mechanisms driving international spillovers of unconventional mone-

tary policy to the US Treasury market, we build on the preferred-habitat model developed by (Gourinchas et al., 2025) (hereafter GRV). GRV's framework captures key features of global fixed income markets, including investor segmentation by bond maturity and issuer, as well as heterogeneous preferences that generate partially segmented asset markets. These segmentation patterns arise naturally due to institutional mandates, regulatory constraints, and risk aversion.

The GRV model formalizes demand and supply for sovereign bonds in a two-country setting with segmented markets and constrained global arbitrageurs. These arbitrageurs—limited in their risk-bearing by capital and balance sheet capacity—reallocate portfolios across maturities and countries to exploit relative value opportunities, partially bridging segmentation but never eliminating it. This framework captures how the interaction between preferred-habitat investors and constrained arbitrageurs shapes equilibrium yields, allowing investor preferences and market segmentation to influence bond pricing and the international transmission of monetary policy shocks through the portfolio balance channel.

Beyond reproducing standard portfolio balance effects, GRV's model offers a powerful lens for understanding how the international transmission of monetary policy depends on the type of intervention. In particular, it provides a clear structural distinction between the effects of conventional monetary policy (CMP) and quantitative easing (QE). In the model, a domestic short-rate cut has limited spillover effects: arbitrageurs take on more foreign currency via the carry trade, but because currency returns and long-term bond returns are only weakly correlated, there is little incentive to hedge with foreign bonds. As a result, foreign yields barely move.

By contrast, domestic QE—a direct expansion of demand for long-term bonds—induces arbitrageurs to offload domestic duration risk and rebalance into foreign bonds, which serve as hedges against portfolio volatility. This reallocation lowers foreign yields even in the absence of direct intervention abroad. In GRV's estimates, a 25 bp conventional rate cut leaves foreign yields essentially unchanged, while a QE shock equal to 10% of GDP reduces domestic 10-year yields by around 40 basis points and foreign yields by roughly half that amount, accompanied by only modest currency depreciation.

This asymmetry arises endogenously from how different policies shift the composition

of arbitrageurs' exposures. CMP affects expected returns primarily through the short rate, to which long-duration assets and FX premia are only loosely connected. UMP, by contrast, imposes a direct reallocation of risk-bearing capacity, triggering cross-asset and cross-border adjustments. Stated plainly, when arbitrageurs must fill an LSAP-generated gap that is concentrated at a narrow collection of maturities, their portfolio exposure to duration risk rises, increasing required compensation and lowering the term premium in the neighborhood of those tenors. These effects are strongest when arbitrageurs operate globally—able to move across both currency and maturity dimensions. In a world with segmented arbitrage—where different actors manage bond and FX exposures independently—such spillovers would be sharply attenuated or entirely absent. Even under floating exchange rates and full capital mobility, GRV show that domestic policies can transmit abroad via risk premium adjustments if arbitrage is global and markets are segmented by investor type. The floating exchange rate alone does not fully insulate the yield curve from foreign shocks, especially when unconventional tools are in play.

While GRV's framework successfully captures this cross-market interaction, it implicitly assumes the degree of substitutability across assets is held fixed. In reality, this substitutability likely varies over time with institutional structure, liquidity, regulation, and macroeconomic conditions. We propose that, during periods of elevated Treasury convenience—driven by flight-to-safety flows, dealer balance sheet constraints, or low net issuance—Treasuries may become especially ill-fitting substitutes for other assets, muting spillovers. Conversely, when convenience yields compress, substitutability rises and spillovers intensify.

We thus extend the GRV model by allowing time variation in asset class substitutability, linking these shifts to the observed behavior of the Treasury convenience yield. We introduce a modeling approach that treats the convenience yield as a proxy for the covariance between asset yields, allowing the "specialness" of Treasuries to evolve over time. This extension preserves the preferred-habitat structure while allowing us to analyze how changes in Treasury convenience affect investor substitutability and, in turn, modulate the strength, persistence, and maturity structure of cross-border policy transmission through portfolio rebalancing.

3.1 Modeling environment

The following describes the modeling environment of GRV to familiarize the reader. We emphasize that none of this exposition is novel to our paper, and readers interested for more details should consult GRV.

Time is continuous and there exist two countries, Home (H) and Foreign (F). In each country indexed by $j \in \{H, F\}$ a continuum of zero-coupon government bonds with maturities on the continuum $\tau \in (0, T)$ may be traded. A bond of maturity τ is valued in time t at P_{jt}^{τ} and pays in units of the issuing country's currency in period $t + \tau$. Thus the yield on the country-j bond of maturity τ in period t is standard: $y_{jt}^{\tau} = -\frac{1}{\tau} \log P_{jt}^{\tau}$.

There are three agents in the model. First, currency traders generate a downward sloping demand curve for Foreign currency as a function of the exchange rate e_t[13], deterministic demand ζ_{et}, and stochastic demand shocks γ_t with exposure θ_e:

$$Z_{et} = -\alpha_e \log e_t - (\zeta_{et} + \theta_e \gamma_t) \tag{2}$$

Second, preferred-habitat bond investor clienteles have similar demand functions for bonds in line with (Vayanos & Vila, 2021). Demand is inversely related to log price with elasticity $\alpha_j(\tau)$ which depends on country and maturity. Similar to currency traders, the demand intercept has both a deterministic and stochastic component. $\zeta_j(\tau)$ is a maturity-country specific deterministic demand component. β_{jt} represent stochastic demand shocks alongside exposure intensity $\theta_j(\tau)$.

$$Z_{jt}^{\tau} = -\alpha_j(\tau) \log P_{jt}^{\tau} - \left(\zeta_j(\tau) + \theta_j(\tau) \beta_{jt}\right) \tag{3}$$

Finally, global arbitrageurs are risk-averse (parameter a), trade in all of the asset markets, and choose foreign currency positions (W_{Ft}) and bond positions (X_{Ht}^{τ} and X_{Ft}^{τ}) in order to maximize a mean-variance tradeoff over wealth W_t, treating the Home currency as the numeraire:

[13] Defined as units of Home currency equivalent to a single unit of Foreign currency.

$$\max_{W_{Ft},\left\{X_{Ht}^{\tau},X_{Ft}^{\tau}\right\}_{\tau\in(0,T)}} \mathbb{E}_t\left(dW_t\right) - \frac{a}{2}\mathbb{V}ar_t\left(dW_t\right) \tag{4}$$

$$dW_t = W_t i_{Ht}dt + \underbrace{W_{Ft}\left[\frac{de_t}{e_t} + \left(i_{Ft} - i_{Ht}\right)dt\right]}_{\text{currency carry trade (CCT)}} + \underbrace{\int_0^T X_{Ht}^{\tau}\left(\frac{dP_{Ht}^{\tau}}{P_{Ht}^{\tau}} - i_{Ht}dt\right)d\tau}_{\text{Home bond carry trade (BCT)}}$$
$$+ \underbrace{\int_0^T X_{Ft}^{\tau}\left(\frac{d\left(P_{Ft}^{\tau}e_t\right)}{P_{Ft}^{\tau}e_t} - \frac{de_t}{e_t} - i_{Ft}dt\right)d\tau}_{\text{Foreign BCT}}$$

There are five exogenous shocks: $\boldsymbol{q}_t \equiv \left[i_{Ht}, i_{Ft}, \gamma_t, \beta_{Ht}, \beta_{Ft}\right]^{\top}$. The first two represent conventional monetary policy shocks. The latter three represent demand shocks for Foreign currency, Home bonds, and Foreign bonds respectively. GRV assume these shocks evolve according to

$$d\boldsymbol{q}_t = \Gamma\left(\bar{\boldsymbol{q}} - \boldsymbol{q}_t\right)dt + \Sigma d\boldsymbol{B}_t$$

where $\boldsymbol{B}_t$ is a vector of independent Brownian motion.

3.2 Equilibrium

The equilibrium with global arbitrage features exchange rates and bond yields which are log-affine in the shocks $\boldsymbol{q}_t$:

$$\log e_t = -\left[\boldsymbol{A}_e^{\top}\boldsymbol{q}_t + C_e + \left(\pi_F - \pi_H\right)t\right] \tag{5}$$

$$\log P_{jt}^{\tau} = -\left[\boldsymbol{A}_j\left(\tau\right)^{\top}\boldsymbol{q}_t + C_j\left(\tau\right)\right] \tag{6}$$

where the vectors $\boldsymbol{A}_e$ and $\boldsymbol{A}_j\left(\tau\right)$ as well as scalars C_e and $C_j\left(\tau\right)$ are functions of model parameters. Substituting equations (5) and (6) into the global arbitrageurs' objective (4), and solving the optimization problem we find[14]

$$dy_{jt}^{\tau} = -\frac{1}{\tau}\left(i_{jt} + \boldsymbol{A}_j\left(\tau\right)^{\top}\boldsymbol{\lambda}_t - \frac{1}{2}\|\boldsymbol{A}_j\left(\tau\right)^{\top}\Sigma\|^2\right)dt + \frac{1}{\tau}\boldsymbol{A}_j\left(\tau\right)^{\top}\Sigma d\boldsymbol{B}_t \tag{7}$$

where $\boldsymbol{\lambda}_t = a\Sigma\Sigma^{\top}\left[W_{Ft}\boldsymbol{A}_e + \sum_j \int_0^T \boldsymbol{A}_j\left(\tau'\right)X_{jt}^{\tau'}d\tau'\right]$ is a vector of the market prices of risk with respect to $\boldsymbol{q}_t$. Equation (7) forms the center of our own arguments after a recharacterization in equilibrium. It represents the (instantaneous) change in yield for a country-j bond of maturity

[14] Ito's Lemma is necessary for taking the derivatives of equations (5) and (6)

τ in period t and depends on the local short rate i_{jt}, market prices of risk, and exposure to the shocks.

Finally, the following market clearing conditions prevail assuming zero net supply of assets

$$W_{Ft} + Z_{et} = 0; \qquad X_{jt}^{\tau} + Z_{jt}^{\tau} = 0 \tag{8}$$

where W_{Ft} and X_{jt}^{τ} represent global arbitrageur positions in Foreign currency and bonds respectively. Z_{et} and Z_{jt}^{τ} represent the preferred-habitat currency and bond trader demand.

3.3 The predicted impact of Quantitative Easing

GRV examine the spillover effects of Foreign QE purchases explicitly (β_{Ft}) and show that the global arbitrageurs act as a central lynchpin to produce spillovers in the Home yield curve through general equilibrium effects. Our central question concerns whether these spillover effects which GRV have identified are state-dependent. Specifically, whether the degree of substitutability between Home bonds and Foreign assets could shape the magnitude of these spillovers. GRV make many simplifying assumptions which imply that the yield covariances are fixed through time. Rather than re-derive all of GRV featuring time-variation in a subset of underlying model parameter(s), we use a set of straightforward counterfactuals to generate hypotheses. Consider the conditional drift in the yield for country-j's bond of maturity τ in time period t

$$\mathbb{E}_t[dy_{jt}^{\tau}] = -\frac{1}{\tau}\left(i_{jt} + \boldsymbol{A}_j(\tau)^{\top}\boldsymbol{\lambda}_t - \frac{1}{2}\|\boldsymbol{A}_j(\tau)^{\top}\Sigma\|^2\right)dt \tag{9}$$

A useful quantity, easily derived from equations (7) and (9), is[15]

$$Cov\left(dy_{kt}^{\tau}, dy_{jt}^{\tau'}\right) = \frac{1}{\tau\tau'}\boldsymbol{A}_k(\tau)^{\top}\Sigma\Sigma^{\top}\boldsymbol{A}_j(\tau') \tag{10}$$

Equation (10) shows that the covariance of asset yields depends only on the variance of structural shocks $\Sigma\Sigma^{\top}$ and the asset-maturity specific exposure to those shocks (which encode all general equilibrium effects as well). Notice the simplifying assumptions made in GRV that imply covariance functions are independent of time/state. Plugging in the definition of $\boldsymbol{\lambda}_t$ and equation (10) into (9) and rearranging terms we find

[15]There is a similar quantity for currency using $\frac{de_t}{e_t} = \mu_{et}dt - \boldsymbol{A}_e^{\top}\Sigma d\boldsymbol{B}_t$.

$$\mathbb{E}_t[dy_{jt}^\tau] = -\left[i_{jt}^* + aW_{Ft}Cov\left(dy_{jt}^\tau, \frac{de_t}{e_t}\right) + \sum_k \int_0^T a\tau' X_{kt}^{\tau'} Cov\left(dy_{jt}^\tau, dy_{kt}^{\tau'}\right) d\tau' \right] dt \tag{11}$$

Thus the expected instantaneous yield depends on three terms:

1. The local short rate (net Itô correction)[16]: $i_{jt}^* \equiv i_{jt} - \frac{1}{2}\|\boldsymbol{A}_j(\tau)^\top \Sigma\|^2$
2. How substitutable the bond is for Foreign currency as proxied through $Cov_t\left(dy_{jt}^\tau, \frac{de_t}{e_t}\right)$. This effect is weighted by arbitrageur risk aversion a and the size of arbitrageurs' existing position in Foreign currency W_{Ft}. If arbitrageurs' are already net-long in Foreign currency ($W_{Ft} > 0$), then bonds which are very substitutable with Foreign currency such that $Cov_t\left(dy_{jt}^\tau, \frac{de_t}{e_t}\right) > 0$ will require a lower expected yield to hold in equilibrium.
3. How substitutable the bond is with other bonds $Cov_t\left(dy_{jt}^\tau, dy_{kt}^{\tau'}\right)$, $k \in \{H, F\}$; similarly weighted by arbitrageurs' risk aversion and extant position in the other bonds $X_{kt}^{\tau'}$.

Now consider a surprise QE purchase program. Denote the country-j of interest to be $j = H$ and that the QE purchases happen in Foreign bonds only. We treat this in a simpler way than GRV do; namely we treat the QE shock as a comparative static such that $Z_{Ft}^\tau \mapsto (Z_{Ft}^\tau)' + QE_t(\tau)$.[17] If Z_{Ft}^τ represents the prevailing demand for foreign bonds of maturity τ in period t from preferred-habitat investors, then $QE_t(\tau)$ is an unexpected demand curve shift. The amount of purchases is perfectly inelastic and maturity-specific. However, we allow for the possibility that preferred-habitat investors may choose to rebalance their portfolios such that they now demand $(Z_{Ft}^\tau)'$ due to price effects instead.

Define the change in Home yields in response to an LSAP to be:

$$\Delta\mathbb{E}_t[dy_{jt}^\tau] \equiv \mathbb{E}_t\left[dy_{jt}^\tau \mid QE_t(\tau) \neq 0\right] - \mathbb{E}_t\left[dy_{jt}^\tau \mid QE_t(\tau) = 0\right]$$

Using the demand functions (2) and (3), the market-clearing conditions (8), and assuming the short rates, risk aversion, and covariances are exogenous produces the following:

[16] This is a consequence of mapping into the log domain (yields) from levels (prices) subject to linear shocks. It is the continuous time analog of Jensen's inequality given log is a nonlinear transformation. There is no particular reason to lump this term in with the short rate, other than to leave the other drift terms readily interpretable.

[17] If the reader would prefer the parametric approach of GRV, treat QE purchases as a $\beta_{Ft} > 0$ MIT shock.

$$\begin{aligned}\Delta \mathbb{E}_t[dy^{\tau}_{Ht}] = &-a\alpha_e Cov\left(dy^{\tau}_{Ht}, \frac{de_t}{e_t}\right)\Delta \log e_t dt \\ &- a\int_0^T Cov\left(dy^{\tau}_{Ht}, dy^{\tau'}_{Ht}\right)\tau'\alpha_H\left(\tau'\right)\left(\Delta \log P^{\tau'}_{Ht}\right)d\tau' dt \\ &+ a\int_0^T Cov\left(dy^{\tau}_{Ht}, dy^{\tau'}_{Ft}\right)\left[QE_t\left(\tau'\right) - \alpha_F\left(\tau'\right)\Delta \log P^{\tau'}_{Ft}\right]\tau' d\tau' dt\end{aligned} \tag{12}$$

The first two terms represent purely general equilibrium effects which operate specifically through the global arbitrageurs' wider portfolio rebalancing channel. If the Foreign QE purchases alter the exchange rate, then the relative returns between currency carry trade and Home bond carry trade change, causing redistribution of assets. The size and magnitude of this change in Home yields depends on the level of substitutability between the Home bond and foreign currency as shown through the lens of yield covariance. Similar rebalancing happens within Home bond markets as a result of relative bond yields changing ($\Delta \log P^{\tau'}_{Ht}$).

3.4 Testing the mechanism

Our main empirical question considers the final, partial equilibrium term

$$a\int_0^T Cov\left(dy^{\tau}_{Ht}, dy^{\tau'}_{Ft}\right)\left[QE_t\left(\tau'\right) - \alpha_F\left(\tau'\right)\Delta \log P^{\tau'}_{Ft}\right]\tau' d\tau' dt \tag{13}$$

That is, the direct spillovers from Foreign QE purchases to Home yields depends on three key quantities: (1) global arbitrageur risk aversion a, (2) the covariance between the Home bond yield and the Foreign bonds targeted for QE purchases, and (3) the magnitude of QE purchases net general equilibrium changes in demand of preferred-habitat investors for foreign bonds. As shown in Section 2, rolling window regressions suggest that the spillovers from ECB monetary policy surprises to the US yield curve vary substantially during periods of ECB unconventional monetary policy. In the context of GRV and ignoring GE effects for now, there are four mechanisms which could affect such dynamic spillovers: (1) dynamic risk-aversion, (2) dynamic $QE_t\left(\tau'\right)$ shock magnitudes, (3) dynamic Foreign yield sensitivity to QE purchases, and (4) dynamic substitutability between US bonds and ECB bonds.

Mechanisms (2) and (3) come from the term $QE_t\left(\tau'\right) - \alpha_F\left(\tau'\right)\Delta \log P^{\tau'}_{Ft}$ and reflect the

net change in demand for European bonds given direct (ECB) QE purchases and subsequent yield effects in European bonds. Unfortunately, we do not directly observe the magnitude of unanticipated QE purchases, and we have no definitive measure to express the degree by which the passthrough from LSAP quantities to ECB asset prices has changed over time. Instead we must instrument for the sum using observable high frequency changes in a collection of yields, calling the resulting factor the monetary policy surprise, which includes asset price reactions to changed expectations about current or future LSAPs at the effective lower bound.

To fix ideas, it can be convenient to consider $\Delta \log P_{Ft}^{\tau'} = g\left(QE_t\left(\tau'\right)\right)$ for some mapping $g\left(\cdot\right)$. We cannot differentiate between a larger monetary policy shock due to a larger magnitude of purchases $QE_t\left(\tau'\right)$ or due to a structural change in the mapping $\alpha_F\left(\tau'\right) \times g\left(QE_t\left(\tau'\right)\right)$ for a constant level of purchases. Although of independent interest, we abstract from this issue in our empirical specifications, based on the notion that the primary object of our interest is changing US sensitivity to external shocks, regardless of provenance. That is, what matters for our purposes is that global investors in a demand system react to a change in prices initiated by policy more when the specialness of Treasuries has diminished. Thus, although we refer to LSAP shocks throughout the text, we caution against interpreting our estimated shock as indicative of a purely identified "QE shock". Rather, we assert that when a common shock impacts yields along the ECB yield curve, spillovers to the US yield curve depend on $Cov\left(dy_{Ht}^{\tau}, dy_{Ft}^{\tau'}\right)$.

This final mechanism is the focus of our empirical tests. Were it possible to observe the complete suite of market expectations regarding yield covariances, we could directly test it. However, the substitutability between sovereign bonds is not observable. Instead, we use the reverse of the Treasury convenience yield as a proxy for substitutability between US Treasuries and same-maturity ECB bonds, because it measures the wedge between otherwise comparable assets attributable to non-pecuniary benefits like pledgeability, liquidity, and safety.

Consider the swap spread, our preferred measure throughout the analysis. Two assets (a Treasury bond and the maturity matched overnight interest swap) in the same currency, with the same tenor and degree of risk, command a different price. Therefore, Treasuries must pos-

sess characteristics unrelated to their cash flows that the market is pricing. That wedge sits on top of the pecuniary spread between Treasuries and any other safe asset. All else equal, when the convenience premium shrinks, either the "special" characteristics that the convenience yield prices have diminished, or the market no longer values them as highly. Thus when Treasuries become less convenient, the wedge shrinks, and Treasuries price factors more like other safe assets, becoming more substitutable. When an investor in German Bunds is nudged away from their target allocation by LSAPs, "special" Treasuries are expensive as a substitute. Less convenient Treasuries, however, have the profile they are looking for—sovereign level safety with long tenor, coupled with a reasonably stable (or easily hedged) exchange rate—without the premium. The literature on Treasury convenience employs a number of empirical measures of the premium. However, because we are focused on agents in international markets who require sovereign level safety, we focus on the swap spread.

This imperfect substitutability would be reflected not only in relative convenience yields but also in a smaller (or more negative) covariance between US bond yields and other yields. The GRV model then suggests the following testable hypotheses about the dynamism of ECB QE surprises, of the convenience yield, and how they are related: first, if a US bond commands a large convenience yield, then $Cov\left(dy_{Ht}^{\tau}, dy_{Ft}^{\tau'}\right)$ is small. Therefore spillovers from a given magnitude of Foreign QE purchases should likewise be small.[18] We expect regressions will show a negative correlation between spillovers and the convenience yield. Second, spillovers should not be limited to US bond maturities identical to those targeted by ECB QE, although the effect should be largest in the target tenor and its nearest neighbors.

4 The Portfolio Balance Channel of Spillovers

We evaluate the mechanisms laid out in the model by conditioning the impact of ECB spillovers to the US yield curve on Treasury (in)convenience. We begin by regressing various segments of the term structure on intradaily ECB monetary policy shocks, interacting the shocks with the level of the level of inconvenience in Treasuries and Bunds. We use the swap spread on Bunds to proxy for Euro area convenience because they are the closest match to US Treasuries

[18] We explore these links explicitly in Section 4.3.

in terms of their non-pecuniary qualities. Regressions take the following form:

$$\Delta y^{(n)}_{US,t} = \alpha + \beta_1 SS^{(n)}_{US,t-1} + \beta_2 MP^{ecb}_t + \beta_3 MP^{ecb}_t \times SS^{(n)}_{US,t-1} + \beta_4 MP^{ecb}_t \times SS^{(n)}_{DE,t-1} + \\ ... + \beta_5 SS^{(n)}_{DE,t-1} + \gamma_1 i^{US}_{t-1} + \gamma_2 i^{EU}_{t-1} + \gamma_3 (y^{(n)}_{US,t-1} - y^{(n)}_{EU,t-1}) + \epsilon^{(n)}_t \quad (14)$$

Convenience yields are proxied by the spread between the sovereign bond yield and the maturity matched overnight index swap; as in Figure 1c, we orient the interpretation toward "inconvenient" Treasuries or Bunds, by expressing the spread as the sovereign yield less OIS—when the Treasury yield rises relative to OIS, Treasuries have become less convenient. $SS^{(n)}_{EU,t-1}$ and $SS^{(n)}_{US,t-1}$ are the n-year swap spreads for Germany and the US ($Y^n_{i,t-1} - Y^{ois,n}_{i,t-1}$), expressed in z-scores, and $y^{(n)}_{US,t}$ is either the yield on the n-year Treasury bond, the n-year term premium, or the expected path of short rates over an n-year horizon. Convenience yields and any daily control variables enter as the *previous* calendar day's value, given that convenience yields, Treasury yields, and policy rates are simultaneously determined on announcement days. So, while t indexes ECB announcement days, $t-1$ refers to the calendar day before an announcement. Due to data restrictions related to the pricing of the spreads, our sample in these regressions covers announcements from January 2000 through December 2022, unless otherwise noted.

We follow the standard practice of controlling for the lagged policy rate in each respective market, as convenience yields and policy rates tend to be highly correlated ((Nagel, 2016)). i^{US}_{t-1} and i^{EU}_{t-1} are the fed funds rate the ECB's main refinancing operations rate (MRO), respectively. In some specifications we include the spread between maturity-matched Treasury and European zero coupon yields to account for the raw return differential.[19] This allays the valid concern that investors could be dissuaded from substituting into Treasuries from European bonds due solely to a divergence in their returns. To avoid excessive influence of outliers, we estimate parameters by robust regression, using an M-estimator as in (Rogers et al., 2014).

Figure 2 displays our baseline results. Because spillovers are concentrated, both theoretically and empirically, at the longer end of the yield curve, we focus the narrative first on estimates for the decomposition of the 10-year yield. Table 2a shows the impact on 10 year yields

[19] Euro area yield curve data can be accessed on the ECB website, which we accessed through Haver.

of a monetary policy shock from the ECB, conditional on the convenience yields on Treasuries and Bunds. Columns 2 - 5 show spillovers to the yield conditioning on the level of the reverse swap spread including and excluding various controls, while column 6 shows results conditioning on the Treasury-Bund spread instead of convenience yields.

In line with the model, positive parameter values in columns 2 - 5 show that the degree to which a loosening shock from the ECB pulls down longer-term Treasury yields is amplified when the convenience yield on Treasuries wanes, or when yields rise relative to maturity-matched OIS ($\beta_2 > 0$ and $\beta_3 > 0$). Across columns, the magnitude is remarkably consistent between specifications. Focusing on our preferred specification in column 5, when convenience yields are at average levels (i.e., its z-score is equal to zero), a loosening by the ECB that lowers 24-month Euro OIS by 10 BP reduces 10 year Treasury yields by 4.59 BP. When the convenience yield is one standard deviation below the mean (meaning Treasuries are less special), the size of spillovers from the ECB expands by 1.42 BP.

To give a sense of the economic significance of the effect, a one standard deviation change in 10 year Treasury yields in our sample is 5.86 basis points. A 4.6 BP drop in 10 year yields (row 1, column 5), which corresponds to the size of the spillover when convenience yields are at their historical average, would fall in the bottom 20% of the unconditional distribution of 10 year Treasury yield changes. A 6 BP drop, which corresponds to the estimated impact of the same sized loosening when the convenience premium is one standard deviation *below* historical average, would fall in the bottom 12% of the unconditional distribution. For additional context, a 10 BP decrease in the two year US Treasury yield in a narrow window around FOMC announcements is associated with a roughly 5 - 6 BP fall in the 10 year US bond yield.[20] Once we control for the lagged Euro area policy rate, the convenience yield on Bunds does not appear to impact the size of spillovers to the US yield curve. In some sense, this is unsurprising. ECB LSAPs included bonds according to their weight in the capital key, such that Bunds themselves are an incomplete representation of the portfolio characteristics requiring substitution in the event of LSAPs. In contrast to the results obtained from convenience yields, conditioning the impact of ECB shocks on the simple yield spread does not appear to alter the size of spillovers (column 7). Turning to the yield decomposition in columns

[20] See SA Table 1 for details.

Figure 2: Spillovers to the Treasury yield, conditional on convenience yields

(a) Spillovers to the 10 year Treasury yield, conditional on convenience yields

	(1) Y_{10}	(2) Y_{10}	(3) Y_{10}	(4) Y_{10}	(5) Y_{10}	(6) Y_{10}	(7) Y_{10}	(8) TP_{10}	(9) SR_{10}	(10) Fo_{9y1y}
ECB	3.30***	4.08***	4.05***	4.58***	4.59***	4.71***	3.71***	2.32***	1.69***	3.63***
	(0.81)	(0.84)	(0.84)	(0.95)	(0.95)	(0.95)	(0.96)	(0.63)	(0.43)	(1.07)
Y^{us}_{10} - Y^{eu}_{10}						-1.34	-1.21			
						(1.16)	(1.16)			
FFR_{t-1}			-0.29	-0.20	-0.19	0.30	0.27	-0.34	0.11	-0.72*
			(0.32)	(0.33)	(0.33)	(0.53)	(0.53)	(0.22)	(0.15)	(0.37)
MRO_{t-1}					-0.22	-1.12	-0.96	0.77**	-0.35	0.95
					(0.54)	(0.92)	(0.92)	(0.36)	(0.25)	(0.61)
Swap $spread^{US}_{10}$		0.53*	0.08	0.12	-0.16	-0.10	0.12	0.64	-0.13	0.48
		(0.32)	(0.59)	(0.59)	(0.91)	(0.91)	(0.91)	(0.61)	(0.42)	(1.03)
Swap $spread^{EU}_{10}$				0.86**	0.87**	0.65	0.73*	0.29	0.33*	0.52
				(0.39)	(0.39)	(0.43)	(0.43)	(0.26)	(0.18)	(0.44)
ECB × Swap $spread^{US}_{10}$		1.58**	1.56**	1.41**	1.42**	1.41**		0.86*	0.20	2.29***
		(0.68)	(0.68)	(0.68)	(0.68)	(0.68)		(0.46)	(0.31)	(0.77)
ECB × Swap $spread^{EU}_{10}$				0.74	0.77	0.84		0.80*	-0.17	0.65
				(0.70)	(0.70)	(0.70)		(0.47)	(0.32)	(0.79)
ECB × Y^{us}_{10} - Y^{eu}_{10}							0.07			
							(0.98)			
Constant	0.43	0.61	1.11*	0.89	1.20	2.91	2.56	-0.02	0.40	0.61
	(0.37)	(0.38)	(0.63)	(0.64)	(1.03)	(1.77)	(1.77)	(0.69)	(0.47)	(1.16)
Observations	266	266	266	266	266	266	266	266	266	266

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

(b) Spillovers to the Treasury yield curve, conditional on convenience yields

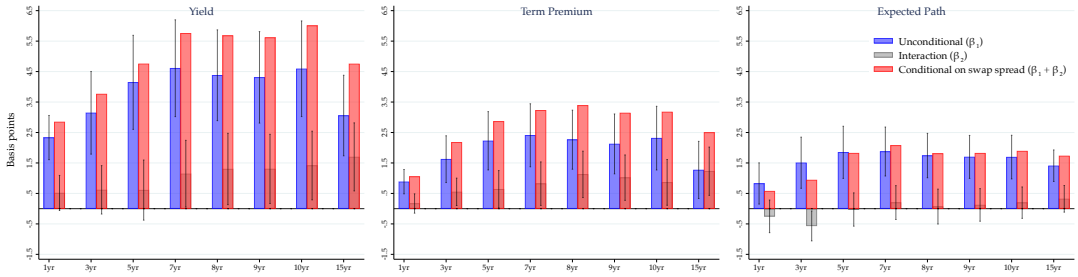


Figure 2a displays estimates regressing changes in 10-year US bond yields, term premium, and expected path of short rates on ECB surprises, conditional on the lagged level of Treasury and Bund convenience yields. Surprises comprise first principal component of intradaily changes in 1-, 3-, 6-, 12-, and 24-month OIS rates, 5-, 10-year German and French bond yields (normalized to raise two year Euro OIS by 10BP). Convenience yields are proxied by the spread between the sovereign bond yield and the maturity matched overnight index swap ($Y - OIS$), normalized to have zero mean and unit variance. An increase in this proxy reflects a decrease in convenience. Estimates are obtained using Huber biweights. Figure 2b summarizes the main result across the yield curve. Blue bars correspond to the impact of monetary policy on the yield decomposition when $Y - OIS$ is at its historical average, while red bars show the impact of a one standard deviation ECB surprise conditional on the convenience premium being one standard deviation below its historical average (base + interaction effect). Spikes within the red bars denote 90% confidence intervals surrounding the interaction term.

8 and 9 shows that the change in the 10 year Treasury yield arises primarily through the term premium (col. 8), given that the parameter estimate on β_3 is positive and statistically significant for the term premium and not statistically different from zero for the expected path of short rates.[21] A diminution of convenience yields, by increasing the substitutability between Bunds and Treasuries, contributes to an increase in spillovers to the 10 year US term premium, consistent with displaced Bund holders increasing their uptake of Treasuries at a higher rate. Because there is no one agreed-upon way to measure the term premium, we also include in the last column a version of our preferred specification where the term premium is proxied using a long forward rate. This model-free proxy also supports our conclusion that ECB UMP weighs on US term premia when the convenience yield is low. The mechanisms we highlight, both in theory and in the evidence presented in column 9, bear no relation to the expected path of short rates over a 10 year horizon.

Figure 2b summarizes regression results across the yield curve, supporting the notion that these mechanisms are concentrated in longer maturities. Blue bars in the figure show parameter values (and 90% robust confidence intervals) associated with the impact of ECB monetary policy surprises when the convenience yield is at its historical average (β_2), while red bars show the impact of a one standard deviation monetary policy surprise conditional on the convenience yield being one standard deviation below its historical average ($\beta_2 + \beta_3$). The confidence intervals within the red bars correspond to the statistical significance of the interaction term, β_3, which tests whether the variation in spillovers conditional on changes in the convenience yield differ significantly from the unconditional impact. The left-most panel, which summarizes the impact of spillovers across the yield curve, suggests that as Treasury convenience fades, spillovers to Treasury yields grow, and this differential impact rises with the maturity of the Treasury bond until the 10-year tenor, waning thereafter.

The middle and right panels display spillovers across maturities in the term premium and expected path of short rates. These estimates suggest that increased sensitivity in long

[21] Using OLS, estimates for the expected path of short rates and the term premium would have to add up to the reaction in the yield. However, M-estimators are not linear in the dependent variable, so the OLS property of linearity does not hold even when the underlying decomposition holds exactly. In supplementary appendix table 2, we show a version of the baseline specification that includes an F-test of equality in the change in the yield with respect to the sum of estimates from the term premium and the expected path of short rates for the interested reader. This test suggests that we cannot reject the null that the change in the components add up to the change in the yield at the relevant maturities.

term bond yields emerges primarily because the term premium responds more forcefully in the face of Treasury inconvenience. At the same time, we observe that the level of the convenience yield has no bearing on spillovers to the expected path of interest rates at any tenor.

4.1 Policy Decomposition

Our main analysis uses a measure of monetary policy designed to reflect the changing exercise of monetary policy over time, summarized by one variable. However, given the present focus on the differing mechanisms brought to bear by conventional versus unconventional monetary policy tools, it makes good sense to decompose the baseline results into long-rate-based and short-rate based tools as best we can. To that end, we follow (Rogers et al., 2018) in generating a three-part monetary policy shock in the following manner.

First, we extract the surprise component of the decision about the target rate based on the change in yield on the one-month OIS on the dates of ECB monetary policy announcements, which we label the "target surprise". Next, we take the residual from a regression of the announcement day change in the implied yield on the 24 month OIS onto the target surprise and label this the "forward guidance surprise". Finally, we take the residual from a regression of the announcement day change in the French and German 10-year bond yields (summarized by their first principal component) onto the target and forward guidance surprises. This "LSAP surprise" is intended to capture changes in long-term interest rates that are associated with announcements related to large-scale asset purchases. As ECB large-scale purchases of any kind began strictly after May 2010 (when the Securities Markets Programme was announced), we restrict this monetary policy surprise measure to equal zero before that date as in (Swanson, 2017) and (Rogers et al., 2018). To ease the comparison between the components, the target, path, and LSAP factors are normalized to raise the 1M OIS, 2Y OIS, and 10 year French bond yield 10 basis points. With these measures in hand, we regress 1-, 5-, and 10-year yields, term premia and expected path of short rates on the three-part shock in the full sample.

The results are displayed in Table 1. Unconditionally and in the full sample, path and LSAP shocks drive nearly all detectable spillovers to US yields. While path shocks impact both the expected path of short rates and term premia across the yield curve, LSAP shocks

influence US yields at a rate that rises with maturity and exclusively through the term premium. Consistent with the portfolio balancing channel of unconventional monetary policy, LSAP shocks play a larger role, which increases with maturity, in driving ECB spillovers to the term premium in particular. As we expect, LSAP-type shocks have no statistically significant impact on the expected path of short rates.

Table 1: Spillovers to the US yield curve, by shock type

	Yield			**Term Premium**			**Expected Path of Short Rates**			**9y1y fwd**
	(1) Y_1	(2) Y_5	(3) Y_{10}	(4) TP_1	(5) TP_5	(6) TP_{10}	(7) SR_1	(8) SR_5	(9) SR_{10}	(10) F_{9y1y}
Target EU	-0.14	-0.07	-0.04	0.39***	0.33	0.28	-0.62***	-0.27	-0.27	-0.39
	(0.19)	(0.37)	(0.39)	(0.10)	(0.23)	(0.26)	(0.19)	(0.21)	(0.17)	(0.44)
Path EU	0.88***	1.76***	1.31***	0.11	0.46**	0.29	0.71***	1.06***	0.88***	0.83*
	(0.18)	(0.36)	(0.38)	(0.10)	(0.22)	(0.26)	(0.19)	(0.20)	(0.17)	(0.43)
LSAP EU	0.13	0.76**	1.26***	0.23**	0.79***	0.90***	-0.01	-0.03	0.13	1.46***
	(0.17)	(0.34)	(0.36)	(0.10)	(0.21)	(0.24)	(0.18)	(0.19)	(0.16)	(0.40)
Constant	0.09	0.31	0.49	0.18*	0.49**	0.52**	-0.08	0.08	0.10	0.70*
	(0.18)	(0.35)	(0.37)	(0.10)	(0.22)	(0.25)	(0.18)	(0.19)	(0.16)	(0.41)
Observations	265	265	265	265	265	265	265	265	265	265

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1 depicts the regressions associated with the policy decomposition exercise where the dependent variables are the yields, term premia, and expected path of short rates for US Treasuries at the 1-, 5-, and 10-year maturity lengths. Regressors are the "target surprise", "forward guidance surprise", and "LSAP surprise" monetary policy shocks as in (Rogers et al., 2018) and (Swanson, 2017).

Table 2 conditions the impact of the 3-part monetary policy shock on the reverse convenience yield ($Y_n - OIS_n$). Although spillovers to yields themselves do not appear to change with shifts in Treasury convenience, appealing to the term premium uncovers the effect we expect to see—when the inconvenience of Treasuries increases, LSAP shocks generate larger spillovers to medium- and long-duration Treasuries. On the other hand, path spillovers (linked to international signaling) do not vary with Treasury inconvenience.

4.2 Robustness and extensions

We pursue a number of robustness checks and extensions in the Supplementary Appendix (SA). Among extensions, we assess the persistence of the spillover, by recasting the baseline regression in a series of local projections in SA Section 7. SA Figure 7 shows that spillovers are not only larger when Treasuries are less convenient, but also longer lived. Digging deeper

Table 2: Spillovers to the US yield curve, conditioned by swap spread

	Yield			Term Premium			Expected Path of Short Rates			9y1y fwd
	(1) Y_1	(2) Y_5	(3) Y_{10}	(4) TP_1	(5) TP_5	(6) TP_{10}	(7) SR_1	(8) SR_5	(9) SR_{10}	(10) F_{9y1y}
Target EU	-0.18	0.23	0.50	0.42***	0.78**	0.77**	-0.56***	0.09	-0.21	0.72
	(0.21)	(0.58)	(0.55)	(0.12)	(0.35)	(0.36)	(0.21)	(0.32)	(0.25)	(0.60)
Tgt×Swap spread$_n$	0.49**	0.29	0.47	-0.03	0.39	0.47*	0.42*	0.31	0.05	0.95**
	(0.24)	(0.39)	(0.39)	(0.13)	(0.24)	(0.25)	(0.24)	(0.21)	(0.18)	(0.42)
Path EU	0.94***	1.73***	1.32***	0.21*	0.41*	0.29	0.46**	1.00***	0.89***	0.88**
	(0.21)	(0.40)	(0.40)	(0.12)	(0.24)	(0.26)	(0.21)	(0.22)	(0.18)	(0.43)
Path×Swap spread$_n$	0.06	-0.12	-0.04	0.10	-0.02	0.00	-0.28*	-0.06	0.04	0.07
	(0.15)	(0.28)	(0.35)	(0.08)	(0.17)	(0.23)	(0.15)	(0.15)	(0.16)	(0.38)
LSAP EU	0.05	0.20	-0.03	0.13	-0.09	-0.33	0.58**	0.23	-0.06	-0.58
	(0.25)	(0.80)	(0.88)	(0.14)	(0.48)	(0.58)	(0.25)	(0.44)	(0.40)	(0.96)
LSAP×Swap spread$_n$	0.17	0.60	1.47	0.33	0.94*	1.48**	-1.37***	-0.29	0.23	2.41**
	(0.48)	(0.90)	(1.12)	(0.27)	(0.54)	(0.74)	(0.48)	(0.49)	(0.51)	(1.21)
Constant	0.05	-0.07	0.72	0.32*	0.32	-0.11	-0.64**	-0.18	0.24	0.44
	(0.31)	(0.95)	(1.03)	(0.17)	(0.57)	(0.68)	(0.31)	(0.52)	(0.47)	(1.12)
Observations	265	265	265	265	265	265	265	265	265	265

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 2 depicts the regressions associated with the policy decomposition, where the dependent variables are the yields, term premia, and expected path of short rates for US Treasuries at the 1-, 5-, and 10-year tenors. Regressors are the "target", "forward guidance", and "LSAP" surprise monetary policy shocks generated according to (Rogers et al., 2018). Each of the three monetary policy surprises is interacted with the maturity-matched swap spread ($Y - OIS$), normalized to have zero mean and unit variance. All regressions include the lagged Fed funds rate and the lagged main refinancing operations rate. Observation counts differ from the baseline because robust regression excludes observations with a Cook's distance statistic greater than one, which is the case for the observations on Oct. 8, 2008. Because excluding this date as an outlier is not uncommon, and because its exclusion in the other specifications are not radically altered thereby, we drop it from these estimates for comparability.

into the policy decomposition, we would expect that purchases weighted more toward the countries in the Euro Area with risky debt would not produce spillovers that change with Treasury convenience. To address this point, we augment our three-factor monetary policy decomposition (target, path, LSAP) with a fourth factor reflecting changes in peripheral yields. Conditioning the factors on the swap spread suggests while "safe" LSAP surprises, generate state dependent spillovers linked to Treasury similarity, "periphery" ones do not (see SA Table 15). In SA Section 5.1, we explore some of the most commonly cited drivers of changing convenience yield in Treasuries like net Treasury issuance and balance sheet constraints. We find that forces related to diminished Treasury convenience are also linked to larger spillovers from the ECB. Finally, SA Section 6 provides further evidence that time-varying spillovers are unlikely to be driven by dynamic uncertainty, information effects, or aggregate risk sentiment.

Our results are robust to using various tenors of the swap spread (see SA Table 17), to using alternative estimates of the term premium (SA Table 18), and to separating out a central bank information effect (SA Section 6.1). Finally, SA Section 8.3 uses an alternative rotation of PCA factors from (Altavilla et al., 2019) to identify target, path, and LSAP surprises, which also shows that ECB LSAP surprises affect to the US term premium more when Treasuries are less convenient.

4.3 Validation of the Mechanism

Our argument hinges on the notion that the swap spread is a valid instrument for the covariance between US and ECB yields (recall equation 13), and that the size of spillovers hinges critically on the degree to which Treasuries are considered sufficiently similar to other safe sovereign bonds. In what follows, we offer three alternative exercises to explicitly link Treasury inconvenience with similarity, and then test the assumption that similarity is uniquely important.

First, we use as a proxy for variation in the Bund-Treasury return correlation the product of 10 year bond return z-scores, which across the time series averages to the Pearson correlation coefficient. Daily changes in this measure can be thought of as the instantaneous contribution to sample correlation. Total return indices at the 10-year tenor are reported by the Fed and the ECB. SA Figure 2a shows the time series of the daily correlation contribution alongside the reverse swap spread (Y – OIS) and the correlation coefficient across the sample ($\rho = .66$). This positive coefficient is consistent with the idea that the reverse swap spread, or Treasury inconvenience, captures increasing similarity between Treasuries and other safe assets.

Second, we use the allocation of bond funds toward/away from US Treasuries as a potential measure of relative convenience using the EPFR country flows data set. Although this data, which starts in September 2005, does not span the entire period of our sample, it does allow us to provide some evidence on the degree to which changing Treasury convenience reflects the degree of switching between Treasuries and Bunds. We start by taking the two principal components of Bund and Treasury allocations. The loadings on the first principal component are both positive, suggesting a flight to safety interpretation, while the second is

Table 3: Spillovers to the 10 year Treasury yield, conditional on alternative proxies for similarity

	Return correlation			Rotation factor		
	(1) Y_{10}	(2) TP_{10}	(3) SR_{10}	(4) Y_{10}	(5) TP_{10}	(6) SR_{10}
ECB	4.08***	2.24***	1.64***	5.99***	3.51***	1.75***
	(0.89)	(0.60)	(0.41)	(1.11)	(0.79)	(0.45)
ECB × corr(Bund, UST 10yr return)	1.73*	1.80**	-0.34			
	(1.02)	(0.69)	(0.47)			
ECB × Rotation factor (relative UST convenience)				-2.74**	-2.85***	0.16
				(1.37)	(0.98)	(0.55)
ECB × Safety factor				-1.51	-1.68**	0.39
				(0.95)	(0.68)	(0.38)
Observations	266	266	266	175	175	175

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3 displays estimates regressing changes in the 10-year US bond yield and decomposition, conditional on the Bund-Treasury rotation factor and return correlation (normalized to have zero mean and unit variance). Surprises comprise first principal component of intradaily changes in 1-, 3-, 6-, 12-, and 24-month OIS rates, 5-, 10-year German and French bond yields (normalized to raise 24-month OIS by 10 BP). Controls include base effects, Fed and ECB policy rates, and a constant. Estimates are obtained using Huber biweights.

positive for the US and negative for Germany, reflecting rotation toward the US.[22] To the extent that the convenience yield summarizes Treasuries' specialness, the rotation factor and the reverse convenience yield (Y - OIS) should be negatively correlated–the less special Treasuries are, the smaller the rotation factor in favor of the US. Supplementary appendix Figure 2c shows this is the case, plotting the swap spread at the 10 year tenor against the rotation factor, in z-scores ($\rho = -0.64$). With these two measure of similarity in hand, we repeat our baseline analysis in Table 3. The results suggest that spillovers grow when the return correlation rises, and they wane when the US rotation factor rises—both findings support our main conclusions.

To validate our approach and provide additional evidence that our hypothesized mechanism turns critically on Treasury substitutability, we narrow in on the other terms in equation 13. In particular, we can test the assumption that the covariance term uniquely explains the change in spillovers by ruling out the possibility that the other mechanisms move with ECB monetary policy. Each of these tests is shown in sequence in Table 4a, using both the baseline

[22]The associated paramter values are displayed in supplementary appendix Table 2b.

monetary policy shock and the shock type decompositions from Table 1.

First, we rule out the possibility that ECB monetary policy (and LSAP-type shocks in particular), directly affect the expected path of US short rates. While the rolling regressions in Figure 1a provide preliminary evidence on this point by showing small effects that are stable over time, Table 4a repeats the baseline and policy decomposition exercises across the term structure. Columns 1 - 6 show that, while the baseline monetary policy measure affects the path of short rates in full sample, these operate through the path factor—the LSAP-type shock has no bearing on the expected short rate.

Second, we test that ECB monetary policy does not directly affect bond covariance on impact, measured two ways. First, columns 7 and 9 show that ECB monetary policy shocks do not move the US convenience yield. Second, Columns 8 and 10 show that ECB monetary policy surprises do not move the Pearson correlation between US and German sovereign bond returns, measured using the product of z-scores as in section Table 3. Columns 1 - 10 therefore provide assurance that using the swap spread as a proxy is unlikely to introduce substantial endogeneity between ECB monetary policy and substitutability in our estimates, and that the time-varying spillovers we observe are unlikely to be driven by a signaling channel.

Finally, we turn to mechanism (1) in equation 13, where we distinguish two separate empirical questions. First, does ECB policy itself alter intermediary constraint intensity? We follow (Du, Hébert, & Huber, 2023) in measuring the shadow cost of intermediary constraints using violations of CIP, conditioning the impact of monetary policy shocks on the first principal component of the lagged CIP deviations (in absolute value) of the U.S. dollar against G10 currencies.[23] Columns 11 and 12 show no evidence that ECB announcement shocks move arbitrageur constaints on impact. This suggests that deviations reflect broader structural features of intermediary balance-sheet conditions rather than an endogenous response to ECB actions. Second, conditional on the prevailing level of CIP deviations, do spillovers vary in magnitude? In Table 4b, we find strong evidence of state dependence: spillovers are significantly larger when CIP deviations are farther from zero. Keeping in mind that G10 CIP deviations are measured as absolute deviations from zero, these results suggest that spillovers

[23]G10 cross currency basis vis-a-vis the dollar is measured at the 1-year tenor (combined using principal components). While the 3-month tenor is a better measure of limits to arbitrage, the time series coverage is inadequate.

from the ECB become larger when intermediary constraints assert themselves (i.e., when CIP deviations move away from zero). These two findings are complementary. The first estab-

Table 4: Alternative Mechanisms

(a) Endogenous responses to ECB monetary policy

	Expected Path of short rates						Contemporaneous covariance				Arbitrageur constraints	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	SR_1	SR_5	SR_{10}	SR_1	SR_5	SR_{10}	$\Delta(Y-OIS)$	$\Delta(\rho(r_{US}^{(10)}, r_{DE}^{(10)}))$	$\Delta(Y-OIS)$	$\Delta(\rho(r_{US}^{(10)}, r_{DE}^{(10)}))$	FX basis	FX basis
ECB	1.09***	1.85***	1.59***				0.12	-0.00			-0.18***	
	(0.37)	(0.42)	(0.36)				(0.29)	(0.00)			(0.05)	
Target EU				-0.59***	-0.33	-0.33**			-0.06	-0.00		-0.03
				(0.18)	(0.20)	(0.17)			(0.13)	(0.00)		(0.02)
Path EU				0.66***	1.08***	0.92***			0.11	0.00		-0.07***
				(0.18)	(0.20)	(0.17)			(0.13)	(0.00)		(0.02)
LSAP EU				-0.01	-0.03	0.12			-0.01	0.00		-0.01
				(0.17)	(0.19)	(0.16)			(0.13)	(0.00)		(0.02)
Observations	266	266	266	266	266	266	266	264	266	264	262	261

(b) Yield spillovers conditional on arbitrageur constraints

	(1) Y_{10}	(2) TP_{10}	(3) SR_{10}	(4) F_{9y1y}
ECB	3.27***	1.36**	1.69***	2.40***
	(0.80)	(0.53)	(0.37)	(0.89)
1yr G10 CIP deviations	-0.22	0.62**	-0.23	1.19**
	(0.43)	(0.28)	(0.20)	(0.48)
ECB × 1yr G10 CIP deviations	1.65**	1.08**	-0.02	2.58***
	(0.69)	(0.45)	(0.31)	(0.76)
Observations	262	262	262	262

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4a displays estimates regressing changes in the expected path of short rates, bond covariance, and the G10 1-year cross currency basis on ECB monetary policy surprises. Shocks either comprise first principal component of intradaily changes in the following: 1-, 3-, 6-, 12-, and 24-month OIS rates, 5-, 10-year German and French bond yields, or are target, path and LSAP surprises. Controls include policy rates and a constant. Estimates are obtained using Huber biweights. An exercise testing the sample pre- and post-2008 can be found in SA Table 20.

lishes that limits to arbitrage are not an unconditional underlying transmission mechanism of the shock itself; the second shows that intermediary constraint intensity contributes to the strength of that transmission. In the model, intermediary risk-bearing capacity is a state variable that scales the price impact of net supply shocks, but is not itself directly altered by those shocks on impact. The empirical results mirror this structure: CIP deviations do not respond to ECB announcements, yet they significantly spillover magnitudes. The spillover mechanism behaves exactly like a portfolio balance model would predict—scaling with intermediary constraints.

The amplification of spillovers in periods of elevated CIP deviations does not overturn our main result regarding Treasury specialness. Rather, it operates through a distinct margin

highlighted by the model. Treasury convenience governs the degree of cross-market substitutability—that is, the exposure of US bonds to foreign effective safe asset supply. CIP deviations, by contrast, proxy intermediary constraint intensity and, with that friction, the intensity of the price response. The two mechanisms are multiplicative rather than competing. The fact that both margins behave as predicted strengthens the portfolio balance interpretation of spillovers.

5 Concluding Remarks and Directions for Future Research

In this paper, we show that international monetary spillovers to the US yield curve are state-dependent and, since the Global Financial Crisis and adoption of unconventional monetary policy tools, governed by Treasury (in)convenience. Using high frequency identification of ECB monetary policy surprises, we document that spillovers intensified in the era of unconventional policy and were strongest when US normalization proceeded out of sync with other advanced economies. The convenience yield, and the special characteristics it prices, are the linchpin of this state dependence: when convenience falls and Treasuries become less "special," their substitutability with other safe sovereigns rises, the portfolio-balance channel strengthens, and foreign shocks exert greater pressure on US long rates. The transmission loads primarily on term premia and is more persistent at longer maturities, consistent with a portfolio balance channel of transmission.

We link this state dependence directly to movements in the convenience yield both theoretically and empirically. In periods where the yield is high relative to maturity-matched OIS (i.e., when the convenience premium is low or negative), when Bund and Treasury returns are highly correlated, or when bond allocations favor Bunds relative to Treasuries, spillovers to the US yield curve grow. Decomposing policy surprises shows that LSAP-type components account for the magnified term-premium response, while the signaling channel—encompassing target and forward-guidance elements and information effects—cannot explain the empirical patterns we observe. Competing narratives on risk sentiment, policy uncertainty, or exchange-rate volatility do not overturn the central role of the convenience yield in governing ECB spillovers to US term premia. Taken together, the evidence implies that the effectiveness of domestic, conventional tightening will be attenuated in environments with foreign QE and Treasury in-

convenience.

We rationalize these findings with a two-country preferred-habitat model featuring segmented markets and constrained global arbitrageurs, extending (Gourinchas et al., 2025) by treating the Treasury convenience yield as a proxy for time-varying cross-asset substitutability (yield covariances). As Treasuries become less "special," foreign unconventional policy shocks transmit more strongly via arbitrageurs' hedging and preferred habitat investors' portfolio rebalancing—concentrated at the targeted tenor and nearby maturities and operating mainly through term premia—so US long-rate insulation is state-dependent rather than constant.

These effects likely extend to other assets considered comparable to Treasuries. For example, to the extent that Treasury inconvenience opens the door to reallocation by price-sensitive investors, it may decrease the spillover to other candidate substitutes, like U.K. Gilts. Furthermore, within-domicile passthrough from Treasuries to corporate borrowing costs—conditional on a waning convenience yield—could have large real and financial consequences. This represents another valuable extension both in terms of the spillover literature but also in measuring the factors that influence domestic policy transmission.

From a theoretical perspective, we have remained silent about a number of other concerns, which contain interesting avenues for future research. First, our focus on the portfolio balance channel as driven through preferred-habitat investors is targeted but perhaps incomplete in analyzing time-varying spillovers. Global arbitrageurs play a critical role in international policy transmission, but we have not examined the degree to which their constraints and risk-preferences amplify or mitigate the spillovers. Similarly, the model is capable of addressing exchange rate risk concerns that may develop from a waning convenience yield. Finally, we treat the convenience yield process (and hence substitutability) as exogenous and do not model its underlying drivers, which future work could address.

Finally, there is the potential for secular changes in the convenience yield to reshape how we consider optimal policy making. Not only is the available mix of monetary policy tools expanding, the changing convenience suggests extant optimal policy making rules may be missing a crucial component. Our results suggest that US monetary policy and yield curve may not be as insulated from foreign shocks as we have historically assumed. In particular, asyn-

chronicity of strategy/tools and timing could hinder the effectiveness of domestic monetary policy.

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