Who drives the U.S. Treasury premium?

Marco Graziano [*] [†]
University of Basel

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Abstract

This paper quantifies the contribution of foreign investor sectors to the premium earned by U.S. Treasuries as a global safe, liquid asset. A portfolio choice model featuring investors with heterogeneous preferences for U.S. Treasuries shows that investors who value convenience display a muted portfolio response to excess returns. In equilibrium, Treasury excess returns are lower but may respond more to changes in debt supply. Structural parameters estimated from European data reveal that the special role of Treasuries considerably dampens investors' yield sensitivity across sectors, and lowers Treasury yields by 50 basis points on average. The official sector stands out as the main source of the Treasury premium, contributing 30 basis points. At a time of high and rising public debt, these results highlight the vulnerability of fiscal sustainability to any erosion of the status of U.S. Treasuries as global safe asset and to strategic diversification away from Treasuries by foreign governments.

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[†] University of Basel, Faculty of Business and Economics, Peter Merian-Weg 6, 4052 Basel `macro.graziano@unibas.ch`

1 Introduction

U.S. Treasuries are one of the most important assets in the world, with a market capitalisation of $39 trillion and a unique role as a safe asset at the centre of the international financial system, providing liquidity, a safe store of value, and collateral for dollar-denominated transactions. These features earn Treasuries a premium, the convenience yield, allowing the U.S. government to borrow at lower rates than other advanced economies.[1]

The convenience yield plays a critical role for U.S. fiscal sustainability (Jiang et al., 2024c), and is driven in large part by foreign investors (Jiang et al., 2022). This funding advantage has, however, eroded since the Great Financial Crisis (Du et al., 2025, Jiang et al., 2025), a particularly concerning development at a time of burgeoning public debt exceeding 120% of GDP and persistent budget deficits regularly above 5% of GDP, levels not seen outside of wartime or major crises. In this environment, even yield movements of a few basis points can suffice to tip the fiscal trajectory onto an unsustainable path.

It is therefore crucial to understand which investor sectors drive the Treasury premium and its decline. The strategic implications for the U.S. government differ starkly depending on the answer. If the funding advantage is driven by the financial sector, its evolution is likely to follow predictable economic considerations such as liquidity demand and collateral value. If instead the fate of U.S. public finances rests in the hands of geopolitically motivated foreign governments, serious concerns of strategic vulnerability arise. This distinction has recently gained urgency in light of the ongoing diversification of official foreign exchange reserves away from the dollar (Ito and McCauley, 2020) and the climate of geopolitical uncertainty surrounding the current U.S. administration, which has prompted even longstanding allies such as Europe to entertain the previously unthinkable possibility of responding to perceived hostility by shedding Treasury holdings (van den Noord and Subacchi, 2025).

This paper asks which foreign investor sectors drive the Treasury premium, going beyond existing rankings based on the size and elasticity of foreign demand (Eren et al., 2025, Fang et al., 2023). While both matter, neither is a sufficient statistic for pricing impact through convenience yields. As this paper shows, decomposing the convenience yield across sectors requires explicit structural modelling to isolate the effect of investor preferences for Treasuries on marginal pricing.

To this end, I develop a model of portfolio choice in which foreign investors across different sectors allocate wealth between U.S. Treasuries and domestic government bonds. Investors are modelled as mean-variance optimisers over wealth, augmented with a sector-specific, increasing and concave preference term for Treasury holdings. This term is a parsimonious, reduced-form representation of the non-monetary benefits that different classes of investors derive from Treasuries: liquidity and collateral value for banks, liability-matching properties for pension funds, and reserve management objectives for official institutions. Crucially, this approach allows the comparison of Treasury preferences across sectors without requiring a separate micro-foundation for each. The concavity of the preference function is the key structural feature: it implies that the marginal benefit of holding Treasuries declines with the portfolio share already allocated to them, which in turn dampens the sensitivity of portfolios to yield changes. In equilibrium, investors who value Treasuries beyond their risk-return profile accept a lower yield relative to comparable assets, generating a Treasury premium. The model delivers four testable predictions:

[1]The literature refers to this phenomenon as either the Treasury premium (Du et al., 2018) or the convenience yield (Jiang et al., 2020, 2024c). I use the two terms interchangeably throughout.

Treasury preferences raise portfolio shares, reduce their sensitivity to excess returns, lower equilibrium yields, thereby generating a Treasury premium, and have an ambiguous effect on how strongly yields respond to increases in government debt supply, the net direction depending on whether the quantity-dampening effect of curvature outweighs the level-shifting effect.

To bring these predictions to the data, I estimate the sector-specific preference parameters via Generalised Method of Moments (GMM), exploiting the first-order conditions of the investor's problem as moment restrictions. The estimation uses quarterly holdings data for four euro area investor sectors: banks, non-bank financial institutions (NBFIs), governments, and households. The data is drawn from the European Central Bank's Securities Holdings Statistics (SHS) database, spanning 2013 to 2022. The euro area setting offers two advantages. First, sectoral sovereign portfolios are directly observable, without the imputation or aggregation required when working with global data (e.g. Arslanalp and Tsuda (2014), Fang et al. (2023)). Second, the cross-country structure of ECB asset purchases under the Public Sector Purchase Programme (PSPP) generates exogenous variation in the relative supply of domestic government bonds across euro area countries (Koijen and Yogo, 2020), providing a credible instrument to identify the curvature of Treasury preferences. Specifically, PSPP purchases varied substantially across countries relative to their cross-sectional average, compressing domestic bond supply differentially and shifting the relative attractiveness of Treasuries. De-meaned PSPP purchases serve as the instrument in the second GMM moment condition, separately from the unconditional moment that identifies the level-shift parameter.

The estimated parameters reveal that all four sectors assign a net convenience yield to Treasuries on average, though the underlying structure varies considerably. Banks and NBFIs display a positive level-shift in preferences: they would accept a yield around 6–7 basis points lower than the no-convenience benchmark to hold any given Treasury portfolio share. Governments and households, by contrast, display a negative level shift, reflecting that they require a higher yield at the baseline. Their safe-haven demand is then driven primarily by the curvature effect rather than by an unconditional willingness to accept lower returns. This feature makes it particularly important to adopt a non-linear approach that appropriately accounts for the curvature effect. The curvature parameter is positive across all sectors, confirming the concavity assumption, and generates additional convenience effects that reduce required yields by a further 1–3 basis points at sectoral portfolio share means when combined with the level shift.

I then carry out experiments within the model, comparing portfolio shares and equilibrium returns at the estimated Treasury preference parameters against the counterfactual case of no Treasury preferences, thereby simulating a loss of the global safe and liquid asset status of U.S. Treasuries.

A first set of experiments quantifies the effect of Treasury preferences on portfolio share levels. If Treasuries lost their special status, European banks would reduce their Treasury portfolio share by 25 percentage points, NBFIs by 20 percentage points, and governments by 15 percentage points, a reduction amounting to between 25% and 33% of each sector's observed average share. Households would reduce their share by only about 2 percentage points, suggesting they hold Treasuries primarily for their risk-return profile. Treasury holdings by the financial sector and the government are therefore in large part attributable to non-monetary payoffs, while household demand is driven mainly by the standard risk-return tradeoff.

The second experiment quantifies how much convenience yield preferences reduce the sensitivity of each sector's portfolio to excess returns, which is the direct channel through which sectors shape equilibrium pricing. In the counterfactual without Treasury preferences, government portfolios would be more than twice as sensitive to yield changes as they are at the estimated parameters; households would be seven times more sensitive. Banks and NBFIs, by contrast, would react only about 1.5 times more strongly: a meaningful dampening, but modest relative to the non-financial sectors. The ranking reflects a key nonlinearity: sectors with portfolio share levels largely driven by Treasury convenience are insulated from yield movements through the curvature of their preferences, which stabilises their holdings and mutes their marginal response to returns. Small sectors with strong preference curvature are therefore disproportionately affected at the margin.

The sectoral decomposition of the Treasury premium is the central finding of the paper. The model-implied premium averages approximately 50 basis points over the sample, peaking at around 60 basis points in early 2020 and declining to roughly 40 basis points by end-2022. This magnitude is broadly consistent with pre-2010 estimates in the existing literature (Du et al., 2018), though the model is estimated on post-2010 data when reduced-form measures of the premium have largely vanished. The discrepancy highlights the advantage of a structural approach that draws on both quantity and price data. Since sectoral contributions to the premium are proportional to both sector size and the convenience-driven dampening of return sensitivity, the inversion of the size-ordering found in the second experiment carries directly into the premium decomposition. Despite holding far larger absolute quantities of Treasuries, the financial sector contributes relatively little: banks account for roughly 7 basis points and NBFIs for a negligible amount. The dominant contributors are instead the government sector, responsible for approximately 30 basis points, and households, who contribute around 15 basis points. The importance of the government sector as a driver of the Treasury premium is consistent with the findings in Jiang et al. (2024b) of particularly low returns on U.S. Treasuries accepted by the foreign official sector. A picture emerges of large financial institutions that are drawn to Treasuries by convenience preferences but whose behaviour as marginal investors is relatively unaffected by convenience, and small non-financial sectors whose convenience-driven return insensitivity makes them the primary source of the Treasury premium.

A final set of results concerns how Treasury convenience shapes the yield response to increases in government debt issuance. Contrary to the conventional view that convenience yields allow the U.S. government to expand borrowing more than other sovereigns for a given increase in yields (Jiang et al., 2024d), the model implies that yields are actually *more* sensitive to debt supply in the presence of convenience preferences than without. Indeed, the experiment shows that the excess return derivative to debt supply in the no-convenience counterfactual is about two thirds of its value at the estimated parameters. The mechanism is driven by the quantity-dampening effect of concave Treasury preferences: as all sectors hold larger and stickier Treasury positions, the market's ability to absorb additional issuance through quantity adjustment is reduced, so prices, or equivalently yields, must do more of the adjustment. Households again account for the dominant share of this effect, with banks and NBFIs contributing in roughly equal measure. The government sector's contribution is negligible, its strong preference curvature offset by the small scale of its holdings. Translated into fiscal terms, the structural estimates imply that a complete loss of Treasury convenience by the European official sector alone would require the U.S. government to fund an additional \$15.2 billion in annual interest expenses, a figure that, if anything, understates the true cost by abstracting from fire-sale dynamics and second-order risk premium effects.

Related literature. This paper is situated in the literature on the convenience yield of U.S. Treasuries. A strand of this literature is concerned with the measurement of convenience yields, typically through a spread between Treasuries and comparably safe or liquid assets such as AAA corporate bonds (Krishnamurthy and Vissing-Jorgensen (2012)), repurchase agreements (Nagel, 2016), overnight indexed swaps (He et al., 2022) and foreign government bonds, adjusted for credit risk differentials and deviations in covered interest parity Du et al. (2018). I contribute by developing a model-based methodology to estimate the convenience yield of U.S. Treasuries relative to euro area sovereign bonds.

Several papers underscore the significant contribution of Treasury convenience to a broad range of macroeconomic phenomena, including the dynamics of nominal and real exchange rates (Engel and Wu, 2018, Valchev, 2021, Jiang et al., 2021, 2024c, Graziano et al., 2026), fiscal sustainability (Jiang et al., 2019, Choi et al., 2024, Jiang et al., 2024d), and global business and financial cycles (Bodenstein et al., 2023, Georgiadis et al., 2023, Jiang et al., 2024a). I expand the literature on convenience yields and fiscal sustainability by distinguishing between two effects: a reduction in equilibrium returns, and a potentially higher sensitivity of yields to debt supply, contrary to conventional wisdom.

A more recent generation of studies looks for the origins and drivers of convenience yields. Acharya and Laarits (2023) emphasises the hedging properties of Treasuries as safe assets, showing that the convenience yield is inversely proportional to the correlation between Treasury and stock returns. Corell et al. (2025) decomposes the sources of convenience yields for European government bonds, identifying regulatory capital advantages as the largest component. I add another dimension to this line of inquiry by asking not when convenience yields arise or what they are, but rather who drives them.

The modelling approach I employ, estimating an asset pricing model that combines price and quantity data, borrows from the demand system asset pricing framework of Koijen and Yogo (2019a), adopted by a rapidly growing literature (Gabaix and Koijen, 2020, Bretscher et al., 2020, Haddad et al., 2021, Gabaix et al., 2022, Nenova, 2024). Unlike the conventional framework, I do not specify the full demand system but focus solely on the choice between US and domestic government bonds. This simpler approach allows to go beyond taking estimated elasticity as primitive parameters, and instead recover the underlying preference parameters directly, taking a step towards understanding the nature of demand heterogeintiy at the core of the Koijen and Yogo (2019a) model. In this respect, the paper is related to the emerging literature that studies the theoretical foundations of demand-based asset pricing by endogenising heterogeneous tastes (Fuchs et al., 2023).

Within the demand system asset pricing framework, Koijen and Yogo (2019b) extracts a dollar convenience yield as a currency-specific latent demand term in a log-linear regression. While this approach benefits from flexibility, making it well suited to analysing jointly a wide range of pricing factors, the direct estimation of structural parameters in a nonlinear model can capture in greater detail the finer implications of a single factor, convenience prefernces, taken in isolation.

A strand of this literature applies the demand system framework to the market for U.S. Treasuries. Chaudhary et al. (2025) decomposes the sectoral contribution to Treasury yield changes, finding that post-2008 the Federal Reserve plays a larger role while the importance of the foreign sector, taken as an aggregate, has diminished. Jansen et al. (2025) applies a similar decomposition to movements in yields along the term structure, finding that domestic banks and the foreign official sector predominate at short and medium maturities, while foreign mutual funds are the most important player at long maturities. Eren et al. (2025) find that domestic banks and mutual funds display elastic demand for Treasuries, while foreign official demand is inelastic. These results are consistent with mine, but I explain cross-sectoral differences in yield sensitivity through the lens of convenience yields. My approach is complementary to these studies: rather than adopting a comprehensive framework that aims to capture overall sectoral differences in Treasury demand succinctly, it hones in on the convenience yield as the feature differentiating demand across sectors and analyses its implications in depth with a bespoke modelling framework.

Closest to this paper, and standing at the intersection of the convenience yield and demand system asset pricing literatures, is Cavaleri (2025), which introduces a demand system with explicit modelling of Treasury convenience as a feature of investor preferences and estimates it on sectoral holdings data, recovering Treasury preference rankings. It finds that, among domestic investors, banks and broker-dealers enjoy the largest convenience yields, while households and insurance companies and pension funds value Treasury convenience little. My paper differs both in subject and in method. I analyse the convenience yield of U.S. Treasury with respect to foreign government bonds, rather than domestic AAA corporate bonds. The two concepts are related but distinct, with the premium against foreign government bonds being more directly informative on the funding advantage of the U.S. government and hence fiscal policy. Since foreign investors are the most plausible source of this premium, I disaggregate foreign demand into sectors, whereas it appears only as an aggregate in Cavaleri (2025). Methodologically, my approach recovers point estimates of Treasury preference parameters rather than rankings, opening the door to quantitative counterfactual experiments on the role of Treasury convenience for demand and yields.

Roadmap. The remainder of the paper is structured as follows. Section 2 lays out a model of sovereign portfolio choice with preference for Treasury convenience yields and derives testable predictions. Section 3 details the estimation procedure that maps the model to the data and reports the estimated Treasury prefernce parameters. Section 4 carries out counterfactual experiments quantifying the effect of Treasury preferences on portfolios and equilibrium returns. Section 5 concludes.

2 A model of portfolio choice with Treasury convenience

2.1 Model setup

Consider the problem of I sectors indexed by $i = 1, \dots, I$, each choosing a share $s_i \geq 0$ of its portfolio invested in U.S. Treasuries, while the rest is invested in the domestic government bond. This formulation implicitly imposes a no-short selling constraint. Let $E := \mathbb{E}[R_{US} - R]$ denote the expected excess return on U.S. Treasuries (R_{US}) relative to the domestic government bond (R). All sectors share risk aversion parameter $\gamma > 0$ and face an excess-return variance $\mathbb{V}[R_{US} - R] = V > 0$ and covariance $\mathbb{C}[R_{US} - R, R] = C$ with domestic returns, treated here as given.

Each sector has a mean-variance objective function in terminal wealth $\tilde{W}_i := s_i(R_{US} - R) + R$, augmented with an increasing, concave additive term $h(s_i)$, which represents the convenience yield from holding U.S. Treasuries. The convenience yield term depends on the portfolio share, rather than holdings, of U.S. Treasuries for algebraic convenience, but the predicitons of the model are qualitatively invariant to this choice.

The Treasury preference function $h(s_i)$ is a reduced form representation of the non-monetary payoffs of various kind that investors receive from Treasuries. The underlying mechanisms giving rise to a convenience yield are highly heterogeneous across different sectors. Banks and investment funds value the liquidity of Treasury bills to meet redemptions of on-demand dollar claims (Doerr et al., 2023), and value notes or bonds as repo collateral (Krishnamurthy, 2002, Laartis et al., 2026). Foreign pension funds, especially in low-interest rate countries, value long-maturity Treasuries as they provide safe returns that match the maturity of their liabilities and fit within their regulatory perimeter (Bernanke, 2005, **?**, Corell et al., 2025). Central bank reserve managers seek Treasuries as a safe and liquid container for their dollar holdings, ultimately motivated by exchange rate policy or geopolitical aims (Bernanke et al., 2011, Krishnamurthy and Lustig, 2019).

Providing a separate micro-foundation for each sector would significantly increase the complexity of the model, without adding much insight. Indeed, as pointed out in Krishnamurthy and Ma (2025), nothing fundamental is lost by adopting this approach: the equilibrium convenience yield simultaneously reflects the combined incentives of all marginal investors, rather than the simple sum of distinct components attributable to liquidity, collateral value or other features.

Sector i's portfolio problem can then be written as follows

$$\max_{s_i} \mathbb{E}[\tilde{W}_i] - \frac{\gamma}{2}\mathbb{V}[\tilde{W}_i] + \psi_{0,i}\, s_i \;+\; \psi_{1,i} \log s_i$$

Appendix A.1 provides a derivation of this problem from the maximisation of exponential utility with an increasing, concave additive term $h(s_i)$ under the assumption of normally-distributed R_{US} and R, in line with the canonical formulation of mean-variance preferences.

To obtain an analytical solution of the investor's problem, I set

$$h_i(s_i) \;=\; \psi_{0,i}\, s_i \;+\; \psi_{1,i} \log s_i,$$

with parameters $\psi_{0,i}$ (level) and $\psi_{1,i}$ (curvature). I assume $\psi_{1,i} \geq 0$ for concavity, implying a declining marginal benefit of Treasury convenience. This functional form follows Krishnamurthy and Vissing-Jorgensen (2012).

2.2 Portfolio shares

Solution. The first-order condition of the investor's problem with respect to s_i is

$$f(E, \psi_{0,j}, \psi_{1,j}) \coloneqq E - \gamma V s_i - \gamma C + \psi_{0,i} + \frac{\psi_{1,i}}{s_i} = 0. \tag{1}$$

Equation (1) can be rearranged into a quadratic in s_i and admits an explicit closed-form positive root, reported in Proposition 1. I select the positive root because $s_i > 0$ is required both by the $\log s_i$ term and by the no-short selling constraint, and the minus root is non-positive when $\psi_{1,i} > 0$.

Proposition 1. *The optimal non-negative U.S. Treasury portfolio share s_i^* of investor sector i's problem is*

$$s_i^* \ = \ \frac{E - \gamma C + \psi_{0,i} \ + \ \sqrt{(E - \gamma C + \psi_{0,i})^2 + 4\gamma V \psi_{1,i}}}{2\gamma V} \tag{2}$$

Proof. In Appendix A.2. □

Absent a convenience yield of U.S. Treasuries, with $\psi_{0,i} = \psi_{1,i} = 0$, the expression collapses to the standard optimal portfolio share of a mean-variance problem. If $\psi_{0,i} \neq 0$ and $\psi_{1,i} = 0$, so that the utility benefity of holding Treasuries is linear in the portfolio share, the presence of a convenience yield (or "inconvenience" for $\psi_{0,i} < 0$) will cause a level shift in the optimal portfolio share, but it will leave its sensitivity to excess returns unaffected. Instead, in the general case $\psi_{0,i} \neq 0$ and $\psi_{1,i} \neq 0$ the convenience yield will affect both the level of the optimal portfolio share and its return sensitivity through $\psi_{1,i}$.

If $\psi_{0,i} > 0$ and $\psi_{1,i} > 0$, s_i^* is larger than its counterpart in the standard mean-variance problem. Investors who value Treasuries beyond their monetary returns are willing to hold a larger portfolio share for any combination of risk and returns than those who do not. The presence of non-monetary payoffs also implies that the problem could admit a non-zero solution for $E - \gamma C < 0$, that is when the risk-return tradeoff of Treasuries is particularly poor.

The different implications of the level and curvature parameter on optimal portfolio shares reveal the limitation of modelling convenience yield as a residual latent demand term in a log-linear regression, as for example in Koijen and Yogo (2020) within a demand system framework.

Portfolio share sensitivity. To qualify these statements more precisely, I compute the derivatives of the optimal portfolio shares to expected excess returns and the parameters regulating the convenience yield, which will also be useful later as ingredients for comparative statics on equilibrium excess returns.

Proposition 2. *The total derivative of optimal portfolio share s_i^* with respect to the equilibrium excess return E is*

$$\frac{\mathrm{d}s_i}{\mathrm{d}E} \ = \ \frac{1}{\gamma V + \psi_{1,i}/s_i^2}. \tag{3}$$

$\frac{\mathrm{d}s_i}{\mathrm{d}E} > 0$ *if* $\gamma V + \psi_{1,i}/s_i^2 > 0$.

Proof. In Appendix A.3.1. □

Therefore, the presence of a diminishing marginal utility of holding Treasuries captured by $\psi_{1,i} > 0$ reduces the sensitivity of Treasury portfolio shares to excess returns. $\psi_{1,i} > 0$ is a sufficient, but not necessary condition. Even with $\psi_{1,i} < 0$, $\frac{\mathrm{d}s_i}{\mathrm{d}E} > 0$ as long as the "inconvenience" from Treasuries is not so strong as to overturn the effect of risk aversion, captured by the condition $\gamma V + \psi_{1,i}/s_i^2 > 0$. This case shouldn't be discarded *a priori*, as Treasury "inconvenience" has been documented both in specific acute episodes such as the COVID pandemic He et al. (2022), and more chronically as a trend starting after the Great Financial Crisis Klingler and Sundaresan (2023), Du et al. (2025), Jiang et al. (2025)

As a higher exposure to Treasuries implies a steeply declining marginal benefit, investors' incentive to rebalance in the face of higher returns is reduced. In this sense, a concave Treasury convenience yield plays the same role as risk aversion γ. Therefore, a precise, model-consistent quantification of the U.S. Treasury premium cannot rely solely on the cross-sectoral comparison of yield elasticities, as pointed out in Cavaleri (2025), and requires direct estimation of structural preference parameters.

Proposition 3. *The partial derivative of optimal portfolio share s_i^* with respect to Treasury preference shifter parameter $\psi_{0,i}$ at fixed E is*

$$\left.\frac{\partial s_i}{\partial \psi_{0,i}}\right|_E = \frac{1}{\gamma V + \psi_{1,i}/s_i^2}. \tag{4}$$

$\left.\frac{\partial s_i}{\partial \psi_{0,i}}\right|_E > 0$ *if* $\gamma V + \psi_{1,i}/s_i^2 > 0$.

Proof. In Appendix A.3.2. □

Note that $\left.\frac{\partial s_i}{\partial \psi_{0,i}}\right|_E = \frac{\partial s_i}{\partial E}$. Both excess returns and the linear component of Treasury preferences produce a level shift in the optimal portfolio share, so their marginal effect is the same.

Proposition 4. *The partial derivative of optimal portfolio share s_i^* with respect to Treasury preference curvature parameter $\psi_{1,i}$ at fixed E is*

$$\left.\frac{\partial s_i}{\partial \psi_{1,i}}\right|_E = \frac{1/s_i}{\gamma V + \psi_{1,i}/s_i^2}. \tag{5}$$

$\left.\frac{\partial s_i}{\partial \psi_{0,i}}\right|_E > 0$ *if* $\gamma V + \psi_{1,i}/s_i^2 > 0$.

Proof. In Appendix A.3.3. □

The optimal share is increasing in both the level and the curvature parameters, provided that the regularity condition $\gamma V + \psi_{1,i}/s_i^2 > 0$ is met. Therefore, the convenience yield acts as an additional incentive to hold U.S. Treasuries beyond their risk-return tradeoff.

2.3 Equilibrium

I now characterise the equilibrium and analyse the properties of Treasury excess returns, focusing on the consequences of Treasury preferences.

Definition. *An equilibrium is defined by the set of portfolio shares s_i $\forall$ i and expected excess return E such that*

1. *s_i satisfies the optimality conditions of investor i's portfolio choice problem $\forall i$.*
2. *The market for U.S. Treasuries clears.*

Market clearing. The model outlined in this section is estimated on holdings data for euro area investors, which make up less than 10% of the total Treasury market capitalisation. Therefore, market clearing requires defining a residual investor sector, which is assumed to display a linear demand in excess returns for simplicity. I will then estimate this linear demand as a regression, separate from the estimation of the structural parameters for convenience yield investors.

The residual demand for Treasuries is assumed linear in E:

$$s_{\text{res}}(E) = s_{\text{res},0} + bE, \tag{6}$$

with $b > 0$ the residual slope. At this stage, I make the natural and innocuous assumption of a positive excess return slope to ensure the determinacy of equilibrium excess returns. Appendix C.1 shows that the assumption is borne out by the estimation of Equation (6). Total supply of Treasuries is the exogenous variable S_t.

Let $w_i > 0$ denote sector i's weight in aggregate private demand (normalized so $\sum_i w_i \leq 1$). Market clearing requires aggregated holdings (sectors and residual) to equal supply:

$$g(E) := \sum_{i=1}^{I} w_i s_i(E; \psi_{0,i}, \psi_{1,i}) + s_{\text{res},0} + bE - S \;=\; 0, \tag{7}$$

where I dropped the time subscript for notational ease.

Equilibrium excess returns. Market clearing defines an implicit funcion of equilibrium excess returns, $g(E)$. Each $s_i(E)$ is increasing in E (see Proposition 2), and under the assumption $b > 0$ $s_{\text{res}}(E)$is strictly increasing in E. Therefore, there exists a unique equilibrium E^* defined by $F(E^*) = 0$, solvable with standard root-finding methods. I now exploit this implicit function to derive comparative statics on equilibrium excess returns.

2.4 Comparative statics

The most directly observable effect of the special role of is the comparatively low return required by investors, especially foreign ones, to hold U.S. government debt (Jiang et al., 2019, 2022). In fact, the Treasury premium is often proxied by the spread between U.S. and other government bonds adjusted for credit risk (Du et al., 2018), paralleled by the Treasury excess return in the model.

Furthermore, the convenience yield also affects the absorption capacity of the market for additional debt issuance, with a robustly negative relationship between Treasury supply and convenience yields (Krishnamurthy and Vissing-Jorgensen, 2012, Du et al., 2018, Jiang et al., 2025, Graziano and Phillot, 2026) and evidence that the U.S. can issue more debt than other countries for a given increase in yield because of the global safe asset status of Treasuries (Jiang et al., 2024d).

I confirm whether the model captures these effects by analysing comparative statics for the effect of Treasury preferences on equilibrium excess returns and their sensitivity to debt supply.

Treasury preference and excess returns

Proposition 5. *The partial derivative of equilibrium excess return E with respect to Treasury preference shifter parameter $\psi_{0,j}$ is*

$$\frac{\partial E}{\partial \psi_{0,j}} \;=\; -\frac{w_j \dfrac{1}{\gamma V + \psi_{1,j}/s_j^2}}{b \;+\; \displaystyle\sum_{i=1}^{I} w_i \dfrac{1}{\gamma V + \psi_{1,i}/s_i^2}}. \tag{8}$$

If $\gamma V + \psi_{1,i}/s_i^2 \;\geq 0 \;\forall i$, *then* $\frac{\partial E}{\partial \psi_{0,j}} \leq 0$

Proof. In Appendix A.3.4. □

As investors value U.S. Treasuries beyond their risk-return profile, they require a lower monetary compensation in equilibrium the stronger their preferences for Treasuries. Instead, if investors attach a strong enough "inconvenience yield" to Treasuries to offset even the effect of risk aversion ($\gamma V + \psi_{1,i}/s_i^2 < 0$) they will require a higher excess return instead. The magnitude of the effect is an increasing function of sector j's excess return sensitivity weighted by its relative size relative to other sectors'. The more prominent a sector in the Treasury market, and the more reactive its demand, the higher the contribution of its Treasury preference to equilibrium excess returns.

Proposition 6. *The partial derivative of equilibrium excess return E with respect to Treasury preference curvature parameter $\psi_{1,j}$ is*

$$\frac{\partial E}{\partial \psi_{1,j}} = -\frac{w_j \dfrac{1}{s_j(\gamma V + \psi_{1,j}/s_j^2)}}{b + \displaystyle\sum_{i=1}^{I} w_i \frac{1}{\gamma V + \psi_{1,i}/s_i^2}}. \tag{9}$$

If $\gamma V + \psi_{1,i}/s_i^2 \geq 0 \; \forall i$, *then* $\frac{\partial E}{\partial \psi_{1,j}} \leq 0$

Proof. In Appendix A.3.5. □

The same properties of the derivative with respect to $\psi_{0,j}$ carry through to $\psi_{1,j}$. Therefore, both the level shifter and curvature of Treasury preferences reduce equilibrium excess returns proportionally to the sector's weight in the market and to its sensitivity to returns. Thus, I can define the model-implied Treasury premium TP as

$$TP := E\Big|_{\psi_{0,j}=\psi_{1,j}=0\,\forall j} - E\Big|_{\psi_{0,j},\psi_{1,j}}, \tag{10}$$

the difference in Treasury excess returns between an equilibrium without Treasury preferences, and one with the realised values of $\psi_{0,j}$ and $\psi_{1,j}$.

Note that, in principle, this Treasury premium is a theoretical object that depends on structural parameters $\psi_{0,j}$ and $\psi_{1,j}$. Therefore, it may differ from the empirical proxies such as Treasury-AAA corporate bond spreads Krishnamurthy and Vissing-Jorgensen (2012) or Treasury-foreign government bond spreads (Du et al., 2018), offering an alternative perspective on the measurement of Treasury convenience.

Both derivatives depend on sectoral weights w_i and on $\psi_{1,j}/s_j^2$, the absolute value of the Treasury term curvature in the objective function. Therefore, the overall contribution of a sector to the U.S. Treasury premium is a function of both the relative size of its holdings and the intensity of diminishing returns in the convenience yield, reflecting marginal pricing.

Treasury supply and excess returns

Proposition 7. *The partial derivative of equilibrium excess return E with respect to U.S. Treasury supply S is*

$$\frac{\partial E}{\partial S} = \frac{1}{b + \displaystyle\sum_{i=1}^{I} w_i \frac{1}{\gamma V + \psi_{1,i}/s_i^2}}. \tag{11}$$

If $\gamma V + \psi_{1,i}/s_i^2 \; \geq 0 \; \forall i$*, then* $\frac{\partial E}{\partial \psi_{1,j}} \geq 0$

Proof. In Appendix A.3.6. □

As in the standard mean-variance model, an increase in debt supply results in a higher equilibrium excess return to compensate risk-averse investors, provided the regularity condition $\gamma V + \psi_{1,i}/s_i^2 \; \geq 0 \; \forall i$ is met. However, Treasury preferences introduce an additional rationale for investors to require a higher return in the face of debt supply: the diminishing marginal utility of Treasury convenience. Note that, just like it does for the sensitivity of portfolio shares to excess returns, the partial effect of the concavity parameter $\psi_{1,i}$ plays the same role as risk aversion, that is it *increases* the responsiveness of excess returns to debt supply. To investigate the total effect of Treasury preferences on the sensitivity of returns to debt supply, I now turn to deriving explicit comparative statics on the second derivatives of supply sensitivity $\partial E/\partial S$ with respect to the convenience parameters.

Treasury preference and return sensitivity to supply

Proposition 8. *The second derivative of excess returns E with respect to Treasury supply S and Treasury preference shifter parameter $\psi_{0,j}$ is*

$$\frac{\partial}{\partial \psi_{0,j}} \left(\frac{\partial E}{\partial S} \right) = -\frac{1}{(b+A)^2} \, w_j \frac{2\psi_{1,j}}{D_j^3 s_j^3}, \tag{12}$$

with

$$A(E) \equiv \sum_{i=1}^{k} w_i \frac{1}{\gamma V + \psi_{1,i}/s_i^2}, \qquad D_j \equiv \gamma V + \psi_{1,j}/s_j^2.$$

$\frac{\partial}{\partial \psi_{0,j}} \left(\frac{\partial E}{\partial S} \right) < 0$ *for* $\psi_{1,j} > 0$.

Proof. In Appendix A.3.7 □

For any investor who derives increasing and marginally diminishing utility from holding Treasuries ($\psi_{1,j} > 0$), the level shift component of their Treasury preferences unambiguously lowers the sensitivity of excess returns to debt supply. The higher absorption capacity at any level of returns implied by $\psi_{0,j}$ dampens the reaction of returns to additional supply, unless the "inconvenience yield" is strong enough to reverse the effect through a heightened investor sensitivity to excess returns.

Proposition 9. *The second derivative of excess returns E with respect to Treasury supply S and Treasury preference curvature parameter $\psi_{1,j}$ is*

$$\frac{\partial}{\partial \psi_{1,j}} \left(\frac{\partial E}{\partial S} \right) = \frac{w_j}{(b+A)^2} \cdot \frac{1}{D_j^2} \left(\frac{1}{s_j^2} - \frac{2\psi_{1,j}}{D_j s_j^4} \right). \tag{13}$$

$\frac{\partial}{\partial \psi_{1,j}} \left(\frac{\partial E}{\partial S} \right) < 0$ *for* $\frac{\psi_{1,j}}{s_j^2} > \gamma V$.

Proof. In Appendix A.3.8 □

Therefore, the overall impact of $\psi_{1,j}$ on the sensitivity of excess returns to debt supply, considering the implicit dependence of the optimal portfolio share on the excess return and curvature parameter, is ambiguous. The sign depends on the balance of two opposing forces acting through the sensitivity of portfolio shares to excess returns: the curvature of Treasury preferences ($\psi_{1,j}/s_j^2$), and risk aversion (γV).

If the former prevails, investors accept lower excess returns for any level of debt supply due to the stronger influence of the baseline convenience yield mediated by the level shift parameter. Recall that, by itself, $\psi_{1,j}$ tends to *amplify* the reaction of excess returns to debt supply, just like risk aversion. Therefore, its dampening effect must act through interaction with $\psi_{0,j}$, as illustrated in Equation (12) If the latter prevails, risk aversion is strong enough to dampen the sensitivity of the optimal portfolio share , acting in conjunction with the partial effect of $\psi_{1,j}$. This reduced absorption capacity will induce the equilibrium to adjust to the additional debt supply through prices rather than quantities at the margin, hence raising excess returns. The relative strenght of the two effects is an empirical question, which I answer, among others, by estimating the model in the following sections.

3 Estimation

The model makes four key predictions on the implications of U.S. Treasury convenience for the portfolios of foreign investors and for equilibrium Treasury returns. (i) Investors who derive a convenience yield from U.S. Treasuries choose a higher share of Treasuries in their sovereign portfolio than those who do not. (ii) Preferences for U.S. Treasuries lower the sensitivity of portfolio shares to excess returns. (iii) Preferences for U.S. Treasuries lower equilibrium excess returns, generating a Treasury premium to which each sector contributes proportionally to its size and return sensitivity. (iv) Preferences for U.S. Treasuries may lower or raise the sensitivity of excess returns to debt supply, depending on the relative strength of the curvature and risk aversion effects.

These predictions concern unobserved counterfactuals, so I need to estimate the structural parameters $\psi_{0,i}$ and $\psi_{1,i}$ to test and quantify them within the model. I estimate the Treasury preference parameters via Generalised Method of Moments (GMM), exploiting the first-order condition of the investor's portfolio problem as a set of moment restrictions. The risk aversion parameter γ is calibrated to $\gamma = 5$, consistent with standard values in the asset pricing literature (Elminejad et al., 2025). The estimation is carried out for four euro area investor sectors: banks (MFI), non-bank financial institutions (NBFI), governments (GOV), and households (HH).

3.1 Estimating equations

FOC moment conditions. The structural parameters $\psi_{0,i}$ and $\psi_{1,i}$ are estimated by exploiting the first-order condition in Equation (1) as a set of moment restrictions. Defining the residual of the FOC as

$$f_{ij}(\psi_{0,i}, \psi_{1,i}; \gamma) \;\coloneqq\; E_j - \gamma V_j s_{ij} - \gamma C_j + \psi_{0,i} + \frac{\psi_{1,i}}{s_{ij}}, \tag{14}$$

the model implies $\mathbb{E}[f_{ij}] = 0$ at the true parameter values, applying the law of iterated expectation given a common γ and treating E_j,V_j and C_j as observable variables proxied by their sample counterparts. Here the index $j = 1, \ldots, J$ denotes euro area investment countries, and each observation s_{ij} represents aggregate euro area sector i's U.S. Treasury share in a portfolio including U.S. Treasuries and country j's government bonds. The cross-sectional variation along the investment country j dimension aligns with the variation used in the identification strategy.

Both the portfolio share s_{ij} and the first and second moments of excess returns, E_j, V_j, and C_j, vary at the country level. The parameters $\psi_{0,i}$ and $\psi_{1,i}$ are sector-specific and common across countries within a sector, while γ is calibrated to the same value for all sectors. Estimating $\psi_{0,i}$ and $\psi_{1,i}$ for each sector requires at least two moment conditions, one for each parameter. The baseline condition exploiting the unconditional expectation of the residual is

$$\mathbb{E}[f_{ij}(\psi_{0,i}, \psi_{1,i}; \gamma)] = 0, \tag{15}$$

and the second condition uses the de-meaned PSPP instrument $\tilde{Z}_j$ as a weighting function:

$$\mathbb{E}\Big[f_{ij}(\psi_{0,i}, \psi_{1,i}; \gamma) \cdot \tilde{Z}_j\Big] = 0. \tag{16}$$

These two moment conditions yield exact identification of $(\psi_{0,i}, \psi_{1,i})$ separately for each sector, given γ. Intuitively, Equation (15) is informative for the level shift parameter $\psi_{0,i}$ as it imposes the baseline moment condition exploiting variation in the intercept given $\psi_{1,i}/s_{ij}$, while Equation (15) is informative on the curvature parameter $\psi_{1,i}$ through $\psi_{1,i}/s_{ij}$, as it uses correlation between portfolio shares and the external instrument for identificaiton.

Since the resulting equations are linear in $(\psi_{0,i}, \psi_{1,i})$, the per-sector GMM system admits an analytical solution. The use of the PSPP instrument as the weighting function in the second moment condition exploits cross-country variation in bond supply to identify the curvature of Treasury preferences, and is discussed further in Section 3.3.

3.2 Data

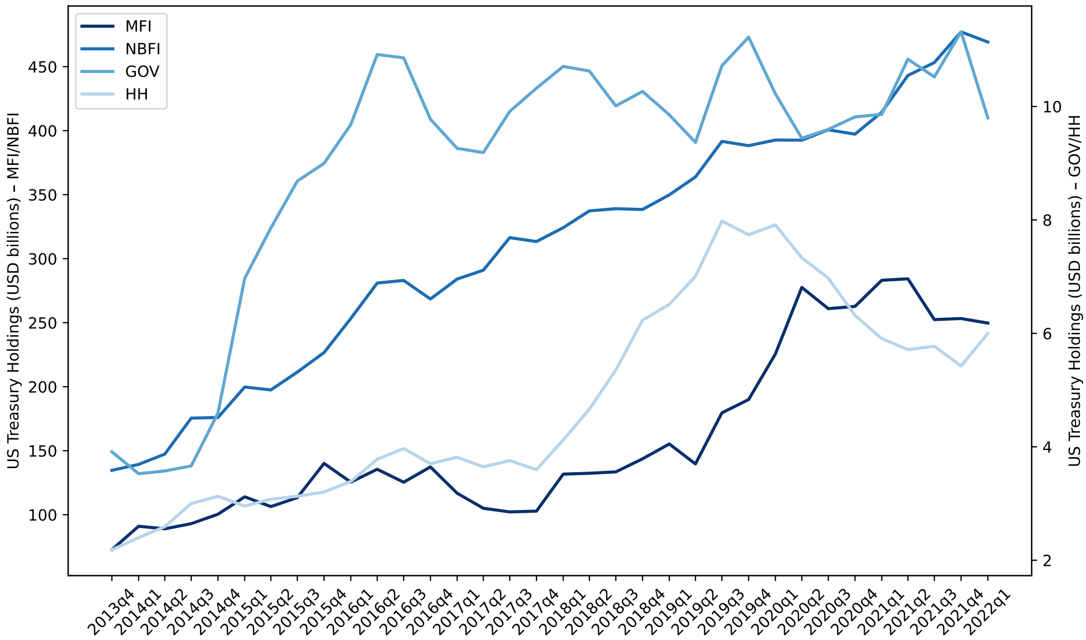
I estimate Equations (15)–(16) with data on euro area and U.S. government bond holdings for MFIs, NBFIs, governments and households resident in the euro area, sourced from the publicly available Securities Holdings Statistics (SHS) dataset by the European Central Bank.[2] Figure 1 plots holdings of U.S. Treasuries for the four sectors. Banks and non-bank financial institutions display holdings of the order of hundreds of billions of dollars, while governments and households only hold single-digit billions. Despite the clear difference in scale, aggregate holdings are not *per se* informative on the relative contribution to equilibrium returns, which in the model depend on both the relative size of sectors and the return sensitivity of their portfolio shares. All sectors display significant variation in Treasury holdings, with a general upward trend over the sample period.[3]

Although euro area investors make up only a small fraction of the Treasury market, they are arguably the main driver of the convenience yield of U.S. Treasuries relative to European bonds, so restricting the analysis to euro area holdings and the Treasury excess return relative to euro area sovereign debt is internally consistent and likely to be informative. The European setting

[2]Holdings by NBFIs aggregate data for insurance companies and pension funds (ICPFs) and other financial intermediaries (OFIs), which in turn include mutual funds, money market funds and all other financial intermediaries except for banks, insurance companies and pension funds. Government holdings include central and local governments, mainly governmental pension funds, and importantly exclude central banks. Holdings by households also include not-for-profit organisations that invest on behalf of households.

[3]The data is available from 2013 Q4 to 2022 Q1, when it was replaced with the Securities Holdings Statistics by Sector (SHSS) database, which does not include holdings of foreign government debt broken down by issuer country.

Figure 1. U.S. Treasury holdings of euro area investors



Holdings of U.S. general government debt securities at all maturities for all monetary and financial institutions (MFI, right-hand axis), non-bank financial institutions (NBFI, right-hand axis), governments (GOV, left-hand axis) and households (HH, left-hand axis) domiciled in the euro area. Source: European Central Bank Securities Holdings Statistics database.

also provides an ideal context to study the contribution of different investor sectors to Treasury convenience yields for several reasons.

First, the available data allows to natively observe the sovereign portfolios of different sectors without the need for assumptions or imputation. Existing literature on the demand for government bonds mainly relies on data that cannot break down foreign Treasury holdings by both country and sector. While the Treasury International Capital database includes foreign holdings of U.S. government bonds at the country level, a sectoral breakdown of foreign holdings is generally not available.[4]

Furthermore, the use of global data for different investor classes would introduce complications in mapping the model to the data. The theoretical model in this paper analyses the simple choice between U.S. and domestic-currency government bonds. While euro-denominated sovereign bonds are a natural choice of domestic asset when focusing on the eurozone, this would not be the case when using global data, requiring the definition of an average Treasury premium or the construction of a synthetic "domestic" government bond.[5]

[4] Some exceptions include Tabova and Warnock (2022), Eren et al. (2025), and Fang et al. (2023).

[5] I use data on the portfolios of aggregate sectors at the eurozone level, so the domestic asset is defined by currency rather than country. This approach is consistent with the assumption that risk premia stem only from exchange rate fluctuations in the model.

Finally, the peculiar structure of purchases under the ECB's Public Sector Purchase Programme (PSPP) quantitative easing policy generates exogenous cross-sectional variation in the relative supply of government bonds across euro area countries, providing an ideal instrument Z_j for Treasury supply in the market clearing moment condition.

3.3 Identification

Expected excess returns. The moment conditions in Equations (15)–(16) require an empirical proxy for E_j, the expected excess return on U.S. Treasuries relative to country j's government bond. I proxy E_j with an observable variable, allowing it to vary over quarters and countries. I replace the population variance V_j and covariance C_j with their respective sample moments computed from the time series of realised returns.

Instrument for Treasury supply. The very stylised partial equilibrium model does not account for the possibility that debt supply is endogenous to portfolio choice through general equilibrium effects and strategic issuance choices. Even variation in debt supply induced by unconventional monetary policy does not fully allay endogeneity concerns, as such policies are adopted in response to highly endogenous macroeconomic conditions. This is especially relevant for European banks, which tend to load up on domestic government bonds in precisely the turbulent times that motivate quantitative easing, either through a "gambling for resurrection" strategy (Acharya and Steffen, 2015) or due to moral suasion by their governments (De Marco and Macchiavelli, 2016, Ongena et al., 2019).

In order to obtain variation in Treasury supply that is exogenous to investors' portfolio choice, I exploit the characteristics of the PSPP, implemented by the ECB starting in January 2015. The ECB bought government bonds issued by all countries with a credit rating of at least BBB− and with maturities from 2 to 30 years.[6] Purchases are apportioned according to a scheme that aims at market neutrality: they are proportional to each country's Capital Key and mirror as closely as possible the maturity structure of outstanding bonds.

The Capital Key for each country is the equal-weighted average of its share of the eurozone's population and GDP. It is updated every five years and whenever the membership of the European Union changes. In my sample, running from 2015 to 2022, the Capital Key changed twice: in 2019 due to a five-yearly update, and in 2020 following the withdrawal of the United Kingdom from the EU. Since country size is plausibly independent of portfolio choice and GDP-related updates are slow-moving, changes in the Capital Key are likely exogenous to the residual of the structural equations. The other source of cross-sectional variation is the difference between the pre-existing maturity structure of PSPP holdings and that of each country's outstanding bonds. Since this difference depends only on governments' decisions on the term structure of their issuance relative to the pre-existing PSPP maturity profile, it plausibly satisfies the exclusion restriction as well. Koijen et al. (2021) also uses PSPP purchases as an instrument for debt supply, relying on purchases predicted by the Capital Key rather than actual amounts.

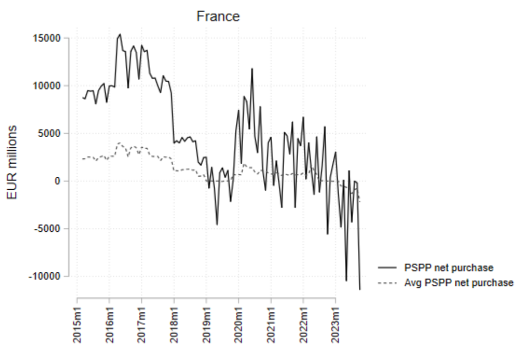
An additional issue is the validity of PSPP purchases as a weighting function in the FOC moment condition (16). PSPP purchases affect expected excess returns E_j through their impact

[6] The restriction on credit rating resulted in the exclusion of Greek bonds. In the context of this paper, excluding Greece helps ensure that the empirical proxy for excess returns is driven by currency risk rather than default risk, consistent with the assumption made in the model.

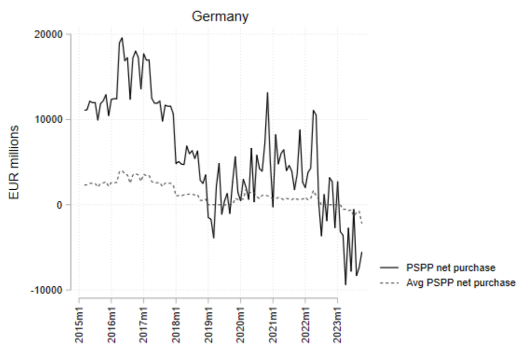
on domestic bond supply, and E_j enters the FOC residual f_{ij} explicitly. This channel is therefore accounted for in the estimating equation. Identification of $\psi_{1,i}$ from this moment condition requires that cross-country differences in PSPP purchase intensity $\tilde{Z}_j$ are uncorrelated with the FOC residual except through their effect on portfolio shares s_{ij} and excess returns E_j, which is plausible given the market-neutral design of the programme.

To further strengthen identification, I subtract the cross-sectional mean $P\bar{S}PP_t$ to remove the common time-series variation in PSPP purchases, which reflects the likely endogenous aggregate size of the ECB's quantitative easing programme. obtaining de-meaned purchases $P\tilde{S}PP_{j,t} = PSPP_{j,t} - P\bar{S}PP_t$. Therefore, I rely only on cross-country differences in purchase intensity for identification. Figure 2 illustrates this source of variation: the solid lines represent purchases for each of the four largest euro area countries, while the dashed line depicts the cross-sectional average. The identifying variation is captured by the difference between the solid and dashed lines.

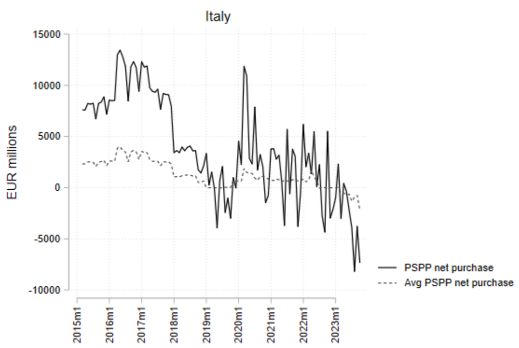
Figure 2. PSPP purchases



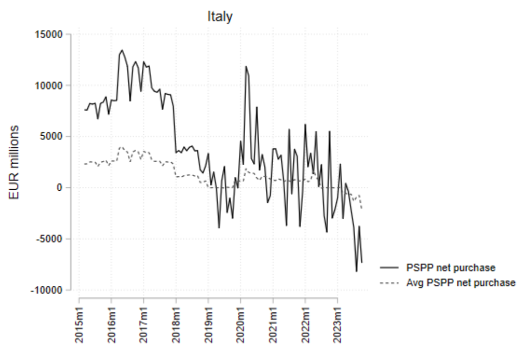
(a) France



(b) Germany



(c) Italy



(d) Spain

Monthly net purchases of sovereign debt under the Public Sector Purchase Programme, all maturities. The solid line depicts monthly net purchases for each country; the dashed line represents the cross-sectional average of monthly net purchases across all eligible countries. Source: European Central Bank.

3.4 Estimation procedure

Overview. The full parameter vector consists of the calibrated risk aversion γ and sector-specific pairs $(\psi_{0,i}, \psi_{1,i})$ for $i = 1, \ldots, I$. The key structural feature that motivates the estimation procedure is the block separability of the moment conditions: the FOC residual f_{ij} in Equation (14) depends only on the parameters of sector i, and not on those of other sectors. I exploit this structure by estimating the preference parameters for each sector separately, conditional on the calibrated γ.

Calibration. The second moments of excess returns, C_j and V_j, are proxied by their respective sample counterparts calculated per-country over the quarter distribution. The risk aversion parameter is set to $\gamma = 5$, the median estimate reported in a survey of the literature on risk aversion estimation (Elminejad et al., 2025). Given γ, the preference parameters $(\psi_{0,i}, \psi_{1,i})$ are estimated via GMM on the FOC moment conditions, separately for each sector.

Estimation of residual demand sensitivity. As a preliminary step, the parameter b measuring the sensitivity of residual investor demand to excess returns is estimated via 2SLS, instrumenting the endogenous excess return $e_{j,t}$ with high-frequency monetary policy shocks from Bauer and Swanson (2022). The estimate $\hat{b}$ enters the market clearing condition used for computing model-implied quantities and comparative statics. Details and results of the 2SLS regression are presented in Appendix C.1.

Estimation of preference parameters. For each sector i, the preference parameters $(\psi_{0,i}, \psi_{1,i})$ are estimated by GMM on the two moment conditions (15) and (16), conditional on $\gamma = 5$. The estimator solves the exactly-identified system

$$\frac{1}{JT} \sum_{j=1}^{JT} \begin{pmatrix} f_{ijt}(\psi_{0,i}, \psi_{1,i}; \gamma) \\ f_{ijt}(\psi_{0,i}, \psi_{1,i}; \gamma) \cdot \tilde{PSPP}_{jt} \end{pmatrix} = \mathbf{0}, \tag{17}$$

where $\tilde{PSPP}_{jt} = PSPP_{jt} - \bar{PSPP}_t$ denotes the cross-sectionally de-meaned PSPP purchases. This problem admits an analytical solution $(\hat{\psi}_{0,i}, \hat{\psi}_{1,i})$ because the moment conditions exactly identify $(\psi_{0,i}, \psi_{1,i})$ given γ, and the moment conditions are linear in the preference parameters.

Inference. The replacement of the variance V_j and covariance C_j by their sample counterparts in the estimation introduces a layer of estimation error that a standard GMM variance formula for the point estimates would understate. Additionally, the estimated sensitivity of residual investor demand to excess returns, $\hat{b}$, introduces a further layer of uncertainty in the model-implied quantities that depend on market clearing. I account for these layers of estimation uncertainty via a clustered bootstrap, which propagates uncertainty across all steps without requiring the analytical derivation of cross-block Jacobians.

The unit of resampling is the country j. Each bootstrap iteration draws J countries with replacement from the original sample, retaining all investor sectors and all time periods for each drawn country. Resampling at the country level preserves the cross-sector dependence within countries. Each bootstrap iteration re-estimates $\hat{V}^{(b)}$, $\hat{C}^{(b)}$, and $\hat{b}^{(b)}$ from the resampled data, then re-estimates $(\hat{\psi}_{0,i}^{(b)}, \hat{\psi}_{1,i}^{(b)})$ from the FOC moment conditions conditional on $\gamma = 5$, and records the resulting parameter vector $(\{\hat{\psi}_{0,i}^{(b)}, \hat{\psi}_{1,i}^{(b)}\})$. Bootstrap standard errors are computed as the standard deviation of the resulting empirical distribution across $B = 1{,}000$ replications.

Summary statistics. Table 1 reports summary statistics for all variables used in the estimation. Panel A shows each euro area sector i's share of U.S. Treasuries in a sovereign portfolio that also includes country j's government bonds, on a bilateral country basis aggregated over all maturities. For example, $s_{\text{MFI,DE}}$ is the Treasury share in the aggregate eurozone banking sector portfolio including U.S. Treasuries and German government bonds. I use bilateral portfolio shares both for consistency with the model and because the identification strategy relies on cross-country variation in PSPP purchases, hence requiring variation in portfolio shares along the same dimension. For this reason, cross-country average U.S. portfolio shares are high, ranging from 63% to 75%, reflecting both the dominant role of Treasuries as a global safe asset and home bias in domestic debt holdings (Coeurdacier and Rey, 2013). Substantial within-sector variation across countries nonetheless ensures enough variability for identification. Panel A also reports statistics for the Treasury holdings of residual investors, divided by the sum of total portfolio size $B_{j,t}$ across sectors, as a normalisation for scale consistency in comparative statics.

Panel B reports summary statistics for the empirical proxy of excess returns, and the instruments used for GMM and 2SLS estimation. $er_{j,t}$ is a proxy for the excess returns of US Treasuries with respect to country j's government bonds, on average for quarter t. Expected excess returns in the model depend on the Treasury convenience yield and on the risk premium attached by investors to uncertain movements in the euro-dollar exchange rate. Investors' expectations are unobservable in my dataset, so I follow the methodology in Koijen et al. (2021) and assume the excess return expectation equals the adjsted current yield spread, proxying $\mathbb{E}[R_{US} - R_j]$ as follows:

$$er_{j,t} = y_{US,t} - y_{j,t} - d_{j,t}$$

where $y_{US,t}$ and $y_{j,t}$ are the yields of US and country j government bonds, and $d_{j,t} \coloneqq CDS_{US,t} - CDS_{j,t}$ is the difference in sovereign CDS rates between the US and country j. All components are averaged over the 1,2,3,5, and 10 year maturities and over quarter t, weighted by the maturity structure of outstanding government debt for country j. This approach relies on controlling for differences in credit risk through $d_{j,t}$, to bring the empirical proxy in line with the assumption of a risk premium arising only through currency fluctuations. In the data, sovereign risk is likely to play an important role in a sample of European government bonds. Excess return have a positive mean of 2%, implying that the dollar risk premium is high enough to overtun Treasury convenience on average in the sample, consistent with the observation of declining convenience yields after the Great Financial Crisis (He et al., 2022, Jiang et al., 2025).

De-meaned PSPP purchases $\tilde{PSPP}_{j,t}$ still display substantial cross-sectional variation, with a mean of 275 mln. euro and a standard deviation of 8.8 bln. euro. The US monetary policy shock by Bauer and Swanson (2022) is measured in basis points, and also shows significant time-series variation in the sample, which I exploit to estimate b.

3.5 Estimated parameters

Figure 3 reports GMM point estimates and 90% bootstrapped confidence intervals for parameters $\psi_{0,i}$ and $\psi_{1,i}$. The level shifter parameter $\psi_{0,i}$ is positive for banks and non-bank financial intermediaries, while it is negative for the government sector and households. Equation (1) implies that banks and would accept a 7 and 6 basis points lower excess return, respectively, to hold any given amount of U.S. Treasuries compared to the case of no linear component in their Treasury preferences. On the contrary, the government sector and households demand a 9 and

Table 1. Summary statistics

	N	Mean	SD	Min	Max
Panel A: Portfolios					
$s_{\text{MFI},j,t}$	680	0.75	0.27	0.09	1.00
$s_{\text{NBFI},j,t}$	646	0.75	0.27	0.14	1.00
$s_{\text{GOV},j,t}$	671	0.63	0.35	0.03	1.00
$s_{\text{HH},j,t}$	646	0.73	0.24	0.07	1.00
$s_{res,t}/\sum_j B_{j,t}$	2643	53.49	270.31	6.33	4066.17
Panel B: Excess returns and instruments					
$er_{j,t}$	2643	0.02	0.03	-0.06	0.12
$\tilde{PSPP}_{j,t}$	2643	275	8793	-11484	43957
MP_t	2643	1.37	4.90	-8.02	10.90

Summary statistics calculated over the country j-sector t distribution separately for each sector i for portfolio shares $s_{i,j,t}$, and over the country j-sector$i$-quarter$t$ distribution for all other variables. Portfolio shares $s_{i,j,t}$ are measured in decimals, excess returns $er_{j,t}$ and monetary policy shocks MP_t are measured in basis points, and de-meaned PSPP purchases $\tilde{PSPP}_{j,t}$ are measured in million euro. Data sources: SHS (sectoral sovereign holdings), Refinitiv Eikon (interest and CDS rates), FRED (Treasury supply), Eurostat (other government debt supply) European Central Bank (PSPP), Bauer and Swanson (2022) (monetary policy shocks).

18 basis points higher return on Treasuries, respectively.

The curvature shift parameter $\psi_{1,i}$ is positive for all sectors, consistently with the concavity assumptions. At the sectoral portfolio share means, the estimates imply that curvature effects lower the required Treasury excess return by 2 basis points for banks, 1.5 basis points for non-bank financial intermediaries, 3 basis points for the government sector, and 1 basis point for households. Therefore, the cumulative level and curvature effect implies that all sectors assign a convenience yield to U.S. Treasuries on average, except for households.

Overall, preference parameters are estimated fairly precisely, with only the confidence interval for banks' level shift parameter crossing zero. Appendix C.2 reports the exact values of parameters and confidence interval bounds.

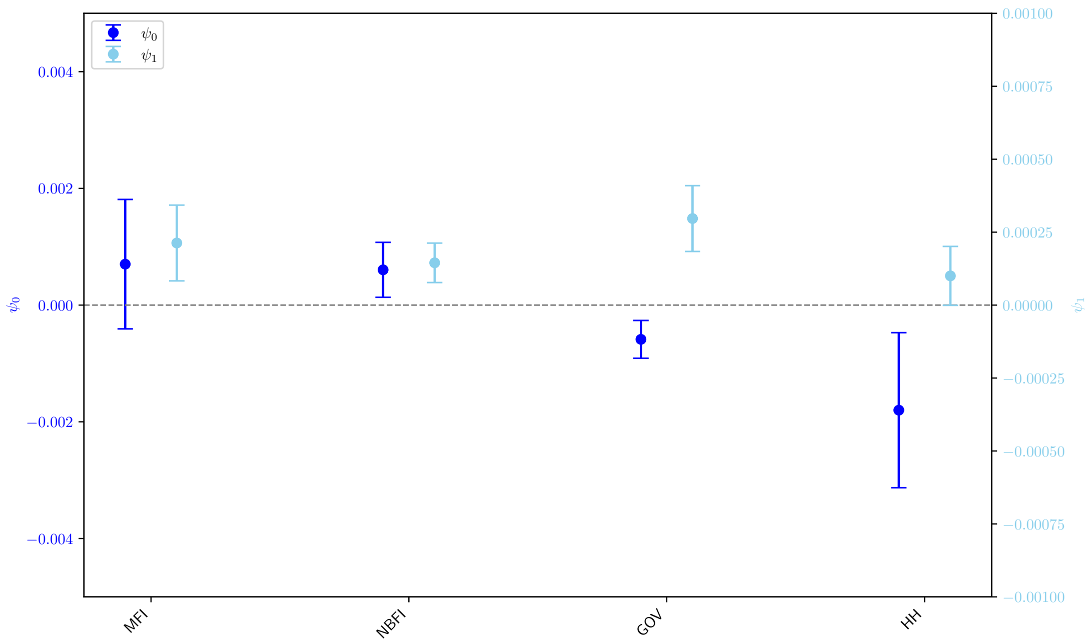
While the size of individual parameters is informative on the relative strength of the level shift and curvature effects within and across sectors, the goal of quantifying the impact of overall convenience yield preferences on the Treasury premium set out in this paper can only be achieved by performing counterfactuals on $\psi_{0,j}$ and $\psi_{1,j}$ jointly, to which I turn in the next section.

4 Model experiments

I carry out counterfactual experiments within the model aimed at quantifying the role of Treasury convenience by foreign investors in determining equilibrium portfolio shares, excess returns, and the sensitivity of excess returns to debt supply. The experiments also decompose the contributions of each sector to the Treasury premium and its sensitivity to debt supply.

All experiments in this section concern model-implied quantities, and take calibrated parameters

Figure 3. U.S. Treasury preference parameter estimates



GMM estimates and 90% bootstrapped confidence intervals for parameters $\psi_{0,i}$ (dark blue, left axis) and $\psi_{1,i}$ (light blue, right axis), by sector. The dashed horizontal line marks zero. Sectors: monetary financial institutions (MFI), non-bank financial intermediaries (NBFI), government (GOV), and households (HH). Data sources: ECB Securities Holdings Statistics ($s_{i,j,t}$), Refinitiv Eikon ($E_{j,t}$, $V_{j,t}$, $C_{j,t}$).

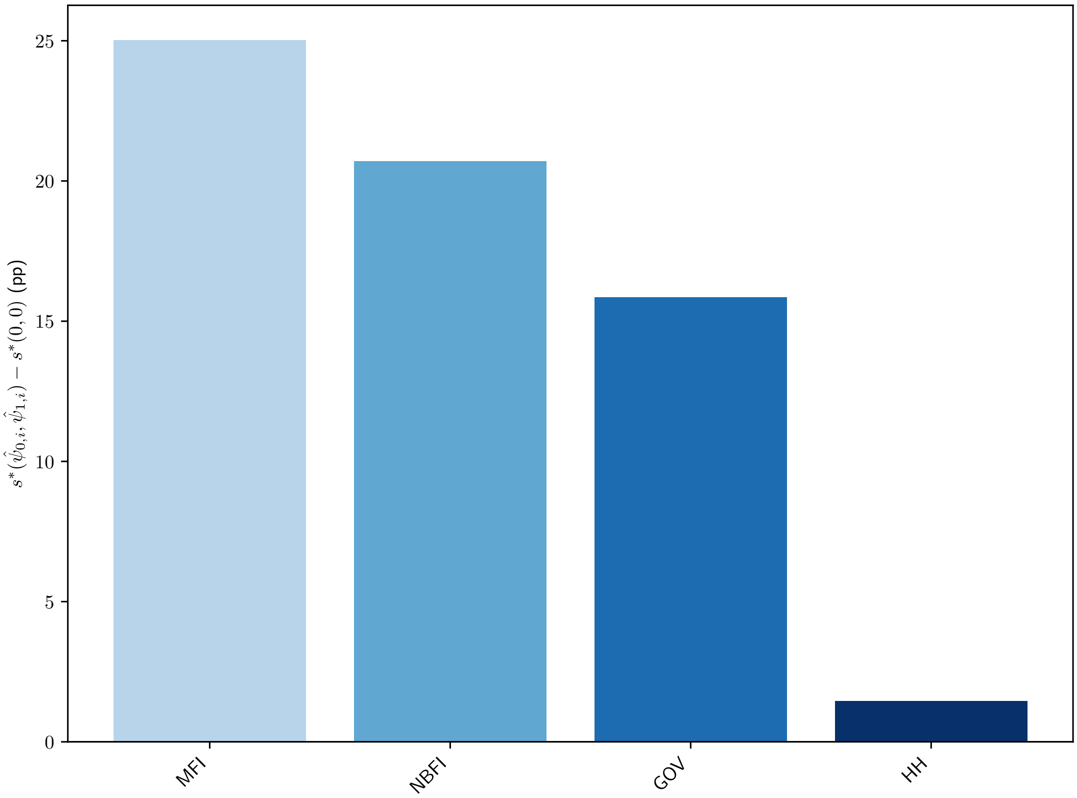
as a fixed inputs, averaged over investment countries. Since the goal of counterfactuals concerns the overall effect of Treasury preferences, including both level shift and curvature, they are all performed as comparison between quantities at the point estimates $(\hat{\psi}_{0,i}, \hat{\psi}_{1,i})$, and quantities at $\psi_{0,j} = \psi_{1,j} = 0$. The case $\psi_{0,j} = \psi_{1,j} = 0$ models the loss of Treasury convenience either for a single sector or for all sectors. Then, investors would simply evaluate Treasuries based on their risk-return profile. This approach allows to calculate the model-implied Treasury premium as $TP := E\Big|_{\psi_{0,j}=\psi_{1,j}=0\,\forall j} - E\Big|_{\psi_{0,j},\psi_{1,j}}$, offering a measure alternative to existing empirical proxies that rely on observed spreads (Krishnamurthy and Vissing-Jorgensen, 2012, Du et al., 2018).

4.1 Portfolio shares

I carry out experiments simulating the effect of Treasury convenience yield loss on the country-quarter average level and return sensitivity of portoflio shares, changing the preference parameters from their estimated values from $(\hat{\psi}_{0,i}, \hat{\psi}_{1,i})$ to 0. All other parameters affecting the optimal portfolio share (E ,V and C) are kept at their country-quarter averages, while γ remains at the calibrated value.

Share levels. In the first experiment, I calculate the difference between the optimal portfolio share at the point estimate for preference parameters, $s^*((\hat{\psi}_{0,i}, \hat{\psi}_{1,i}))$, and the share in the counterfactual without any convenience yield, $s^*(0,0)$.

Figure 4. Portfolio share level experiment



Difference in optimal Treasury portfolio shares between estimated preference parameters and the no-convenience-yield counterfactual, $s^*(\hat{\psi}_{0,i}, \hat{\psi}_{1,i}) - s^*(0,0)$, expressed in percentage points. Excess returns $E_{j,t}$, return variance $V_{j,t}$, and covariance $C_{j,t}$ are held at their country-quarter averages; γ is fixed at the calibrated value. Sectors: monetary financial institutions (MFI), non-bank financial intermediaries (NBFI), government (GOV), and households (HH). Data sources: ECB Securities Holdings Statistics ($s_{i,j,t}$), Refinitiv Eikon ($E_{j,t}$, $V_{j,t}$, $C_{j,t}$).

Figure 4 displays the results. If Treasuries lost their special status as global safe assets, European banks would reduce their Treasury portfolio share by 25 percentage points, non-banks by 20 percentage points and governments by 15 percentage points. The drop is large, ranging from 25% to 33% of the average observed share. Treasury holdings by these three sectors are then in large part attributable to their preference for the non-monetary payoffs of Treasuries, highlighting the importance of convenience yields for bolstering foreign demand by financial institutions and governments. On the other hand, households would only reduce their Treasury portfolio share by about 2 percentage points, suggesting that they mainly value Treasuries for their risk-return tradeoff. Note that, despite the negative $\psi_{0,HH}$ and the small positive $\psi_{1,HH}$, households still choose a higher Treasury share than in the no-convenience yield counterfactual due to the nonlinearity of the model.

While the change in share levels can shed light on the effect of convenience yield on aggregate foreign demand for Treasuries, it is not informative on the pricing impact attributable to each sector, as it depends crucially on marginal behviour and hence on the sensitivity of portfolios to excess returns.

Sensitivity to excess returns. In the second experiment, I calculate the ratio of the optimal portfolio share sensitivity to excess returns in the no-convenience yield counterfactual, $\frac{\partial s^*}{\partial E}\Big|_{(0,0)}$ to the portfolio share sensitivity at the estimated Treasury preference parameters, $\frac{\partial s^*}{\partial E}\Big|_{(\hat{\psi}_{0,i},\hat{\psi}_{1,i})}$. Since the derivative depends on the portfolio share level itself, I input the re-optimised portfolio share $s^*(0,0)$ when calculating the counterfactual $\frac{\partial s^*}{\partial E}\Big|_{(0,0)}$, hence accounting for second-order effects as well. A ratio larger than 1 implies that Treasury preferences dampen the reaction of investor's portfolios to excess returns, as predicted by the model outside of the edge case of strong Treasury "inconvenience".

Figure 5 displays the results. Absent Treasury convenience, the sensitivity of portfolio shares would be larger for all sectors. European banks and non-banks would react roughly 1.5 times more strongly to Treasury returns in the counterfactual, while governments' sensitivity would more than double. Households are the most striking : their portfolios would be a full seven times more sensitive to excess returns if they only valued Treasuries for their monetary risk-return profile.

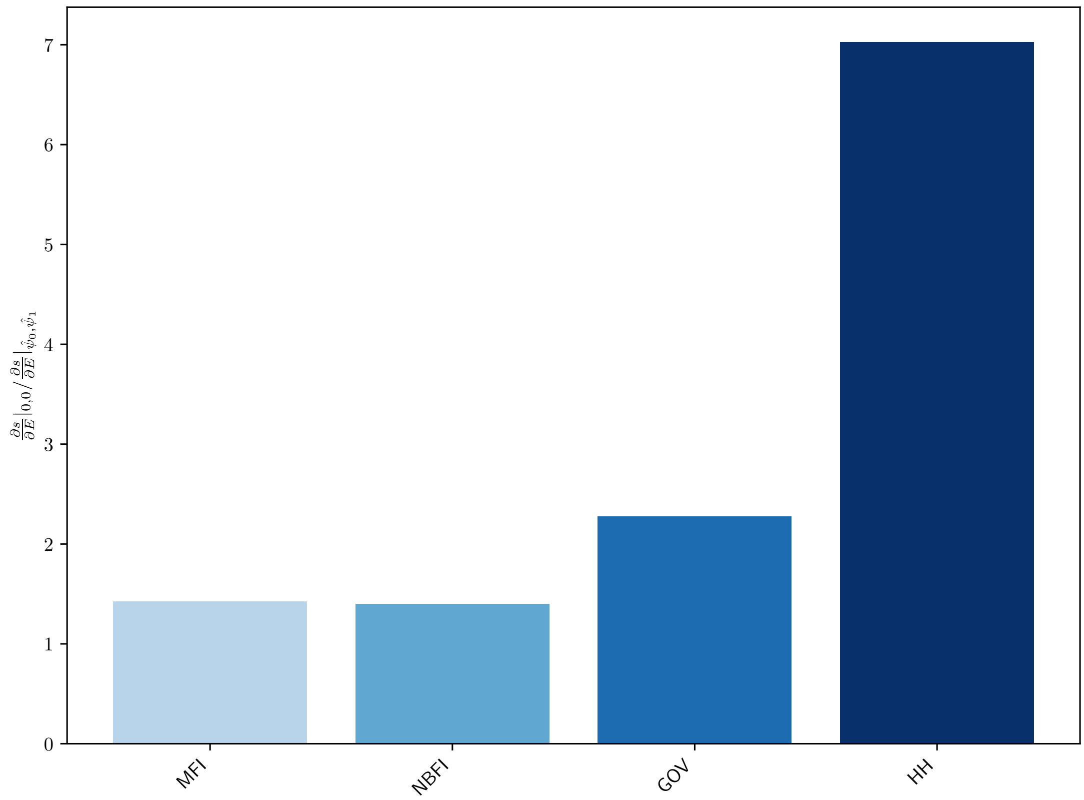
The large reduction of government due to Treasury preference is consistent with the foreign official sector as a source of stable, liquidity-driven demand for Treasuries, as characterised in Krishnamurthy and Vissing-Jorgensen (2007), Eren et al. (2025) and Jansen et al. (2025). However, the analysis in the previous literature relies only on the comparison of estimated yield elasticities, while this counterfactual explicitly quantifies the role of convenience yield preferences, separately from other factors affecting elasticities like risk aversion.

The ranking of sectors by convenience-driven excess return sensitivity is the mirror image of the ranking by portfolio shares. Due to the diminishing marginal benefits of Treasury convenience, sectors with large portfolio shares are relatively insensitive to excess returns through the curvature term of preferences. Therefore, neutering Treasury preferences has only a limited effect on their return sensitivity. As a consequence, the role of sectors in marginal pricing is an inverse function of their portfolio shares *ceteris paribus*. Sectors who value Treasury convenience highly maintain large and stable holdings without reacting strongly to excess returns, dulling their impact as marginal investors.

4.2 Excess returns

This set of experiments measure the model-implied Treasury premium and decompose sectoral contributions to both its level and its sensitivity to U.S. government debt supply. Throughout, excess returns $E_{j,t}$ are defined as the solution of the market-clearing condition in Equation (7), and averaged across Euro area investment countries. All other determinants of equilibrium excess

Figure 5. Portfolio share sensitivity experiment

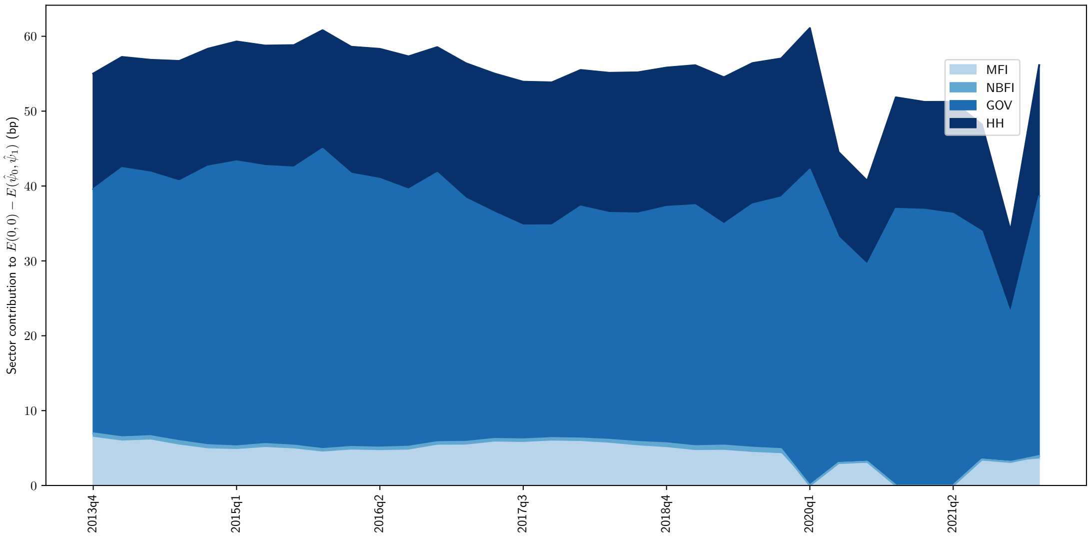


Ratio of optimal portfolio share sensitivity to excess returns in the no-convenience-yield counterfactual relative to estimated parameters, $\frac{\partial s^*}{\partial E}\big|_{(0,0)}$ / $\frac{\partial s^*}{\partial E}\big|_{(\hat{\psi}_{0,i},\hat{\psi}_{1,i})}$. The counterfactual derivative is evaluated at the re-optimised share $s^*(0,0)$. Excess returns $E_{j,t}$, return variance $V_{j,t}$, and covariance $C_{j,t}$ are held at their country-quarter averages; γ is fixed at the calibrated value. A ratio greater than one implies that Treasury preferences dampen the sensitivity of portfolio shares to excess returns. Sectors: monetary financial institutions (MFI), non-bank financial intermediaries (NBFI), government (GOV), and households (HH). Data sources: ECB Securities Holdings Statistics ($s_{i,j,t}$), Refinitiv Eikon ($E_{j,t}$, $V_{j,t}$, $C_{j,t}$).

returns are taken as fixed, including residual investor holdings estimated as a linear function of excess returns.

Sectoral contribution to Treasury premium. In the third experiment, I calculate a quarterly time series of the model-implied Treasury premium, defined as the difference between Treasury excess returns in the counterfactual without Treasury preferences, $E(0.0)$, and at the estimated Treasury preference parameters, $E(\hat{\psi}_{0,i}, \hat{\psi}_{1,i})$. All other time-varying variables are calculated as the cross-country average in a given quarter. In the model, excess returns arise due to both convenience yields and to the foreign exchange risk premium. Therefore, the difference isolates the convenience-yield component of excess returns.

Figure 6. Sectoral contribution to Treasury premium



Sectoral contributions to the model-implied Treasury premium $TP := E(0,0) - E(\hat{\psi}_0, \hat{\psi}_1)$, expressed in basis points. Each sector's contribution is computed as the increment in TP when that sector's preference parameters are set to zero while all others remain at estimated values. Time-varying variables $E_{j,t}$, $V_{j,t}$, $C_{j,t}$, and S_t are averaged across investment countries j within each quarter t. Sectors: monetary financial institutions (MFI), non-bank financial intermediaries (NBFI), government (GOV), and households (HH). Data sources: ECB Securities Holdings Statistics ($s_{i,j,t}$), Refinitiv Eikon ($E_{j,t}$, $V_{j,t}$, $C_{j,t}$), FRED (S_t).

Figure 6 displays the results. The overall Treasury premium hovers around 50 basis points, with a peak at around 60 basis points in first quarter of 2020, and a trough at circa 40 basis points at the end of 2022. The model-implied Treasury premium is about the same order of magnitude as the empirical proxy built in Du et al. (2018) for the 5-year Treasury premium relative to euro area government bonds before 2010. Interestingly, the model is estimated with post-2010 data, when the Du et al. (2018) Treasury premium vanishes. The discrepancy highlights the advantage of a structural approach that incorporates data on quantities as well as prices, on which empirical proxies solely rely. Speculatively, a reduced-form empirical measure may miss equilibrium interdependencies between the latent, unobserved convenience yield and CIP deviations based on overnight rates, which feature in the Du et al. (2018) Treasury premium and widened after the Great Financial Crisis.

Time-series variation in the Treasury premium is an increasing function of aggregate Treasury holdings of European investors, the only ones earning a convenience yield from Treasuries in the model, relative to others. Then, the drop towards the end of the sample corresponds to a decline in the relative weight of European investors in the Treasury market.

The contribution of each sector to the Treasury premium is proportional to both its size and the sensitivity of its portfolio share to excess returns, and specificallt to the importance of Treasury preferences in the latter. Importantly, nonlinearities imply that sectoral contributionss are not the simple sum of the excess returns required for each sector's first-order condition to hold, as implied by the estimated $\psi_{0,i}$ and $\psi_{1,i}$.

The largest contributor is the government sector, responsible for about 30 basis points on average. This result is consistent with Jiang et al. (2024b), which finds that the foreign official sector accepts particularly low returns on U.S. Treasuries The household sector follows, with an average contribution of about 15 basis points. Banks account for about 7 basis points, while the contribution of NBFIs is negligible. The vanishingly small role of non-banks of is consistent with findings of low elasticity by insurers in the government debt asset pricing literature (Jansen et al., 2025).

Quantitatively, the outsized role of Treasury preferences in the return sensitivity of nonfinancial sector portfolios dominates, despite their very small size relative to the financial sector. A picture emerges of large financial institutions who value Treasury convenience at the baseline but without a large effect on their behaviour at the margin, and small but convenience-sensitive non-financial investors, with the latter playing a critical role in marginal pricing and hence in determining the Treasury premium.

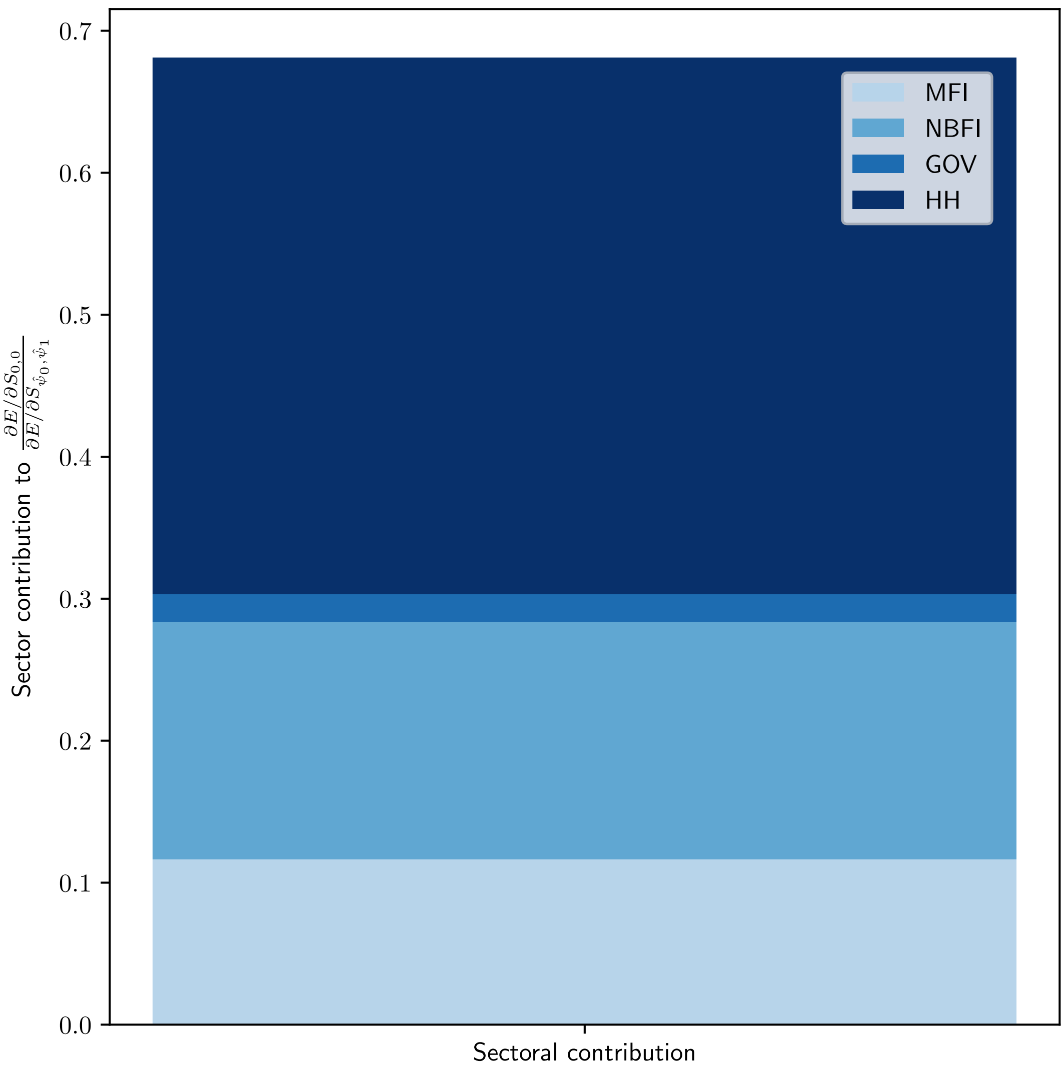
Therefore, the model unveils a significant vulnerability of U.S. fiscal sustainability to a loss of convenience yield of U.S. Treasuries for the European official sector in particualar. If European government investment and pension funds decided to simply stop extending a special status to U.S. government debt, perhaps in retaliaion to perceived hostility by the current American administration, the resulting would require the U.S. government to fund additional $15.2 billion in interest expenses. This estimate is likely conservative, because the analysis stops short of considering wholesale strategic shedding of U.S. Treasury holdings, and does not model fire-sale or risk premium effects that might trigger second-order increases in Treasury yields.

Sensitivity to debt supply. In the fourth and final experiment, I quantify the effect of convenience yield preferences on the absorption capacity of Treasury supply by foreign investors. In the model, additional U.S. government debt issuance represented by an increase in S requires excess returns to rise to compensate investors for holding the larger supply. As shown in Section 2.4, a concave Treasury utility function has an ambiguous effect on the sensitivity of excess returns to debt supply. On the one hand, the level shifter reduces excess returns for all values of debt supply. On the other, the diminishing marginal benefits of Treasury holdings act in concert with risk aversion to dampen adjustments through quantities, hence necessitating a larger movement in returns for the market to clear.

To quantify the relative strength of these forces and the role played by different sectors in shaping them, I calculate the ratio between the derivative of exces returns with respect to debt supply in the no-convenience counterfactual, $\partial E/\partial S\Big|_{0,0}$ to the same derivative at the estimated Treasury preference parameters, $\partial E/\partial S\Big|_{\hat{psi}_{0,i},\hat{psi}_{1,i}}$. A ratio larger than 1 implies that Treasury convenience dampens the sensitivy , while a ratio smaller than 1 implies that Treasury convenience amplifies it. All other variables are kept fixed at their country-sector means.

Figure 7 displays the results. The overall ratio is about 0.67, so the reaction of excess returns to debt supply is actually *higher* with Treasury convenience than without, implying that the U.S. government cannot rely on European investors to accept particularly small raises in yields to absorb the accelerating Treasury supply of recent years.

Figure 7. Sectoral contribution to excess return debt supply sensitivity



Sectoral contributions to the ratio $\partial E/\partial S\big|_{0,0} \,/\, \partial E/\partial S\big|_{\hat{\psi}_0,\hat{\psi}_1}$. Each sector's contribution is computed as the increment in the ratio when that sector's preference parameters are set to zero while all others remain at estimated values. Return variance $V_{j,t}$, covariance $C_{j,t}$, portfolio shares $s_{i,j,t}$, and sector weights w_i are held at their country-sector means; γ is fixed at the calibrated value. A ratio greater than one implies that Treasury convenience dampens the sensitivity of excess returns to debt supply. Sectors: monetary financial institutions (MFI), non-bank financial intermediaries (NBFI), government (GOV), and households (HH). Data sources: ECB Securities Holdings Statistics ($s_{i,j,t}$), Refinitiv Eikon ($V_{j,t}$, $C_{j,t}$), FRED (S_t).

The sectoral breakdown reveals that European households are responsible for the lion's share of the effect, consistently with the very large role of Treasury preferences in dampening their portfolio share sensitivity. Next come banks and non-banks, with a sizeable and roughly equal contribution. The portion attributable to the government sector is negligible, as the relatively strong curvature of their Treasury preferences is not enough to compensate for the very small size of its holdings.

Therefore, the complex, nonlinear interplay between level and curvature effects in Treasury preferences overturns the conventional wisdom that convenience yields necessarily allow the U.S. government to issue additional debt without moving yields much, as argued for example in Jiang et al. (2024d).

5 Conclusion

This paper asks a simple but consequential question: which foreign investors drive the U.S. Treasury premium, and with what implications for fiscal sustainability? The answer that emerges from a portfolio choice model with heterogeneous convenience preferences is fiscally concerning.

The Treasury premium is not primarily a financial-sector phenomenon. Despite holding the largest absolute quantities of U.S. government debt, banks and non-bank financial intermediaries contribute little to the 50-basis-point funding advantage enjoyed by the U.S. Treasury. The dominant contributors are instead the foreign official sector, responsible for roughly 30 basis points, and households, who account for a further 15 basis points. The sectors that sustain the premium are precisely those whose behaviour is likely least governed by financial calculus.

This has direct and uncomfortable implications for U.S. fiscal policy. At a time of public debt exceeding 120% of GDP and persistent budget deficits, the funding advantage of the U.S. government rests not on the predictable liquidity and collateral demands of financial institutions, but on the willingness of foreign governments to extend a special status to U.S. Treasuries. That willingness is geopolitical in nature, and therefore fragile in ways that conventional economic analysis does not capture. A reorientation of reserve management by foreign central banks and sovereign wealth funds, whether driven by strategic considerations, shifts in the international monetary system, or a reassessment of the dollar's role, would strike at the largest single source of the Treasury premium with respect to European sovereigns.

A second implication cuts against a widely held view. Convenience preferences do not insulate the U.S. government from yield pressure as debt expands; the model implies they amplify it. By anchoring large and sticky Treasury positions across investor sectors, convenience preferences reduce the market's capacity to absorb additional issuance through quantity adjustment, placing a greater burden on prices. The U.S. government therefore cannot rely on the safe-asset premium to soften the yield impact of accelerating debt supply. If anything, the erosion of that premium, and the loss of the convenience-driven stickiness that comes with it, could paradoxically ease the yield response to new issuance, even as it raises the baseline cost of borrowing. The fiscal arithmetic of the convenience yield is thus more treacherous than it appears.

The results of this paper are however obviously limited to the contribution of European investors, and the analysis would benefit from an extension to global data along the lines of Arslanalp and Tsuda (2014) and Fang et al. (2023). The assumption of no foreign exchange hedging is also unsatisfactory, as demand for dollar assets is inextricably linked with that for currency hedging, especially at a time of heightened dollar volatility Du and Huber (2024). The current version of the model also does not distinguish between short- and long-term Treasuries, which cater to different clienteles and give rise to markedly diverging convenience yields Diamond and Tassel (2022), Jansen et al. (2025), Jiang et al. (2025). These areas provide fertile ground for future extensions.

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A Proofs

A.1 Mean-variance utility derivation

Consider the problem of an investor in sector i choosing the portfolio share of US Treasuries s_i with gross rate of return R_{US}, which is risky because of fluctuations in the exchange rate. The portfolio also comprises domestic government bonds with riskless gross rate of return R, and residual share $1-s_i$. The investor derives utility from their final wealth $\tilde{W}_i := s_i(R_{US}-R)+R$, and directly from holding US Treasuries due to a convenience yield. The investor's utility function is

$$U(\tilde{W}_i, s_i) = -e^{-\gamma(\tilde{W}_i + h(s_i))},$$

where is an increasing, concave funcion of $h(s_i)$. This utility function preserves the desirable properties of standard exponential utility, namely it is increasing and concave in $\tilde{W}_i$, and it displays constant absolute risk aversion with risk aversion coefficient γ.

Furthermore, by taking the first and second derivatives with respect to s_i,

$$U'(s_i) = \gamma h'(s_i) e^{-\gamma(\tilde{W}_i + h(s_i))} > 0$$
$$U''(s_i) = \gamma e^{-\gamma(\tilde{W}_i + h(s_i))} \left(h''(s_i - \gamma(h'(s_i))^2\right) < 0.$$

Therefore, due to the CES specification the marginal utility of holding Treasuries is declining, so investors require a higher monetary return to absorb more Treasuries in equilibrium. This mechanism is widely used in the literature to link the outstanding amount of US government debt with the equilibrium convenience yield (Krishnamurthy and Vissing-Jorgensen (2012) and Engel and Wu (2018), among others).

Assume that $R_{US} \sim N\left(\mu_{US}, \sigma^2_{US}\right)$, so that $\tilde{W} \sim \left(\mu_W, \sigma^2_W\right)$, with $\mu_W = s_i(\mu_{US}-R)+R$ and $\sigma^2_{W_k} = s_i^2\sigma^2_{US}$.

Then, write expected utility in terms of the density function of $\tilde{W}$,

$$\mathbb{E}\left[-e^{-\gamma(\tilde{W}+h(s_i))}\right] = \int_{-\infty}^{\infty} -e^{-\gamma(\tilde{W}+h(s_i))} \frac{1}{\sigma_W\sqrt{2\pi}} e^{-\frac{\tilde{W}-\mu_W}{2\sigma^2_W}} \, d\tilde{W}$$
$$= e^{-\gamma h(s_i)} \int_{-\infty}^{\infty} -e^{-\gamma \tilde{W}} \frac{1}{\sigma_W\sqrt{2\pi}} e^{-\frac{\tilde{W}-\mu_W}{2\sigma^2_W}} \, d\tilde{W}$$

Now, following the same steps as the derivation of standard mean-variance preferences by collecting the terms under the integral that depend on $\tilde{W}$,

$$\mathbb{E}\left[-e^{-\gamma(\tilde{W}+h(s_i))}\right] = e^{-\gamma h(s_i)} \int_{-\infty}^{\infty} -e^{-\gamma\left(\mu_W - \frac{\gamma}{2}\sigma^2_W\right)} \frac{1}{\sigma_W\sqrt{2\pi}} e^{-\frac{\left(\tilde{W}-\mu_W+\gamma\sigma^2_W\right)^2}{2\sigma^2_W}} \, d\tilde{W}$$
$$= e^{-\gamma\left(\mu_W - \frac{\gamma}{2}\sigma^2_W + h(s_i)\right)} \underbrace{\int_{-\infty}^{\infty} \frac{1}{\sigma_W\sqrt{2\pi}} e^{-\frac{\left(W_k-\mu_W+\gamma\sigma^2_W\right)^2}{2\sigma^2_W}} \, d\tilde{W}}_{=1}$$
$$= e^{-\gamma\left(\mu_W - \frac{\gamma}{2}\sigma^2_W + h(s_i)\right)}.$$

It follows that

$$\max_{s_i} \mathbb{E}\left[-e^{-\gamma(W_k+h(s_i))}\right] = \max_{s_i} \mu_W - \frac{\gamma}{2}\sigma_W^2 + h(s_i).$$

Therefore, maximising expected utility with an exponential utility function in wealth and US Treasuries reduces to standard mean-variance preferences with an additive term for US Treasury holdings, which is increasing and concave due to the CES specification for Treasuries in the utility function.

A.2 Optimal portfolio share

Proposition 1

Proof. Starting from the FOC (restate for convenience)

$$E - \gamma V s_i - \gamma C + \psi_{0,i} + \frac{\psi_{1,i}}{s_i} = 0.$$

Multiply by s_i

$$s_i E - \gamma V s_i^2 - \gamma C s_i + \psi_{0,i} s_i + \psi_{1,i} = 0.$$

Rearrange grouping terms in powers of s_i:

$$-\gamma V s_i^2 + (E - \gamma C + \psi_{0,i}) s_i + \psi_{1,i} = 0.$$

Multiply by -1 to put into standard quadratic form:

$$\gamma V s_i^2 - (E - \gamma C + \psi_{0,i}) s_i - \psi_{1,i} = 0.$$

Let

$$a = \gamma V, \qquad b = -(E - \gamma C + \psi_{0,i}), \qquad c = -\psi_{1,i}.$$

Then the two roots are

$$s_i = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{E - \gamma C + \psi_{0,i} \pm \sqrt{(E - \gamma C + \psi_{0,i})^2 + 4\gamma V \psi_{1,i}}}{2\gamma V}.$$

If $\psi_{1,i} > 0$ the discriminant exceeds $(E - \gamma C + \psi_{0,i})^2$ so the square root term exceeds the absolute value of the linear term. The "minus" root is therefore non-positive:

$$\frac{E - \gamma C + \psi_{0,i} - \sqrt{(E - \gamma C + \psi_{0,i})^2 + 4\gamma V \psi_{1,i}}}{2\gamma V} \leq 0,$$

and it is strictly negative for $\psi_{1,i} > 0$. Because $s_i > 0$ is required by the domain of the log convenience term and by the no-short selling constraint, I discard the minus root and keep the plus root, so

$$s_i^* = \frac{E - \gamma C + \psi_{0,i} + \sqrt{(E - \gamma C + \psi_{0,i})^2 + 4\gamma V \psi_{1,i}}}{2\gamma V}.$$

□

A.3 Derivatives of s_i^*

A.3.1 Proposition 2

Proof. Define

$$f_i(E, s_i) \equiv E - \gamma V s_i - \gamma C + \psi_{0,i} + \frac{\psi_{1,i}}{s_i}.$$

The first-order condition in Equation (1) implies $f_i(E, s_i(E)) \equiv 0$.

Compute partial derivatives:

$$f_E = \frac{\partial f_i}{\partial E} = 1, \qquad f_s = \frac{\partial f_i}{\partial s_i} = -\gamma V - \frac{\psi_{1,i}}{s_i^2}.$$

Differentiate $f_i(E, s_i(E)) = 0$ with respect to E applying the Implicit Function Theorem and solve for $\mathrm{d}s_i/\mathrm{d}E$:

$$0 = f_E + f_s \frac{\mathrm{d}s_i}{\mathrm{d}E} \quad \Rightarrow \quad \frac{\mathrm{d}s_i}{\mathrm{d}E} = -\frac{f_E}{f_s} = \frac{1}{\gamma V + \psi_{1,i}/s_i^2}.$$

□

A.3.2 Proposition 3

Proof. Differentiate $f_i(E, s_i) = 0$ with respect to $\psi_{1,i}$ holding E fixed:

$$0 = f_{\psi_0} + f_s \frac{\partial s_i}{\partial \psi_{0,i}},$$

where $f_{\psi_0} = \partial f_i / \partial \psi_{0,i} = 1$. Hence

$$\frac{\partial s_i}{\partial \psi_{0,i}}\Big|_E = -\frac{f_{\psi_0}}{f_s} = \frac{1}{\gamma V + \psi_{1,i}/s_i^2}.$$

□

A.3.3 Proposition 4

Proof. Differentiate $f_i(E, s_i) = 0$ with respect to $\psi_{1,i}$ holding E fixed:

$$0 = f_{\psi_1} + f_s \frac{\partial s_i}{\partial \psi_{1,i}}, \qquad f_{\psi_1} = \frac{\partial f_i}{\partial \psi_{1,i}} = \frac{1}{s_i}.$$

Thus

$$\frac{\partial s_i}{\partial \psi_{1,i}}\Big|_E = -\frac{f_{\psi_1}}{f_s} = \frac{1/s_i}{\gamma V + \psi_{1,i}/s_i^2}.$$

□

A.3.4 Proposition 5

Proof. Applying the Implicit Function Theorem to $g(e)$, compute $\partial F / \partial \psi_{0,j}$:

$$\frac{\partial F}{\partial \psi_{0,j}} = w_j \frac{\partial s_j}{\partial \psi_{0,j}}\Big|_E = w_j \cdot \frac{1}{\gamma V + \psi_{1,j}/s_j^2}.$$

Thus

$$\frac{\partial E}{\partial \psi_{0,j}} = -\frac{w_j \dfrac{1}{\gamma V + \psi_{1,j}/s_j^2}}{b + \displaystyle\sum_{i=1}^{I} w_i \frac{1}{\gamma V + \psi_{1,i}/s_i^2}}$$

Since $w_j \;\geq 0 \;\forall j$ by construction, and b is assumed ≥ 0, if $\gamma V + \psi_{1,i}/s_i^2 \;\geq 0 \;\forall i$ then $\frac{\partial E}{\partial \psi_{0,j}} \leq 0$. □

A.3.5 Proposition 6

Proof. Applying the Implicit Function Theorem to $g(e)$, compute $\partial F/\partial \psi_{1,j}$:

$$\frac{\partial F}{\partial \psi_{1,j}} = w_j \frac{\partial s_j}{\partial \psi_{1,j}}\Big|_E = w_j \cdot \frac{1/s_j}{\gamma V + \psi_{1,j}/s_j^2}.$$

Thus

$$\frac{\partial E}{\partial \psi_{1,j}} = -\frac{w_j \dfrac{1}{s_j(\gamma V + \psi_{1,j}/s_j^2)}}{b + \displaystyle\sum_{i=1}^{I} w_i \frac{1}{\gamma V + \psi_{1,i}/s_i^2}}.$$

Since $w_j \;\geq 0 \;\forall j$ by construction, and s_i and b are assumed ≥ 0, if $\gamma V + \psi_{1,i}/s_i^2 \;\geq 0 \;\forall i$ then $\frac{\partial E}{\partial \psi_{0,j}} \leq 0$. □

A.3.6 Proposition 7

Proof. Applying the Implicit Function Theorem to $g(e)$ with $\partial F/\partial S = -1$,

$$\frac{\partial E}{\partial S} = -\frac{-1}{\partial F/\partial E} = \frac{1}{b + \displaystyle\sum_{i=1}^{k} w_i \frac{1}{\gamma V + \psi_{1,i}/s_i^2}}.$$

Since $w_j \;\geq 0 \;\forall j$ by construction, and b is assumed ≥ 0, if $\gamma V + \psi_{1,i}/s_i^2 \;\geq 0 \;\forall j$ then $\frac{\partial E}{\partial \psi_{0,j}} \geq 0$. □

A.3.7 Proposition 8

Proof. Let

$$A(E) \equiv \sum_{i=1}^{k} w_i \frac{1}{\gamma V + \psi_{1,i}/s_i^2}, \quad D_j \equiv \gamma V + \frac{\psi_{1,j}}{s_j^2}, \quad s_j' \equiv \frac{\mathrm{d}s_j}{\mathrm{d}E} = \frac{1}{D_j}.$$

Then $\partial E/\partial S = 1/(b + A)$. Differentiate with respect to $\psi_{0,j}$:

$$\frac{\partial}{\partial \psi_{0,j}} \Big(\frac{\partial E}{\partial S} \Big) = -\frac{1}{(b+A)^2} \cdot \frac{\partial A}{\partial \psi_{0,j}}.$$

Only the jth term of A depends (directly) on $\psi_{0,j}$ or $\psi_{1,j}$, so

$$\frac{\partial A}{\partial \psi_{0,j}} = w_j \frac{\partial}{\partial \psi_{0,j}} \Big(\frac{1}{D_j} \Big) = -w_j \frac{1}{D_j^2} \frac{\partial D_j}{\partial \psi_{0,j}}.$$

Compute $\partial D_j/\partial\psi_{0,j}$. Because $D_j = \gamma V + \psi_{1,j}/s_j^2$, the only dependence on $\psi_{0,j}$ is through s_j:

$$\frac{\partial D_j}{\partial\psi_{0,j}} = \frac{\partial}{\partial\psi_{0,j}}\Big(\frac{\psi_{1,j}}{s_j^2}\Big) = -2\psi_{1,j}s_j^{-3}\frac{\partial s_j}{\partial\psi_{0,j}}\Big|_E.$$

Using $\partial s_j/\partial\psi_{0,j}\big|_E = 1/D_j$ I obtain

$$\frac{\partial D_j}{\partial\psi_{0,j}} = -2\psi_{1,j}\frac{1}{s_j^3}\frac{1}{D_j}.$$

Hence

$$\frac{\partial A}{\partial\psi_{0,j}} = -w_j\frac{1}{D_j^2}\left(-2\psi_{1,j}\frac{1}{s_j^3}\frac{1}{D_j}\right) = w_j\frac{2\psi_{1,j}}{D_j^3 s_j^3}.$$

Substituting into the derivative of $\partial E/\partial S$:

$$\frac{\partial}{\partial\psi_{0,j}}\Big(\frac{\partial E}{\partial S}\Big) = -\frac{1}{(b+A)^2}\,w_j\frac{2\psi_{1,j}}{D_j^3 s_j^3}. \tag{18}$$

Since $w_j\ \geq 0\,\forall j$ by construction, and b is assumed ≥ 0, if $\psi_{1,j} > 0$ then $\frac{\partial}{\partial\psi_{0,j}}\left(\frac{\partial E}{\partial S}\right) < 0$

□

A.3.8 Proposition 9

Proof. Compute $\partial A/\partial\psi_{1,j}$:

$$\frac{\partial A}{\partial\psi_{1,j}} = w_j\frac{\partial}{\partial\psi_{1,j}}\Big(\frac{1}{D_j}\Big) = -w_j\frac{1}{D_j^2}\frac{\partial D_j}{\partial\psi_{1,j}}.$$

Compute $\partial D_j/\partial\psi_{1,j}$:

$$\frac{\partial D_j}{\partial\psi_{1,j}} = \frac{\partial}{\partial\psi_{1,j}}\Big(\gamma V + \frac{\psi_{1,j}}{s_j^2}\Big) = \frac{1}{s_j^2} - \frac{2\psi_{1,j}}{s_j^3}\frac{\partial s_j}{\partial\psi_{1,j}}\Big|_E.$$

Use $\partial s_j/\partial\psi_{1,j}\big|_E = \dfrac{1/s_j}{D_j}$. Therefore

$$\frac{\partial D_j}{\partial\psi_{1,j}} = \frac{1}{s_j^2} - \frac{2\psi_{1,j}}{s_j^3}\cdot\frac{1/s_j}{D_j} = \frac{1}{s_j^2} - \frac{2\psi_{1,j}}{D_j s_j^4}.$$

Plugging into $\partial A/\partial\psi_{1,j}$:

$$\frac{\partial A}{\partial\psi_{1,j}} = -w_j\frac{1}{D_j^2}\left(\frac{1}{s_j^2} - \frac{2\psi_{1,j}}{D_j s_j^4}\right).$$

Hence the derivative of $\partial E/\partial S$ w.r.t. $\psi_{1,j}$ is

$$\frac{\partial}{\partial\psi_{1,j}}\Big(\frac{\partial E}{\partial S}\Big) = -\frac{1}{(b+A)^2}\left[-w_j\frac{1}{D_j^2}\left(\frac{1}{s_j^2} - \frac{2\psi_{1,j}}{D_j s_j^4}\right)\right]. \tag{19}$$

I can rewrite (19) as

$$\frac{\partial}{\partial \psi_{1,j}}\left(\frac{\partial E}{\partial S}\right) = \frac{w_j}{(b+A)^2} \cdot \frac{1}{D_j^2}\left(\frac{1}{s_j^2} - \frac{2\psi_{1,j}}{D_j s_j^4}\right).$$

Since $w_j \geq 0 \, \forall j$ by construction, $(b+A)^2 > 0$ and $D_j^2 > 0$,

$$sign\left(\frac{\partial}{\partial \psi_{1,j}}\left(\frac{\partial E}{\partial S}\right)\right) = sign\left(\frac{1}{s_j^2} - \frac{2\psi_{1,j}}{D_j s_j^4}\right).$$

Hence,

$$\frac{\partial}{\partial \psi_{1,j}}\left(\frac{\partial E}{\partial S}\right) < 0 \iff \left(\frac{1}{s_j^2} - \frac{2\psi_{1,j}}{D_j s_j^4}\right) < 0.$$

Rearranging,

$$\frac{\psi_{1,j}}{s_j^2} < \gamma V.$$

□

B Data sources

Table A1 provides an overview of all data sources used in the paper.

C Estimation details

C.1 Estimation of b

Residual investor demand enters the market clearing condition and is defined as

$$s_{\text{res}}(E) = s_{\text{res},0} + bE,$$

so GMM estimation of requires an esimate for b as input. I estimate b via a 2SLS regression that instruments $e_{j,t}$, the empirical proxy for E, with U.S. monetary policy shocks for Bauer and Swanson (2022). These shocks are constructed as changes in Eurodollar futures contracts in a 30-minute window around FOMC announcements and Fed Chair speeches, and account for the Federal Reserves's response to macroeconomic news by residualising the shocks with respect to relesases of a wide range of macroeconomic and financial data. I estimate the 2SLS regressions on the same sector-quarter-country dataset as the main GMM estimation for consistency, but I only use time-series variation in the U.S. monetary policy shocks for identification by employing country-by-sector fixed effects.

The first-stage regression is

$$er_{j,t} = a_i \times a_j + c\, MP_{j,t} + \varepsilon_t,$$

where $a_i \times a_j$ are sector-by-country fixed effects absorbing sector- and investment country-specific variation, and $MP_{j,t}$ is the Bauer and Swanson (2022) monetary policy surprise.

The second-stage regression is

Table A1. Data sources

Variable	Description	Source	Coverage
$s_{i,j,t}$	Sectoral holdings of U.S. and euro area sovereign debt	ECB Securities Holdings Statistics (SHS)	2013 Q4 – 2022 Q1
$s_{\text{res},j,t}$	Residual Treasury demand as share of total holdings	ECB Securities Holdings Statistics (SHS)	2013 Q4 – 2022 Q1
$y_{US,t}$	U.S. government bond yields (1, 2, 3, 5, 10 year)	Refinitiv Eikon	2013 Q4 – 2022 Q1
$y_{j,t}$	Country j government bond yields (1, 2, 3, 5, 10 year)	Refinitiv Eikon	2013 Q4 – 2022 Q1
$CDS_{US,t}$, $CDS_{j,t}$	U.S. and country j sovereign CDS rates	Refinitiv Eikon	2013 Q4 – 2022 Q1
S_t	Outstanding U.S. Treasury debt supply	FRED	2013 Q4 – 2022 Q1
$S^{dom}_{j,t}$	Outstanding domestic government debt supply, country j	Eurostat	2013 Q4 – 2022 Q1
$PSPP_{j,t}$	Monthly PSPP net purchases of sovereign debt, country j	European Central Bank	2015 Q1 – 2022 Q1
MP_t	U.S. monetary policy surprises (Eurodollar futures)	Bauer and Swanson (2022)	2013 Q4 – 2022 Q1

All bond yields and CDS rates are averaged over quarters and over the 1, 2, 3, 5, and 10 year maturities, weighted by the maturity structure of outstanding government debt for each country j. SHS data are available publicly from the ECB Statistical Data Warehouse. Monetary policy surprises from Bauer and Swanson (2022) are constructed as changes in Eurodollar futures contracts in a 30-minute window around FOMC announcements and Fed Chair speeches, residualised with respect to macroeconomic and financial data releases. ECB: European Central Bank. FRED: Federal Reserve Bank of St. Louis.

$$s_{res,i,j,t} = a_i \times a_j + b\,\hat{er}_{j,t} + \varepsilon_t,$$

where $s_{res,i,j,t}$ is residual Treasury demand as a fraction of total sector i government bond holdings in millions, a scale normalisation for consistency with the unit of measure of the market clearing condition in the GMM model, and $\hat{er}_{j,t}$ is the predicted value from the first-stage regression.

Table A2 reports results for the first- and second-stage regressions. A one percentage point U.S. monetary policy shock raises Treasury excess returns by about one percentage point, in line with theory and implying an approximately one-to-one pass-through of monetary policy rates to U.S. government bond yields, keeping country j yields fixed. However, the effect is estimated imprecisely: the standard error is of the same order of magnitude as the coefficient, and the F-stat for the first stage is rather low at 1.40.

The second-stage estimate $\hat{b}$ implies that a one percentage point increase in the excess return of U.S. Treasuries over country j raises residual Treasury demand by 0.95 units of total bond holdings of sector i, corresponding to about a third of a standard deviation for both the explanatory and dependent variable.

Table A2. 2SLS estimation of b

Variable	Coefficient	(Std. Error)
Panel A: First-stage ($E_{j,t}$)		
US MP shock$_t$	1.045	(1.511)
Intercept	2.324	(1.849)
Panel B: Second-stage (s_{res0})		
$E_{j,t}$	0.952	(0.687)
Intercept	-1.850	(1.584)
Observations	1860	
Fixed effects	Country × Sector	
First-stage F-stat	1.40	

Coefficients and standard errors from the first-stage regression (Panel A) and the second-stage regression (Panel B). Heteroskedasticity-robust standard errors in parentheses. Data sources: Bauer and Swanson (2022), Refinitiv Eikon, SHS, FRED.

C.2 Treasury preference parameter estimates

Table A3 reports the exact values of estimated parameters and 90% bootstrapped confidence intervals.

Table A3. Treasury preference parameters

	MFI	NBFI	GOV	HH
ψ_0	0.0007 [-0.0004, 0.0018]	0.0006 [0.0001, 0.0011]	-0.0006 [-0.0009, -0.0003]	-0.0018 [-0.0031, -0.0005]
ψ_1	0.0002 [0.0001, 0.0003]	0.0001 [0.0001, 0.0002]	0.0003 [0.0002, 0.0004]	0.0001 [-0.0000, 0.0002]

Parameter estimates and 90% bootstrapped confidence intervals from the GMM estimation of Equations (15) and (16)