Treasury Market Intermediation and the Role of Levered Demand

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Abstract

This paper develops a model for Treasury market intermediation. In our framework, Treasury securities are absorbed by a combination of unlevered investors and leveraged intermediaries—primarily hedge funds and securities dealers—who are constrained by risk tolerance, margin requirements, and regulatory balance-sheet costs. The difference in yield between Treasury securities and matched-maturity swaps against risk-free interest rate benchmarks (i.e., "swap spreads") therefore reflects the compensation required for intermediaries to warehouse Treasury collateral while hedging interest-rate risk. Our model also naturally explains margin spirals as well as the impact of shifts in hedge fund risk management practices (i.e., the rise of "pod shops").

An important and observable implication is that increases in Treasury supply steepen the maturity slope of the swap-spread curve. Absorbing additional supply requires leveraged investors to expand relative-value trades, but holding longer-maturity spreads exposes them to greater volatility of returns. Reflecting this, levered investors demand additional compensation to absorb Treasury supply at longer maturities. The slope of the swap-spread curve therefore provides a diagnostic of the elasticity of intermediary balance sheets and the resilience of Treasury market intermediation.

We present empirical evidence to support the model's predictions. Further, episodes such as the Treasury market dysfunction of March 2020 and the April 2025 "Liberation Day" tariff announcement illustrate how shocks to volatility and leverage constraints can steepen the swap-spread curve as intermediaries rapidly reduce risk. These findings suggest that monitoring the swap-spread curve can provide policymakers with a forward-looking indicator of stress in Treasury market intermediation and the capacity of the financial system to absorb fluctuations in Treasury supply.

1 Introduction

It is by now a cliché to call the market for United States Treasury securities the most important in the world. The public debt of the federal government of the United States is widely viewed as a nearly riskless store of value and a benchmark against which tens of trillions of debt instruments from issuers around the world are priced (see e.g., Duffie, 2020; Krishnamurthy and Vissing-Jorgensen, 2012). Treasuries remain by far the most popular official reserve asset among foreign banks. And Treasury collateral forms the foundation for trillions in short-term borrowing and lending that is critical to the proper functioning of global commerce and financial activity.

Because of this central role, the smooth functioning of the Treasury market is a prerequisite to the smooth functioning of the broader financial system. Episodes of dysfunction can quickly propagate into other asset classes and critical markets (Duffie and Keane, 2023). In the extreme, this can threaten financial stability. This high degree of interconnectedness has led the Federal Reserve to intervene aggressively to stabilize Treasury markets when they break down, most recently in 2020 but also on many other occasions (Fleming and Ruela, 2020; Menand and Younger, 2025).

This is particularly important in the context of the longer-run fiscal trajectory of the United States. A large and growing public debt burden has garnered intense focus from policy makers, politicians, academics, and even late-night comedians for many decades now. Most academic work in this area focuses on fundamental dynamics such as the interaction between fiscal policy, growth, and the natural rate of interest (see e.g., Bohn, 2005; Ghosh et al., 2013; Blanchard, 2019). Hard limits are controversial, but there is a general sense that rising public indebtedness increasingly threatens adverse macroeconomic outcomes, often with non-linear effects (Reinhart and Rogoff, 2010; Caner et al., 2010; Checherita-Westphal and Rother, 2010; Auerbach, 2011; Panizza and Presbitero, 2013; Herndon et al., 2014). But the long-term sustainability of the U.S. public debt is as much about market microstructure as it is about macroeconomic and other more structural constraints. The ability of the Treasury market to efficiently absorb and distribute risk without an outsized impact on yields is an (often unstated) assumption of more fundamentally oriented work.

But that assumption has been increasingly challenged by events. Starting in 2014, when the "flash rally" briefly but severely disrupted trading in the world's most important market, episodes of dysfunction in the Treasury market seem to be coming with greater frequency. A growing literature emphasizes the role of intermediary balance sheet constraints and funding frictions in determining the functioning of Treasury markets (Duffie, 2013, 2018, 2020; Boyarchenko et al., 2020; Liang and Parkinson, 2020; Menand and Younger, 2023; Duffie et al., 2023; Duffie, 2023; Liang and Zhu, 2025, 2026). When risk-bearing capacity becomes scarce, arbitrage relationships that normally anchor prices can break down, revealing the underlying limits

of market intermediation (Fleming and Ruela, 2020; Kashyap et al., 2025).

A central theme emerging from this literature is the increased reliance of Treasury markets on demand from leveraged intermediaries. In March 2020, fragility became visible primarily through the unwinding of relative value trades in Treasury futures ("cash-futures basis trades," or just "the basis"; Menand and Younger, 2023). More recently, episodes of market volatility have manifested through large movements of Treasuries relative to interest rate swaps ("swap spreads"; Bolingbroke and MacKenzie, 2025). Levered relative value strategies in Treasuries are nothing new, nor have markets previously struggled to contend with rapid unwinds. The collapse of Long-Term Capital Management (LTCM) is often cited as the first such instance in which financial stability was threatened by the disorderly unwind of Treasury relative value positions (President's Working Group on Financial Markets, 1999). But the situation today differs in terms of both the scale of the overall exposure, the centrality of levered demand in clearing the Treasury market, and the revealed frictions and costs of dealers intermediating large risk transfers, particularly under conditions of broader market stress.

Although evaluating the resilience of the Treasury market is clearly essential, identifying observable indicators that reveal when constraints are becoming binding is a persistent challenge. Fleming (2003) develops practical measures of Treasury market liquidity based on trading costs and price impact, providing widely used benchmarks for market functioning (e.g., for example, during the Covid pandemic Logan, 2020a,b). However, these indicators often react only after liquidity has already deteriorated. What is often needed for monitoring purposes is a forward-looking diagnostic that tracks the level of fragility rather than pointing to dysfunction once it has already arrived.

This paper argues that Treasury swap spreads—and in particular the maturity slope of swap spreads—are a valuable diagnostic of Treasury market fragility. Swap spreads are a relative value trade in which a levered investor purchases a Treasury security financed via repurchase agreements ("repos"; for a detailed history and explanation of the role of repo in Treasury markets, see Menand and Younger, 2023) while hedging interest rate exposure using an interest rate swap the details of which are matched to the bond. The "spread" is the difference between the yield-to-maturity of the Treasury and the fixed rate on the swap. In frictionless markets this position should earn little or no net return. In other words, the spread should be equal to the expected difference in financing costs in the Treasury (repo) and swap (short-term interest rate benchmark such as LIBOR or SOFR; see e.g., Alternative Reference Rates Committee, 2023). Positive expected returns from holding swap spreads therefore reflect the compensation required for intermediaries to warehouse Treasury collateral and bear associated risks. In this sense, to first order swap spreads can be interpreted as the equilibrium price of intermediation capacity over a horizon corresponding to the maturity of the Treasury security. This interpretation is consistent with intermediary asset-pricing frameworks in which

financial intermediaries' balance sheet constraints shape equilibrium asset prices (He and Krishnamurthy, 2013; Gabaix and Koijen, 2021).

To formalize this intuition, the paper develops a tractable equilibrium model linking swap spreads to the risk-bearing capacity of financial intermediaries. The model extends the framework of Kashyap et al. (2025) which explicitly models the interaction between Treasury supply, constrained and heterogeneous intermediaries, and the emergence of relative value trading opportunities. We extend that model by explicitly incorporating shadow dealer balance sheet cost, risk-bearing capacity across intermediaries, pro-cyclical margin requirements, and different hedge fund risk management policies (i.e., mechanical and threshold-based de-risking). Dealers intermediate transactions and provide financing through the repo market, while hedge funds engage in relative-value strategies such as basis and swap spread trades. These intermediaries differ in their risk sensitivities, balance sheet costs, and alternative investment opportunities.

A key feature of the extended model is a decomposition of swap spreads into two components: a *tightness* component that reflects the effective elasticity of intermediary demand for Treasury collateral, and a *reservation premium* that captures the hurdle compensation required for intermediaries to allocate scarce resources to fixed income relative value trades. This decomposition highlights four distinct channels through which fragility can arise. First, shocks such as increases in volatility or reductions in available balance sheet capacity reduce the elasticity of intermediary demand and steepen the relationship between Treasury supply and the compensation required to absorb it. Second, shocks such as increases in shadow balance sheet costs or attractive alternative trading opportunities raise reservation premia and shift spreads even when supply conditions are unchanged. Third, the model naturally explains margin spirals in which an exogenous volatility shock can generate a vicious cycle of deleveraging and volatility, in the extreme leading to dysfunction. Finally, hedge fund de-grossing and mechanical risk reduction can exacerbate those dynamics.

We can then use this model to interpret trends observed in the relationship between the pricing of swap spreads and other market observables. We specifically find that over the long-run the maturity slope of swap spreads is more strongly driven by volatility, the weighted average maturity (WAM) of federal debt, and dealer balance sheet constraints than other factors. Interpreted through the lens of our model, this casts new light on the source of fragility in Treasury markets and suggests potential policy solutions to achieve greater resiliency. Finally, our model reveals a channel by which shifts in the composition of hedge fund strategies, particularly the rise of multi-strategy funds (or "pod shops"), can reduce the resiliency of the market.

The remainder of the paper proceeds as follows. Section 3 develops the theoretical model and derives equilibrium expressions for swap spreads and their maturity structure. Section 3.3 considers origins and impact of margin spirals, and Section 5 expands the discussion to include new hedge fund risk management policies. Section 4 presents empirical evidence on the determinants of the maturity slope of swap spreads.

Section 6 discusses the implications of these findings for monitoring Treasury market resilience and for the design of policy interventions. Section 7 concludes.

2 Related Literature

This paper relates to four overlapping elements of the literature: Treasury market resilience, intermediary balance-sheet constraints, hedge-fund relative-value trading, and debt supply and maturity-composition effects.

First, a growing post-2020 literature studies the resilience of the Treasury market and the causes of market dysfunction. Duffie (2018, 2023) links Treasury market liquidity to intermediation frictions and dealer balance-sheet constraints. Building on this perspective, Kashyap et al. (2025) analyze how interactions between dealers, hedge funds, and asset managers can generate fragility in Treasury markets and examine the role of central bank interventions in stabilizing market functioning. Empirical analyses of the March 2020 episode further document the sharp deterioration in Treasury market liquidity and the role of constrained intermediaries during periods of stress (Fleming and Ruela, 2020).

Second, the paper connects to the literature on dealer balance-sheet constraints and liquidity provision. Boyarchenko et al. (2020) show that dealer balance sheets are closely linked to bond market liquidity and that constraints on dealer intermediation can amplify price movements. Related work emphasizes the importance of intermediary capital and balance-sheet capacity in determining asset prices and liquidity conditions across financial markets (Adrian et al., 2017; He and Krishnamurthy, 2013).

Third, this paper relates to work on funding liquidity, leverage, and pro-cyclical margin. Brunnermeier and Pedersen (2009) and Gorton and Metrick (2012) show how margin requirements and funding constraints can generate feedback loops between market liquidity and funding conditions. Recent experience, particularly the Covid pandemic, has shown that de-leveraging by hedge funds and other leveraged investors can play an important role in amplifying price movements (Younger, 2021).

Finally, the paper relates to the literature on supply and demand dynamics in government debt markets. For example, Krishnamurthy and Vissing-Jorgensen (2012) document the special demand for Treasury securities and its implications for pricing, while Greenwood and Vayanos (2014) show that changes in government debt supply and maturity composition affect bond risk premia through preferred-habitat channels.

This paper contributes by developing a tractable equilibrium model that links swap spreads to the distribution of risk-bearing capacity across intermediaries and by showing that the maturity slope of swap spreads provides a useful diagnostic of Treasury market fragility. Relative to existing work that focuses on levels of spreads or specific and generally shorter-horizon arbitrage trades like cash-futures basis, the

framework emphasizes how volatility, duration supply, and intermediary balance-sheet constraints jointly determine the elasticity of intermediation capacity in Treasury markets.

Before proceeding to our model, a critical definition is in order. In this paper, Treasury market resilience refers to the ability of the market to absorb shocks to supply, demand, and volatility without large and persistent deviations from fundamental pricing relationships. A resilient Treasury market is characterized by elastic intermediary demand for government debt, allowing arbitrage relationships to remain intact even when volatility rises or supply shocks occur. Conversely, fragility arises when the marginal demand for Treasury securities is provided by leveraged intermediaries with limited balance sheet capacity, making the elasticity of demand highly state dependent. When volatility rises or financing conditions tighten, these intermediaries may be forced to reduce positions rapidly, leading to large price dislocations.

3 A Model of Swap Spreads

Our model builds on Kashyap et al. (2025) and extends their work to consider risk aversion among intermediaries and a term structure of near-arbitrage pricing discrepancies (i.e., swap spreads of varying maturity). Figure 1 illustrates the intuition underlying the model. Swap spreads are determined by the intersection of Treasury supply and intermediary demand. When intermediary balance sheet capacity is abundant, the demand curve for Treasury collateral is relatively elastic and spreads remain small. When volatility rises or balance sheet constraints bind, the demand curve becomes steeper, increasing the compensation required to warehouse Treasury risk and steepening the maturity slope of swap spreads.

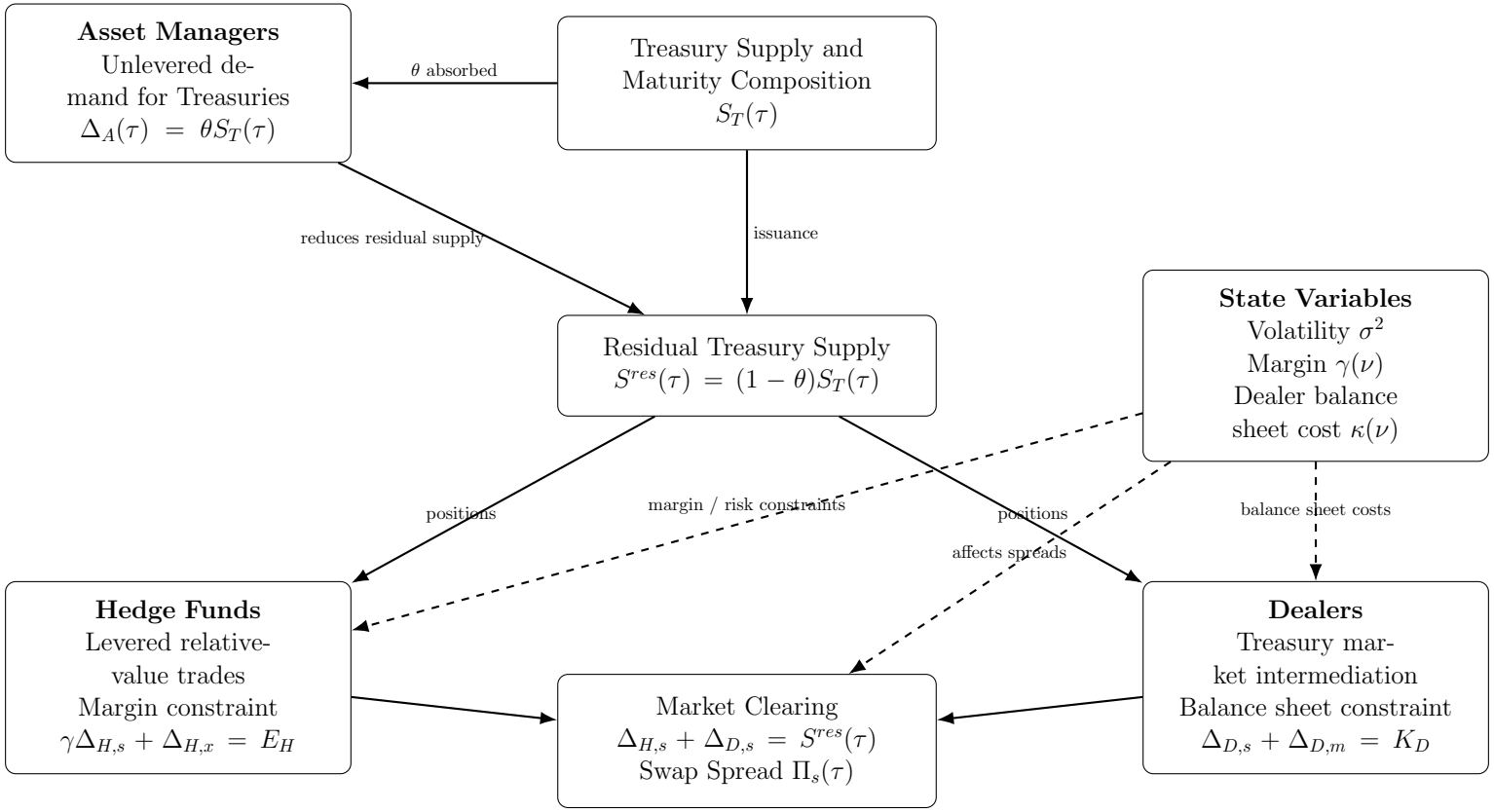


Figure 1: Sources of demand and market clearing in the model.

The model presumes that arbitrage returns Π can be earned over a given horizon by owning (they are "long") Treasury securities, financed overnight at the repo rate (y_r)[1], hedged with an opposite position (they are "short") in a derivative that is linked to the risk-free rate (y_r).

Kashyap et al. (2025) focus on Treasury futures, the pricing of which can deviate from the arbitrage-free implied price as:

$$P_F = P_T \left(1 + y_r + \Pi_b\right) \tag{1}$$

where P_F is the futures price, P_T is the market price of the optimal security[2] to deliver into the contract at maturity, and Π_b is the expected return from owning the security and being short the future, holding the position to delivery (i.e., a cash-futures basis trade). If the cash repo leg maturity is matched to the contract maturity (i.e., time to delivery or τ_F), then Π_b can be rewritten as:

$$\Pi_b(\tau_F) = y_i(\tau_F) - \int_0^{\tau_F} y_r(t)dt = y_i(\tau_F) - \mathbb{E}\left[y_r\right]_{\tau_F} \tag{2}$$

where y_i is the implied repo rate inferred from the pricing of the futures contract relative to its deliverable bond(s) (for details, see Burghardt and Belton, 2005).

A long position in swap spreads consists of a long position in the Treasury security and a short in a matched-maturity swap with its notional sized to the dollar duration of the Treasury security at the inception of the trade. In that swap, the holder of the spread position is contractually obligated to pay a fixed rate of return (the "par rate", set at trade inception) in exchange for floating rate payments tied to an benchmark interest rate. The owner of a long spread position therefore earns the difference in rate between the yield on the Treasury security (Y_T) and the par fixed rate on the swap (Y_S)) versus paying the difference in rate between overnight financing costs on the bond (y_r) and the swap index (which we take to be the overnight risk-free rate y_s). They are therefore exposed to changes in this expected compensation (spread duration) but not movements in interest rates. For an arbitrary swap maturity τ, we define the expected returns over the full holding period of the swap spread as:

$$\Pi_s(\tau) = (Y_T - Y_s) - \int_0^{\tau} \left[y_r(t) - y_s(t)\right] dt = y_i(\tau) - \mathbb{E}\left[y_r - y_s\right]_{\tau} \tag{3}$$

Intuitively, swap spreads are very similar to Treasury futures basis trades. They both involve the ownership of a Treasury security, financed via repo, against an offsetting position in an interest rate derivative.

[1]Specifically, the "bid" side of the repo market often referred to as general collateral repo. The typical transaction is one in which a securities dealer is lending cash to a levered investor, often a hedge fund, collateralize by Treasury securities. For an overview of the repo market, see Menand and Younger (2023).

[2]In practice, Treasury futures contracts have many deliverables generating significant embedded optionality (Burghardt and Belton, 2005). Kashyap et al. (2025) abstract away from this operational complexity by assuming a single deliverable.

They are not explicitly exposed to the level of interest rates. Rather, expected returns from holding these positions are related to the difference between cash funding and derivative-implied funding, often with a sizeable maturity mismatch. Swap spreads, however, conceptually provide more information because they capture frictions to arbitrage over longer horizons.

3.1 Model Specification

We incorporate this maturity dependence into the KSWY model as follows.

We begin with the hedge fund block. Hedge funds earn returns:

$$\Pi_H(\tau) = \Delta_{H,s}(\tau)\Pi_s\ (\tau) + \Delta_{H,x}\Pi_x \tag{4}$$

where $\Delta_{H,s}$ is their net exposure to a swap spread of maturity τ with expected returns $\Pi_s(\tau)$ and $\Delta_{H,x}$ is their exposure to an alternative position with expected returns Π_x that is independent of τ. We also assume Π_x is declining linearly with exposure:

$$\Pi_x = \alpha - \frac{\beta}{2}\Delta_{H,x}. \tag{5}$$

The hedge fund is assumed to optimize its exposure to spreads and alternatives subject to some degree of risk aversion by maximizing the following:

$$\pi_H(\tau) = \Delta_{H,s}(\tau)\Pi_s(\tau) - \Delta^2_{H,s}(\tau)\frac{\eta_H\sigma^2_s(\tau)}{2} + \Delta_{H,x}(\tau)\Pi_x(\tau) - \Delta^2_{H,x}(\tau)\frac{\eta_H\sigma^2_x(\tau)}{2} \tag{6}$$

where σ is the variance in returns relative to expectations from holding the position to maturity and η_H captures hedge fund risk aversion.

We assume the hedge fund needs to fund some portion of its spread position (i.e., including haircuts on the securities and initial margin on the swaps) with equity (E_H) such that:

$$\gamma\Delta_{H,s} + \Delta_{H,x} = E_H \tag{7}$$

where we assume hedge fund equity is fixed and does not vary with the market environment.

Collecting terms and expanding, we have:

$$\pi_H(\tau) = \text{const.}\ + \Delta_{H,s}\left[\Pi_s(\tau) + \gamma\left(-\alpha + \beta E_H + \eta_H E_H\sigma^2_x\right)\right] - \frac{\Delta^2_{H,s}}{2}\left[\gamma^2 + \eta_H\left(\sigma^2_s(\tau) + \gamma^2\sigma^2_x\right)\right] \tag{8}$$

This yields the first order condition:

$$\Delta^{\star}_{H,s} = \frac{\Pi_s(\tau) + \gamma\left(-\alpha + \beta E_H + \eta_H E_H \sigma_x^2\right)}{\gamma^2 + \eta_H\left(\sigma_s^2(\tau) + \gamma^2\sigma_x^2\right)} \tag{9}$$

$$\Delta^{\star}_{H,x} = E_H - \gamma\Delta^{\star}_{H,s} \tag{10}$$

Now we proceed to the dealer block. Dealers are assumed to allocate their balance sheet between swap spreads $\Delta_{D,s}$ and market making $\Delta_{D,m}$. Market-making returns are assumed to have a much lower volatility than spreads (and, thus, we ignore it) and follow a linear scaling similar to hedge fund alternatives as:

$$\Pi_m = a_m - b_m \Delta D, m \tag{11}$$

We also include a firm balance sheet limit of $\Delta_{D,s} + \Delta_{D,m} = K_D$. Finally, we add a shadow cost of balance sheet that scales linearly with balance sheet allowed to proprietary positions such as swap spreads $\kappa\Delta_{D,s}$. This is intended to capture the marginal impact of regulatory leverage constraints (e.g., the Supplementary Leverage Ratio, or SLR; Basel Committee on Banking Supervision, 2013) that have been frequently cited as constraining bank-affiliated securities dealers (see e.g., Liang and Parkinson, 2020; Duffie et al., 2023; Duffie, 2023, 2025; Liang and Zhu, 2025, and references therein) as well as other factors (e.g. internal allocations, franchise value, etc.). Finally, we also assume the dealer is risk-aware, this time quantifying their level of aversion with η_D. Putting these pieces together, the dealer is seeking to maximize:

$$\pi_D = \Delta_{D,s}\Pi_s - \kappa\Delta_{D,s} - \Delta^2_{D,s}\frac{\eta_D\sigma_s^2}{2} + \Delta_{D,m}\Pi_m \tag{12}$$

$$= \text{const.} + \Delta_{D,s}\left[\Pi_s - \kappa + a_m - 2b_m K_D\right] - \frac{1}{2}\Delta^2_{D,s}\left[\eta_D\sigma_s^2 + 2b_m\right] \tag{13}$$

which gives an additional first order condition:

$$\Delta^{\star}_{D,s} = \frac{\Pi_s - \kappa + a_m - 2b_m K_D}{\eta_D\sigma_s^2 + 2b_m} \tag{14}$$

Finally, we use the same asset manager block as KSWY which assumes:

$$\Delta_A(\tau) = (1-\theta)S_T(\tau) \tag{15}$$

or that asset managers and other "real money" market participants (i.e., those which do not rely on leverage) absorb a certain fraction $(1-\theta)$ of Treasury supply with maturity τ in securities format and the rest as derivatives. These factors are taken to be exogenous (for more details, see e.g., Treasury Borrowing Advisory

Committee, 2024; Kashyap et al., 2025; Barth et al., 2024; Barth and Kahn, 2025).

For the market to clear,

$$\Delta_{H,s}(\tau) + \Delta_{D,s}(\tau) + \Delta_A(\tau) = S_T(\tau) \tag{16}$$

$$\implies \Delta^{\star}_{H,s}(\tau) + \Delta^{\star}_{D,s}(\tau) = \theta S_T(\tau) \tag{17}$$

For convenience, we define terms using the general form:

$$\Delta = \frac{\Pi - \text{Resrvation Premium}}{\text{Tightness}} \tag{18}$$

where tightness is the inverse of demand slope and the reservation premium captures the opportunity cost of owning spreads as opposed to engaging in alternative activities (an "intercept" term). This terminology follows the market microstructure tradition of describing liquidity provision through (i) the elasticity of intermediary balance sheets and (ii) the hurdle compensation required to deploy scarce resources such as capital and liquidity. This treatment of elasticity parallels the market-depth/price-impact concept Kyle (1985) and the inventory/holding-cost perspective in dealer models such as Stoll (1978) and Grossman and Miller (1988). More broadly, this approach aligns with intermediary asset pricing frameworks in which financial intermediaries' balance sheet capacity determines equilibrium asset prices (He and Krishnamurthy, 2013; Gabaix and Koijen, 2021). Reservation premia correspond to sector-specific indifference thresholds (reservation prices in return units) that reflect outside options and shadow costs; in this sense, they capture the compensation required for intermediaries to warehouse risk when their balance sheets are scarce. In the Treasury market, this language is consistent with the emphasis on limited intermediation capacity and balance-sheet constraints in prior work on Treasury market functionality and related discussions of dealer capacity and risk absorption (e.g., Duffie et al., 2023; Kashyap et al., 2025; Barth and Kahn, 2025). Specifically:

- **Hedge fund tightness (slope)**: $A(\nu) = \gamma^2 + \eta_H \left[\nu + \gamma^2 \sigma_x^2\right]$
- **Dealer tightness (slope)**: $B(\nu) = 2b_m + \eta_D \nu$
- **Hedge fund reservation premium (intercept)**: $C_H = \gamma \left[\alpha - \beta E_H - \eta_H E_H \sigma_x^2\right]$
- **Dealer reservation premium (intercept)**: $C_D = \kappa - a_m + 2b_m K_D$

where $\nu \equiv \sigma_s^2$ for convenience throughout the rest of the paper.

Solving for excess spread returns:

$$\Pi_s(\tau) = \underbrace{\theta S_T(\tau) \frac{A(\nu)B(\nu)}{A(\nu)+B(\nu)}}_{\text{Intermediation Capacity}} + \underbrace{\frac{B(\nu)C_H + A(\nu)C_D}{A(\nu)+B(\nu)}}_{\text{Reservation Premium}} \tag{19}$$

In this formulation, swap spreads are determined by a combination of market capacity and intermediation costs.

Market capacity responds to supply with a slope equal to the harmonic mean of hedge fund and dealer tightness:

$$\Lambda(\nu) = \frac{A(\nu)B(\nu)}{A(\nu)+B(\nu)} = \left(\frac{1}{A(\nu)} + \frac{1}{B(\nu)}\right)^{-1} \tag{20}$$

This term captures the effective price elasticity of the levered community with respect to collateral that asset managers cannot absorb. Both intermediaries supply capacity simultaneously, and the marginal price is pinned down by the combined inverse slopes (i.e., tightness). In other words, $\Lambda(\nu)$ quantifies how much expected compensation must rise to induce the constrained intermediary sector to absorb one additional unit of residual supply. This intuition is consistent with preferred habitat models in which the maturity composition of government debt affects bond risk premia and term structure dynamics (Greenwood and Vayanos, 2014).

As noted above, the reservation premium captures the effective hurdle rate for swap spreads as opposed to alternatives. For hedge funds, this is informed by the risk-return tradeoffs for the alternative investment given equity and leverage constraints. For dealers, the intercept is informed by the returns from market-making activities and shadow balance sheet costs in the context of a balance sheet constraint (Duffie, 2020; Boyarchenko et al., 2020; Duffie et al., 2023; Duffie, 2023, 2025). The overall reservation premium (i.e., intercept) is equal to a weighted average hedge fund and dealer constants, for which the weightings are the tightness of the opposite side. In other words, when dealers are tight hedge funds set the intercept; when hedge funds are tight, then dealers set the intercept.

To begin, we observe that, as with the original KSWY model the level of swap spreads is directional with supply. We have from above that $A(\nu)$ and $B(\nu)$ are positive for all allowable parameter choices. Then, taking the derivative we have:

$$\frac{d\Pi_s}{dS(\tau)} = \theta\Lambda(\nu) \tag{21}$$

which is also positive. In other words, increasing supply raises the equilibrium expected returns from owning swap spreads.

The same is true of κ. Since κ only enters through C_D, we have:

$$\frac{d\Pi_s}{d\kappa} = \frac{A(\nu)}{A(\nu)+B(\nu)} = \frac{\Lambda(\nu)}{B(\nu)} \tag{22}$$

which again is positive for all allowable parameter choices. This confirms the intuition and more empirical arguments offered by others that increased dealer balance sheet costs, whether from the SLR or other regulations, are passed through to returns on swap spreads because the market is effectively "renting" more loosely constrained balance sheet among hedge funds and other levered market participants to warehouse collateral.

3.2 Statics and Dynamics of the Term Structure of Swap Spreads

We can, however, go a step further and consider the term structure of swap spreads. From the chain rule we have:

$$\frac{d\Pi_s}{d\tau} = \underbrace{\frac{\partial \Pi_s}{\partial \tau}}_{\substack{\text{Maturity} \\ \text{Channel}}} + \underbrace{\frac{d\Pi_s}{d\nu}\frac{d\nu}{d\tau}}_{\substack{\text{State-Dependent} \\ \text{Tightness Channel}}} \tag{23}$$

which after some algebra, simplification and rearranging yields:

$$\frac{d\Pi_s}{d\tau} = \underbrace{\theta S'(\tau)\Lambda(\nu(\tau))}_{\text{Maturity Channel}} + \underbrace{\theta S(\tau)\Lambda'(\nu(\tau))\nu'(\tau)\Omega_{risk}(\nu)}_{\text{State-dependent tightness: risk}} + \underbrace{\Lambda'(\nu(\tau))\nu'(\tau)(C_H - C_D)\Omega_{inc}(\nu)}_{\text{State-dependent tightness: incidence}} \tag{24}$$

where

$$\Omega_{risk}(\nu) = \frac{\eta_H B^2(\nu) + \eta_D A^2(\nu)}{[A(\nu)+B(\nu)]^2} > 0 \tag{25}$$

$$\Omega_{inc}(\nu) = \frac{\eta_H B(\nu) - \eta_D A(\nu)}{[A(\nu)+B(\nu)]^2}. \tag{26}$$

The risk term (Ω_{risk}) is strictly positive, consistent with the general premise that warehousing longer-maturity spreads requires higher excess returns to compensate for greater mark-to-market volatility over the holding period (leading to a higher variance of returns).

The incidence term (Ω_{inc}),[3] on the other hand, captures how volatility reallocates marginal price-setting power across heterogeneous intermediaries. Its magnitude depends on the relative tightness (elasticities) of demand from those two market participants which in turn determines whether hedge funds or dealers

[3]In the context of our model, "incidence" is chosen by analogy to tax incidence, which which describes how economic burdens are distributed across agents depending on relative elasticities. Like intermediation incidence, tax incidence depends on relative elasticities of supply and determining which sector bears the economic cost of tax shocks (see e.g., Harberger, 1962; Atkinson and Stiglitz, 1980).

effectively set the marginal spread when volatility changes. Its sign is set by the inversely weighted average tightness $\eta_H B(\nu) - \eta_D A(\nu)$ and which sector has the higher reservation premium $C_H - C_D$.

From this it is interesting to observe that the term structure of swap spreads is not strictly upward sloping. This remains true even if we assume the volatility of total returns from owning spreads is increasing with maturity.

This is particularly interesting given the empirical observation that the term structure of swap spreads flipped from negatively to positively sloped around 2008. At the time, the most important change in the broader market environment was a substantial shift in the outlook for the federal deficit and the associated forecast for the supply of Treasuries. This makes sense in that, while the sign of the term structure is ambiguous, an increase in supply expectations will generically cause it to steepen. For example, if we hold the weighted average maturity (WAM) of new supply fixed, we have:

$$\frac{d}{dS(\tau)}\frac{d\Pi_s}{d\tau} = 2\theta\sigma_s\sigma_s'\Omega_{risk}(\nu) > 0 \tag{27}$$

However, the same is not true for θ. Taking that derivative:[4]

$$\frac{d}{d\theta}\frac{d\Pi_s}{d\tau} = \frac{\partial S(\tau)}{d\tau}\Lambda(\nu) + 2\sigma_s\frac{d\sigma_s}{d\tau}S(\tau)\Omega_{risk}(\nu) \tag{28}$$

There is a critical level of supply for which an increase in θ will steepen the term structure of swap spreads:

$$S^\star(\tau) = -S'(\tau)\frac{A(\nu)B(\nu)}{2\sigma_s\sigma_s'}\frac{A(\nu)+B(\nu)}{\eta_H B^2(\nu) + \eta_D A^2(\nu)} = -\frac{S'(\tau)}{2\sigma_s\sigma_s'(\tau)}\frac{\Lambda(\nu)}{\Omega_{risk}(\nu)} \tag{29}$$

Finally, we can consider the impact of increasing the shadow cost of balance sheet on the term structure of swap spreads. Here again the sign of the impact is ambiguous given:

$$\frac{d}{d\kappa}\frac{d\Pi_s}{d\tau} = 2\sigma_s\sigma_s'\frac{\eta_D A(\nu) - \eta_H B(\nu)}{\left[A(\nu)+B(\nu)\right]^2} \tag{30}$$

which shows that increasing dealer risk aversion will exacerbate the marginal impact of variation in shadow balance sheet costs and vice versa if:

$$\frac{\eta_D}{\eta_H} > \frac{B(\nu)}{A(\nu)}. \tag{31}$$

[4] $S'(\tau)$ is not strictly signed in principle, but in practice is almost always negative reflect the fact that is is generally more expensive and not always optimal for governments to raise debt preferentially in longer maturities (Belton et al., 2018).

3.3 Pricing Dynamics and Margin Spirals

A key input into our model is the margin (γ) needed to support swap spread and other fixed income relative value positions. Margin enters through the hedge fund block and has a direct pass-through into the pricing and term structure of swap spreads. The impact of γ on swap spread pricing and term structure is ambiguous in generality:

$$\frac{d\Pi_s}{d\gamma} = \theta S(\tau)\frac{A'(\gamma)B^2(\gamma)}{\left[A(\gamma)+B(\gamma)\right]^2} + \frac{A'(\gamma)B'(\gamma)(C_D - C_H) + C'_H(\gamma)(A(\gamma)B(\gamma)+B^2(\gamma)}{\left[A(\gamma)+B(\gamma)\right]^2} \tag{32}$$

But margining is rarely static. Standard practice among clearinghouses is to size initial margin to potential costs associated with a liquidation. That generally scales with volatility (e.g., value-at-risk, or VaR frameworks; Heckinger et al., 2016; Roberson, 2018; CME Group, n.d.; LCH Ltd., n.d.). In principle, this can lead to margin spirals in which an initial volatility shock can force margin calls leading to liquidations in a vicious cycle that can become self-reinforcing (Murphy et al., 2016). This was most clearly on display during the Covid pandemic (see e.g., Schrimpf et al., 2020; Fleming and Ruela, 2020; Younger, 2021; BCBS and CPMI and IOSCO, 2022).

This dynamic falls out naturally from our model given a plausible set of assumptions. First, we endogenize margin by assuming a VaR-style functional form:

$$\gamma(\nu) = \gamma_0 + \phi\sqrt{\nu} + \psi\kappa(\nu) \tag{33}$$

where $\phi > 0$ is the VaR weight and $\psi\kappa(\nu) \geq 0$ (with $d\kappa/d\nu > 0$) is the risk-sensitive shadow cost of balance sheet (see e.g., Adrian and Shin, 2010).

For example, we consider a standard Uhlenbeck and Ornstein (1930) stochastic volatility process with mean-reversion, non-linear feedback and noise (see also Heston, 1993; Brunnermeier and Pedersen, 2009; Strogatz, 2015) for the variance in swap spreads (ν). In continuous time:

$$d\nu_t = \mu(\nu) + \sigma_\nu dW_t \text{ with} \tag{34}$$

$$\mu(\nu) = \underbrace{-\lambda(\nu_t - \bar{\nu})}_{\text{Mean Reversion}} + \underbrace{\chi\left(\Pi_{s,t} - \bar{\Pi_s}\right)}_{\text{Feedback}} \tag{35}$$

A margin spiral can be define by the condition that deviations from equilibrium become self-reinforcing. In other words, the drift is positive. Assuming the system was previously in equilibrium ($\nu = \bar{\nu}$ and $\Pi_s = \bar{\Pi_s}$

we consider a local perturbation $\delta\nu$ such that :

$$-\lambda\delta\nu + \chi\left(\frac{d\Pi_s}{d\nu}\delta\nu\right)^n = 0 \tag{36}$$

which gives a threshold perturbation of:

$$(\delta\nu)^\star = \left[\frac{\lambda}{\chi}\left(\frac{d\Pi_S}{d\nu}\right)^{-n}\right]^{\frac{1}{n-1}} \tag{37}$$

We then have (again via the chain rule):

$$\frac{d\Pi_s}{d\nu} = \underbrace{\frac{\partial\Pi_s}{d\nu}}_{\substack{\text{Direct}\\ \text{Tightness}}} + \underbrace{\frac{\partial\Pi_s}{d\gamma}\frac{d\gamma}{d\nu}}_{\substack{\text{Margin}\\ \text{Pro-cyclicality}}} + \underbrace{\frac{\partial\Pi_s}{d\kappa}\frac{d\kappa}{d\nu}}_{\substack{\text{Risk-sensitive}\\ \text{shadow B/S cost}}} . \tag{38}$$

Reusing the above notation, we have:

$$\frac{d\Pi_s}{d\nu} = \theta S(\tau)\Omega_{risk}(\nu) + \underbrace{\Omega_{inc}(\nu)\left[C_H(\nu) - C_D(\nu)\right]}_{\text{Incidence shift}} + \underbrace{\Omega_{res}(\nu)}_{\substack{\text{Reservation}\\ \text{Shift}}} \tag{39}$$

given

$$\Omega_{res} = w_H(\nu)\frac{C_H(\nu)}{\gamma}\frac{d\gamma}{d\nu} + w_D(\nu)\frac{d\kappa}{d\nu}. \tag{40}$$

where

$$w_H(\nu) = \frac{B(\nu)}{A(\nu)+B(\nu)}, \tag{41}$$

$$w_D(\nu) = \frac{A(\nu)}{A(\nu)+B(\nu)}, \tag{42}$$

$$w_H(\nu) + w_D(\nu) = 1 \;\forall\; \nu \tag{43}$$

Once again the incidence term captures how volatility reallocates price-setting power across intermediaries with different reservation premia. This suggests margin is pro-cyclical anytime the intermediary which tightens faster with volatility (i.e., $\eta_H B(\nu) - \eta_D A(\nu) > 0$) is also the side that has the higher reservation premium (e.g., $C_H - C_D$). Put differently, the presence of a non-zero incidence term in $d\Pi_s/d\nu$ reveals a structural amplification mechanism that does not rely on exogenous factors such as increased supply or higher shadow balance sheet costs, but is generated simply by heterogeneity in the elasticities and reservation premia of key intermediaries.

The reservation-shift term captures how volatility directly raises those premia through procyclical margin and shadow balance-sheet costs. Importantly, this term can contribute to spirals absent significant shifts in Treasury supply or the marginal risk-taker. Rather, it reflects differential hurdle rates. In particular, if κ is risk-sensitive (i.e., $d\kappa/d\nu > 0$) then shadow balance sheet costs among dealers will feed directly into the spiral.

4 Empirical Results

Having written a simple model for the drivers of pricing in swap spreads, the next logical step is to try to find empirical validation of those assumptions. Rather than fit the parameters explicitly, we can use a regression analysis to establish directionality consistent with the model predictions. This is sufficient for our purposes as it validates the intuition underlying the model.

For swap spreads we calculate true asset swaps which adjust the swap details to incorporate deviations of the bond price from par and the precise timing of bond coupons. In that sense, they are a more pure reflection of Π_s than matched-maturity asset swaps, for which the present value of the swap is par and the payment dates may be somewhat offset. These data are available for 3- and 12-month Treasury bills as well as 2-, 5-, and 10-year Treasury note and 30-year Treasury bonds. For the bonds, we use the most recently issued Treasury securities for each tenor. For the swap itself we utilize overnight index swaps (OIS) linked to the effective federal funds rate (EFFR; for a detailed description and model for the federal funds market, see Afonso and Lagos, 2015). We obtain these data going back to 1998 and calculate the average level of spreads and the slope in bp per year.

To begin, we make a simple and stylized but nonetheless significant observation. Although the average level of swap spreads is often discussed in reference to deficit expectations, the data do not consistently bear this out. We can, for example, compare the spread curve intercept (i.e., the intercept of a regression of swap spreads versus maturity) across the curve to 1-year ahead annual net Treasury supply forecasts from the Congressional Budget Office (CBO). The result shows that while there was some loose correlation between these two terms prior to the GFC, more recently it has be reduced essentially to zero (Figure 2). That is not inconsistent with our model, for which multiple factors drive the intercept and slope of swap spreads.

To begin, we source additional data that tracks some of the factors embedded in the model. More frequent estimates of expected Treasury supply and the maturity composition of Treasury debt can be sourced from the Treasury Borrowing Advisory Committee (TBAC). For supply, we use expectations for net issuance of marketable debt in the quarter after announcement, provided quarterly going back to 1998 as well.[5] These

[5] `https://home.treasury.gov/policy-issues/financing-the-government/quarterly-refunding/`

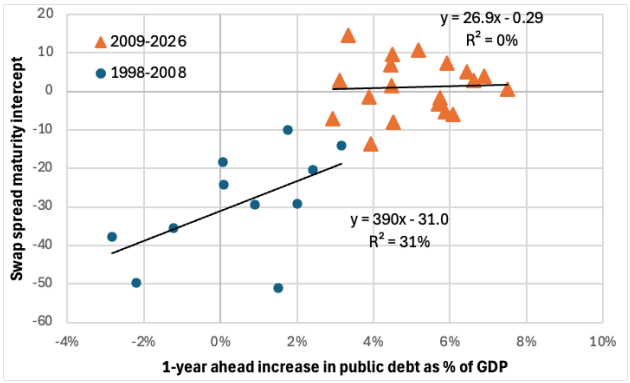


Figure 2: Swap spread curve intercept (the intercept of a linear regression of swap spreads against maturity in years) versus 1-year ahead net supply of Treasuries as a % of GDP a the time of forecast (produced by CBO).
Source: CBO, J.P. Morgan, FRED, author's calculations.

data are adjusted for net purchases of Treasury debt by the Federal Reserve banks for that quarter as provided in FRB H.4.1 tables.[6]. The TBAC also calculates WAM for Treasury debt both including and excluding securities held by the Fed in the System Open Market Account (SOMA).[7].

Finally, effective margin can be inferred from Treasury futures data provided by the Chicago Mercantile Exchange (CME). We calculate an effective margin:

$$\tilde{\gamma} = \frac{1}{\mathrm{OI}_T} \sum_{i=1}^{N_F} \gamma_i \mathrm{OI}_i \tag{44}$$

where γ_i is the initial margin (also referred to as maintenance margin requirement) for each contract, OI_i is the open interest in notional for that contract and OI_T is the total open interest across all contracts. This is admittedly not *per se* the same as margin for swaps. But the models follow a similar methodology and should be reasonably consistent with each other.

The results are show in Table 1.

Near-term Treasury supply expectations enter with a negative but statistically insignificant coefficient. This is consistent with the model's prediction that the effect of supply on the maturity slope is ambiguous and depends on the interaction between maturity composition and risk-bearing capacity. Empirically, the slope appears to be driven primarily by volatility and intermediation capacity rather than short-horizon issuance expectations.

quarterly-refunding-archives/quarterly-refunding-financing-estimates-by-calendar-year

[6] https://www.federalreserve.gov/releases/h41/,avavailable on FRED at https://fred.stlouisfed.org/series/WSHOTSL (2002 to present) and https://fred.stlouisfed.org/series/RAGSOTBO (1914 to 2008) We use *ex post* data for this adjustment under the assumption that market expectations around quantitative easing (QE) purchases are well-formed roughly one month in advance. The two exceptions are the fall of 2008 and the spring of 2020 during which large QE and market functioning purchase programs would likely not have been anticipated broadly by market participants.

[7] https://home.treasury.gov/system/files/221/2026-1st-Quarter.xls

Table 1: Determinants of the Maturity Slope of Swap Spreads

	(1)
Intercept	-8.878***
	(-4.419)
Effective Margin	72.462
	(1.589)
Realized Variance of Avg Swap Spread	0.000169**
	(2.528)
6-month expected net Treasury supply (ex-QE purchases)	-0.000634*
	(-1.855)
Treasury Debt WAM (ex-SOMA)	0.206***
	(5.721)
Dealer B/S as % of Total Treasury Debt Oustanding	-2.584***
	(-6.515)
Observations	88
R^2	73.9%
Adjusted R^2	72.3%
Residual Std. Error	1.233

Notes: This table reports OLS estimates of the determinants of the maturity slope of swap spreads over the sample period 2003–2025. The effective margin is calculated as the weighted average of initial margin requirements for each Treasury futures contract for which the weights are gross open interest. The realized variance is calculated as the three month standard deviation of average true asset swap spreads. 6-month Treasury supply is taken from TBAC announcements as of the Quarterly Refunding Meeting covering the quarter in which the meeting takes place as well as the subsequent quarter. Actual and anticipated QE-related Treasury purchases are taken from Federal Open Market Committee statements and other announcements made prior to the time of the release of the quarterly refunding documents. Treasury Debt weight excludes SOMA holdings and is calculated by the Treasury as part of the Quarterly Refunding Documents Dealer balance sheet is total financial assets held by securities dealers in FRB Z.1 data divided by total marketable Treasury debt outstanding net of SOMA holdings. All variables are observed at or before the date of release of the quarterly refunding documents by the U.S. Treasury
t-statistics are reported in parentheses below coefficient estimates.
Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.
Source: U.S. Treasury, FRB Z.1, J.P. Morgan

Notes: This table covers 2003 Q3 to 2025Q3.

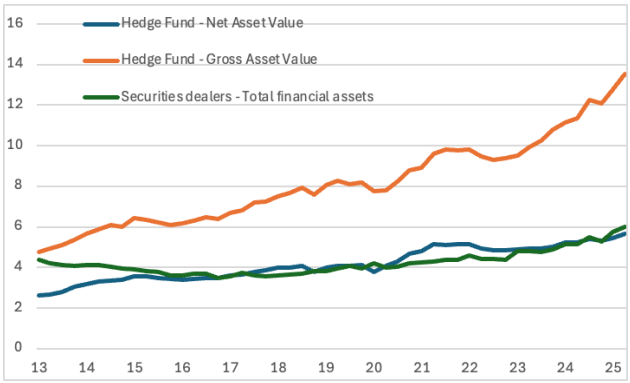


Figure 3: Total AUM of hedge funds (gross and net asset value) compared to securities dealers.
Source: SEC Private Funds Statistics, FRB Z.1

The broader implication is that the persistence of significant excess returns from owning swap spreads is not, as some have argued, primarily evidence of a lack of intermediation capacity. Or, in the language of our model, it is not evidence of tightness in intermediary balance sheets. Quite the contrary in fact. Here we find evidence that the consolidated intermediary balance sheet—importantly in our model including both hedge funds and dealers—is, along with demand from asset managers, sufficiently elastic to absorb the sizeable increase in collateral supply.

That said, this result does not necessarily imply that dealers are not constrained. In fact, we see a statistically significant negative coefficient with the size of their balance sheet that dealer intermediation capacity is quite relevant. Rather, it suggests that hedge fund balance sheets have stepped in to provide elasticity when banks have been unable or unwilling to do so. By implication, the interplay between hedge fund and dealer tightness has become the primary determinant of marginal price formation. As a consequence, the WAM of Treasury debt shows up with a positive coefficient at high statistical significance in our regression analysis.

It is also interesting to note that effective margin is also not statistically significant over the long-run. That suggests hedge funds have generally been able to source sufficient equity capital to support ever increasing Treasury relative value positions without a large and persistent price response. That high level observation is consistent with the spectacular growth of hedge fund assets under management over the past twenty years even as dealers have retrenched. That growth is particularly striking in recent years when viewed in gross terms–consistent with an increasing allocation of hedge fund capital to relative value style strategies (Figure 3).

It is important to note, however, that in key moments margin dynamics can dominate. In Figure 4 we show the effective margin versus maturity slope over time. It is clear that rising margin is correlated to a steeper term structure of swap spreads during the Taper Tantrum of 2013 and inflation shock of 2022-23.

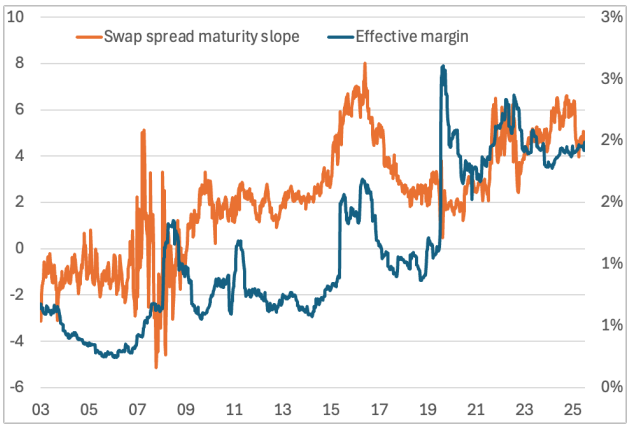


Figure 4: Effective margin versus swap spread maturity slope
Source: CME, CFTC, author's calculations

The same was true briefly during the Covid market shock of 2020, but the effect was very short-lived since the Fed very quickly initiated massive market functioning purchases during those critical weeks (Logan, 2020a; Fleming et al., 2021; Duffie and Keane, 2023; Menand and Younger, 2023, 2025). Overall, there is ample evidence to suggest that margin spirals can drive self-reinforcing volatility and deleveraging during periods of broader stress (Fleming and Ruela, 2020; Younger, 2021; BCBS and CPMI and IOSCO, 2022; Kahn and McCormick, 2025).

5 The Role of "Pod Shops"

In the above discussion we have treated hedge funds as a single consolidated entity. That is, at the risk of understatement, a gross oversimplification. Risk management policies, internal capital allocation, risk taking authorization, and principal areas of focus vary widely among different funds. They can, however, be broadly categorized by investment style: discretionary long/short equity (often organized around sector specialists with relatively stable gross/net targets), event-driven and relative-value (where position sizing is frequently tied to deal terms, carry, or spread dynamics), discretionary macro (where risk is often expressed through rates, FX, and commodities with tighter top-down drawdown governance), and systematic/quant (where exposures are typically governed by model-driven constraints and portfolio-level limits).

A more recent—and increasingly dominant—organizational form cuts across these style buckets: the multi-manager "platform" or "pod shop," in which a centralized allocation function continuously budgets risk across many semi-autonomous portfolio manager teams (pods) (Acadian Asset Management, 2024; Morgan Stanley Investment Management, 2024; INSEAD Knowledge, 2025; Trustnet, 2025). Their goal is for specialists in narrow areas of focus to generate weakly correlated (or, ideally, uncorrelated) returns

that improve the risk-adjusted returns of the consolidated fund. In practice, this design turns what used to be a single "fund" into something closer to an internal capital market, with a central risk management organization dynamically reallocating equity risk capital across the platform (Blotnick, 2025). Data and industry reporting suggest that multi-manager assets have grown rapidly in recent years as large allocators have shown greater risk aversion in their exposure to alternative investments (and, in some cases, have been willing to pay considerably higher fees to source high Sharpe ratio returns; Reuters, 2023; Financial Times, 2025).

The concentration of hedge fund risk capital in "pod shops" has implications for the behavior of hedge fund activity more broadly. Industry reporting on multi-manager platforms describes highly mechanical risk controls. Overall public evidence is mostly anecdotal, but some reporting has suggested these funds operate tight stop-loss rules, rapid de-grossing when drawdown thresholds are breached, as well as centralized risk-management and capital allocation (Rubinstein, 2023; Trustnet, 2025). This reporting is supported by some empirical observations such as sudden market "blips" when concentrated pod exposures are unwound (INSEAD Knowledge, 2025), and reports of crowded trade exits during volatility episodes.

We can formalize mechanical de-risking thresholds through the following modification:

$$\hat{A}(\nu) = \underbrace{A(\nu)}_{\substack{\text{Structural}\\ \text{tightness}}} + \underbrace{a_{\mathcal{L}}\mathcal{L}(\nu)}_{\text{De-risking}} \tag{45}$$

$$\hat{C}_H(\nu) = \underbrace{C_H(\nu)}_{\substack{\text{Structural}\\ \text{Reservation}\\ \text{Premium}}} + \underbrace{c_{\mathcal{L}}\mathcal{L}(\nu)}_{\text{De-risking}} \tag{46}$$

where $\mathcal{L} \in [0,1]$ captures the non-linear response of hedge funds to volatiltiy. We assume that the increase in hedge fund tightness is at a maximum at ν^* (i.e., $\frac{d^2\mathcal{L}}{d\nu^2}\Big|_{\nu^*} = 0$ at ν^*), $\mathcal{L}$ is increasing in ν (i.e., $d\mathcal{L}/d\nu > 0 \ \forall \ \nu$), and that $\mathcal{L}$ asymptotically approaches zero for large and small ν (i.e., $\mathcal{L}((\nu) \approx 0$ for $|\nu - \nu^\star| \gg 0$). The replicates idea that de-risking is most acute around a critical volatility level, dealer tightness is unaffected by de-risking in very low volatility environments, and that tightness is stable but higher in very high volatility environments.

Then we return to:

$$\frac{d\Pi_s}{d\nu} = \underbrace{\frac{\partial \Pi_s}{d\nu}}_{\substack{\text{Direct}\\ \text{Tightness}}} + \underbrace{\frac{\partial \Pi_s}{d\mathcal{L}}\frac{d\mathcal{L}}{d\nu}}_{\substack{\text{De-risking}\\ \text{Pro-cyclicality}}} \tag{47}$$

where

$$\frac{d\hat{A}(\nu)}{d\nu} = \eta_H + a_{\mathcal{L}}\frac{d\mathcal{L}}{d\nu} \text{ and } \frac{d\hat{C}_H(\nu)}{d\nu} = c_{\mathcal{L}}\frac{d\mathcal{L}}{d\nu}. \tag{48}$$

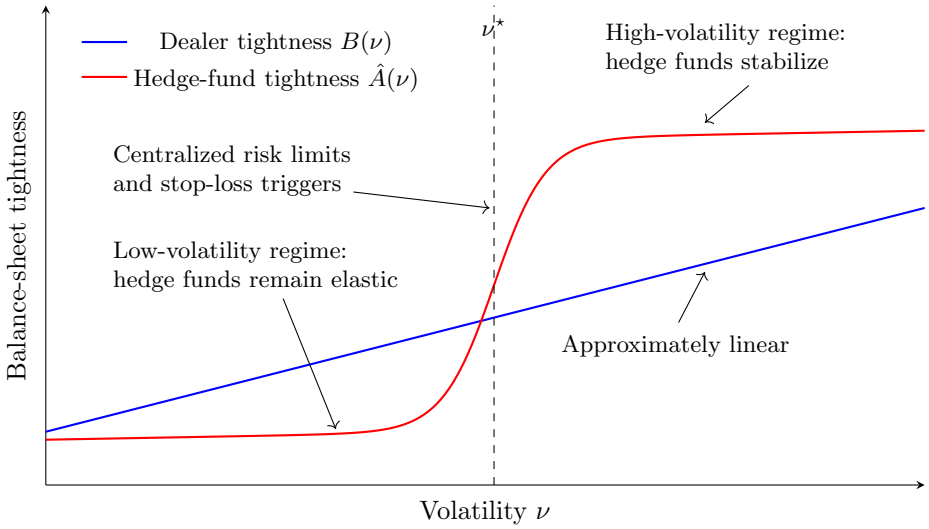


Figure 5: Illustrative tightness for hedge funds with mechanical de-risking/de-grossing versus dealers. Dealer balance-sheet tightness rises approximately linearly with volatility, while hedge-fund tightness increases sharply around the critical volatility threshold $\nu^\star$.

That returns an adjusted sensitivity of swap spread prices with volatility that mirrors the discussion in §3.3:

$$\frac{d\hat{\Pi}_s}{d\nu} = \theta S(\tau)\hat{\Omega}_{\text{risk}} + \hat{\Omega}_{\text{inc}}(\hat{C}_H - C_D) + \hat{\Omega}_{\text{res}} \tag{49}$$

where

$$\hat{\Omega}_{\text{risk}} = \frac{B^2\hat{A}' + \hat{A}^2B'}{(\hat{A}+B)^2},\ \hat{\Omega}_{\text{inc}} = \frac{B\hat{A}' - \hat{A}B'}{(\hat{A}+B)^2},\ \text{and}\ \hat{\Omega}_{\text{res}} = \hat{w}_H\hat{C}'_H + \hat{w}_DC'_D \tag{50}$$

$$\text{with}\quad \hat{w}_H = \frac{B}{\hat{A}+B}\ \text{and}\ \hat{w}_D = \frac{\hat{A}}{\hat{A}+B} \tag{51}$$

From this it is clear that increasing the influence of threshold-based hedge fund de-risking (i.e., larger $a_{\mathcal{L}}$) will steepen the swap spread curve through the risk if $a_{\mathcal{L}} > 0$ and $\mathcal{L}' > 0$ (both consistent with our assumptions) and reservation premium channel if $c_{\mathcal{L}} > 0$ and $\mathcal{L}' > 0$ (again, consistent with our assumptions). The impact of the modified indicence channel is ambiguous, but including non-linear hedge fund de-risking does steepen the swap spread term structure if:

$$\frac{\hat{A}'}{\hat{A}} > \frac{B'}{B}\ \text{and}\ \hat{C}_H - C_D > 0. \tag{52}$$

This, in turn, requires a growth rate function for which:

$$\frac{\mathcal{L}'}{\mathcal{L}} > \frac{B'}{B}\frac{1+\xi}{\xi} - \frac{1}{\xi}\frac{A'}{A} \tag{53}$$

where $\xi = a_{\mathcal{L}}\mathcal{L}/A$ compares the non-linear component of hedge fund tightness to the unmodified hedge fund tightness.

This leads us to some intuitive conclusions. First, if ξ is small, and the linear component of hedge fund tightness dominates, then its growth rate must be very large to change the incidence. Likewise, if ξ is large, and this non-linear component dominates, then it will influence the incidence even if its growth is slow. Finally, the above condition is most likely to be satisfied at $\nu^\star$ where $\mathcal{L}'$ is at a maximum.

Going back to §3.3, we recall that the magnitude of volatilty shock required to trigger a margin spiral scales as:

$$\delta\nu^\star \sim \left[\frac{d\Pi_s}{d\nu}\right]^{-\frac{n}{n-1}} \tag{54}$$

which suggests that, to the extent the above conditions are satisfied and introducing $\mathcal{L}$ increases $d\Pi_s/d\nu$, it lowers the threshold to triggering a runaway margin spiral.

The upshot is fairly intuitive. Trigger-based de-risking does not just make hedge funds tighter; it makes hedge-fund tightness more nonlinear in volatility. Around draw-down and stop-loss thresholds, the growth rate of hedge-fund tightness can exceed that of dealers. When that happens, intermediary demand becomes abruptly less elastic, reservation premia rise, and the sensitivity of swap spreads to volatility increases. The result is a lower threshold for self-reinforcing deleveraging.

6 Policy Implications

6.1 The Benefits (and Costs) of Cleared Repo

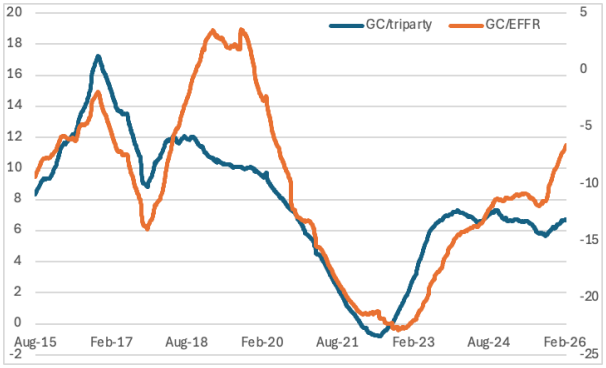
As noted above, a regression analysis of the maturity slope of swap spreads suggests that, at least on a consolidated basis, intermediary balance sheet capacity (i.e., that provided by levered investors including dealers and hedge funds) has been sufficiently elastic to absorb a substantial increase in net issuance of Treasury securities.

That stylized fact is consistent with empirical results interpreted through the lens of our model. But it glosses over an important but as yet unarticulated assumption. In our model, hedge funds are constrained by their access to equity capital and dealers are constrained by their access to balance sheet. In other words, we implicitly assume hedge funds can source whatever quantity of leverage they demand and their equity will support given margin requirements (γ) at a roughly constant price.

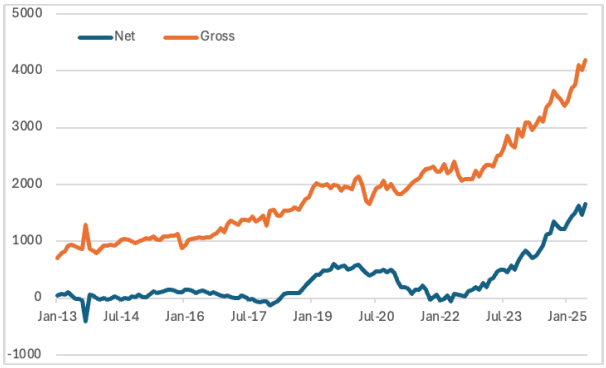
That may seem a strong assumption. But the empirical evidence presented above supports that conclusion. Further, signals from the pricing of various short-term interest rates also indicate that repo balance sheet has been very elastic in recent years.

That evidence comes specifically from the behavior of different segments of the repo market. Matched-book repo typically involves dealers borrowing cash from money market mutual funds (MMMFs) at the triparty rate and lending to hedge funds and other levered market participants at the general collateral (GC) rate (for details see e.g., Copeland et al., 2010, 2015; Baklanova et al., 2015; Treasury Market Practices Group, 2025). The spread between those two rates (both overnight term) captures compensation repo dealers require to perform that intermediation and captures the combined impact of regulatory costs, internal charges, and hurdle rates for return on equity. We can comapre the evolution of that spread to the difference between GC and interest on reserve balances (IORB), the rate at which commercial banks are remunerated for their deposits at Federal Reserve banks (for details, see Hughes and Younger, 2026). This GC/IORB spread captures the marginal cost of reallocating cash to repo from passive reserves. Data collected over the past ten years suggest that GC/triparty has been considerably more stable than GC/IORB—a sharp contrast to the 2015-2019 period (Figure 6a). This is true even as repo dealers have intermediated a massive expansion in overall repo supply to hedge funds in both gross and net terms (Figure 6b).

6b).



(a) 1-year average repo spreads in bp



(b) Gross versus net repo held by hedge funds

Figure 6: Repo spreads versus total repo exposure among hedge funds in $bn

Note: GC is from dealer marks as of the close, triparty rates from the Federal Reserve Bank of New York (Federal Reserve Bank of New York, n.d.), and IORB from the Federal Reserve Board. Hedge fund data is from Tables 8.16 and 8.17 of the SEC Private Funds statistics.

Source: FRBNY, J.P. Morgan DataQuery, FRB, SEC Private Funds Statistics

The ability of dealers to achieve this feat owes to two key underlying structural supports.

First, money center banks remain an important and highly elastic source of leverage supply. This is simply a consequence of the nature of their role in the banking system, which tends to rely more on traditional lending than other GSIBs.Therefore, their overall activity tends to be bound by risk-based capital requirements than SLR or other leverage-based requirements. As a consequence, they have ample capacity—at least conceptually—to engage in incremental repo and other activities that have relatively low risk weights.[8]

[8]Neither repo nor Treasury market making is strictly risk-free from an RWA perspective. Both generate Basel market and

Further, the dealers at many money center banks consider repo a key element of the franchise value of a full service banking and market making model, in which repo offerings facilitate much higher return on capital activities.

The second is a dramatic increase in the availability of cleared repo. Analogously to clearing in derivatives markets, clearing in repo involves the novation of bilateral transactions to a centralized counterparty (CCP; Committee on Payment and Settlement Systems and Technical Committee of the International Organization of Securities Commissions, 2012). That CCP then acts as counterparty to all transactions—the buyer (in this case, of collateral) to all sellers and the seller to all buyers. The credit of the CCP is maintained by funded and contingent resources committed by its members to support its liquidity and mutualize losses.

Clearing has many purported benefits, including reduced counterparty risk, better data for market monitoring, and the ability to more effectively enforce market standards around risk management through CCP membership requirements (Duffie, 2020; Inter-Agency Working Group for Treasury Market Surveillance, 2021; Gensler, 2023; Yadav and Younger, 2025; Liang and Zhu, 2025, 2026). But, for repo elasticity in particular, a key benefit is more efficient netting. Under standard accounting rules, dealers with sufficiently similar and offsetting repo positions can net them down for regulatory and balance sheet accounting purposes. A prerequisite to claim that the offsetting trades face the same counterparty. In principle, when a higher proportion of trades are cleared, and therefore face the same CCP, netting efficiencies increase and dealers can support a larger gross balance sheet with the same capital and liquidity resources. While the details are somewhat more complicated than this more conceptual description, there is evidence that greater access to clearing lowers the marginal shadow costs to supply more leverage to the Treasury market (Bowman et al., 2024).

Previously, access to clearly generally required direct membership in the CCP which in practice was limited to predominantly banks, bank-affiliated dealers, independent dealers, and a handful of other large complex financial institutions. The vast majority of cash providers (MMMFs) and borrowers (hedge funds) were excluded from membership and had to trade bilaterally. In recent years, however, the Depository Trust Clearing Corporation (DTCC)–the dominant CCP in Treasury markets as well as other areas (Awrey and Macey, 2022)–has taken steps to significantly increase access to clearing. Instead of offering an expanded direct membership program, DTCC allowed its members to sponsor a much broader set of other market participants to access the CCP (Copeland et al., 2025).

Since initially expanding the program in the spring of 2018, sponsored repo has grown exponentially and is now a key component of the overall Treasury repo market. This has more than outpaced the growth of

operational risk, which are synthetic RWA that contribute to overall risk-based capital requirements. Repo also generates RWA from counterparty credit exposure to DTCC and other CCPs. But on the whole Treasuries consume very little risk-based capital.

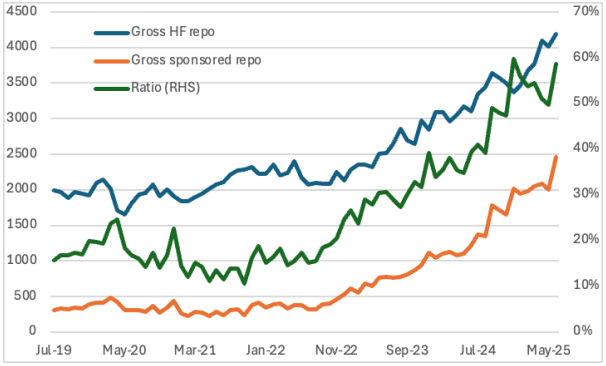
hedge fund leverage in Treasury markets (Figure 7a). The primary participants in this expansion of gross repo balance sheet have been former broker-dealers, which have significantly increased their netting efficiency over the same period (Figure 7b). Although there are common ways to improve netting efficiency among purely bilateral trades—i.e., cash-neutral packages are also common and have been for some time (Bowman et al., 2024)—the contemporaneous growth in hedge fund leverage and sponsored repo suggests it has played a key role in maintaining the elasticity of repo dealer balance sheets.

Despite the success of the DTCC Sponsored Service, Treasury repo remains a predominantly bilateral market (Gensler, 2023, 2024; Hempel et al., 2023, 2025). This has led has led regulators to mandate central clearing across most of the secondary and Treasury repo markets (Securities and Exchange Commission, 2024; Commodity Futures Trading Commission, 2012). Although the deadlines associated with that mandate have been pushed back somewhat relative to the initial deadlines (U.S. Securities and Exchange Commission, 2025a), the new rules appear to be broadly on track for implementation over the next couple of years, which should bring the vast majority of repo into scope for mandatory clearing. While a dramatic change to the structure and operations of the Treasury market, it is unclear if mandatory clearing will significantly improve elasticity. Work by Bowman et al. (2024), for example, finds that dealers have already largely optimized their matched-book repo exposures through a combination of selective use of sponsored repo and bilateral netting via cash-neutral packages. Under normal market conditions, at least, the marginal improvement offered by mandatory clearing is likely modest at best.

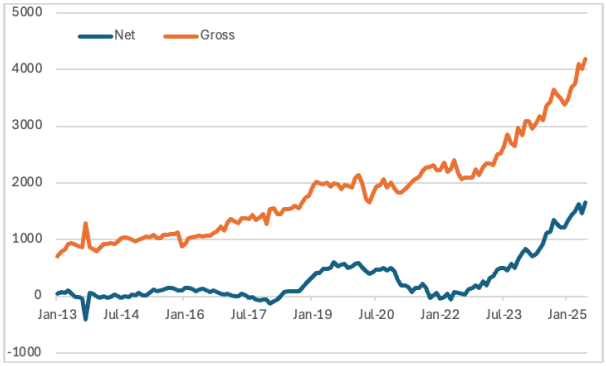
That said, it stands to reason that increased central clearing gives dealers more "surge capacity" during periods of market stress. That increased capacity arises from the nature of the lower than expected efficiency gains from mandatory clearing under more normal market conditions. Those gains are modest because dealers, especially money center banks, tend to warehouse a maturity gap between their lending to hedge funds (several days to a month or two) and their borrowing from MMMFs (overnight). This maturity gap renders a sizable fraction of their matched book ineligible for netting. However, as Yadav and Younger (2025) notes, dealers can term in their lending through price incentives and other means in response to improve their marginal netting efficiency in the event of a demand shock. This reduces fire sale risk and improves Treasury market resilience.

But these benefits come at a cost. As Yadav and Younger (2025) note, the critical role of Treasury CCPs not just in Treasury markets but in the global financial markets more broadly. But more immediately, sponsored repo strongly incentivizes leverage-constrained intermediaries to reduce the maturity gap within the matched book. Accordingly, Primary Dealer Statistics collected by the Federal Reserve Bank of New York suggest that overnight repo now accounts for more than 60% of repo lending by primary dealers, up from closer to 40% before the Sponsored Service was expanded (Figure 7c). That ratio would also like

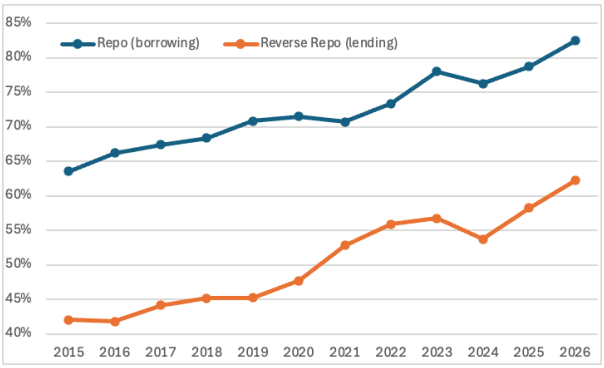
increase in a stress event in which dealers were forced to rapidly expand their balance sheets. The result would be a shorter-dated repo market more prone to run risk and operational issues of the type that arose in March 2020 (Menand and Younger, 2023).



(a) Gross hedge fund repo versus gross sponsored service volumes (LHS; both in $bn) and the ratio of the two (RHS; %).



(b) Netting efficiency for money center banks, former broker/dealers, and custody banks over three time periods.



(c) Fraction of repo (borrowing) and reverse repo (lending) held by primary dealers.

Figure 7: Repo spreads versus total repo exposure among hedge funds in $bn
Source: DTCC, SEC Private Funds Statistics, FRBNY Primary Dealer Statistics

6.2 SOFR swaps

The rise of sponsored repo has interacted positively with changes to the structure and conventions of derivatives markets. For the first forty years or so since they were first traded in the early-1980s, interest rate swaps referenced the London Interbank Offered Rate (LIBOR). LIBOR was designed to track short-term unsecured rates for interbank borrowings among Eurobanks in London, but gradual evolved into a much more broadly used interest rate benchmark. Then, when it was revealed that some quotes submitted by Libor panelists were manipulated to their benefit, global regulators decided to transition to a transactions-based risk-free benchmark. In the United States, LIBOR was replaced with the Secured Overnight Financing Rate (SOFR)

Index (see Alternative Reference Rates Committee, 2023, and references therein).

SOFR is designed to track overnight financing rates in the Treasury repo market (Logan, 2018). The headline index represents a volume-weighted and clipped median across the rate at which hedge funds borrow (general collateral, or GC rates) and the rate and money market funds (MMFs) lend (triparty rates using the Tri-Party General Collateral Rate (TGCR), produced as part of the SOFR index calculation; for details on this taxonomy and the structure of the repo market, see Copeland et al., 2010, 2015; Baklanova et al., 2015; Inter-Agency Working Group for Treasury Market Surveillance, 2021; Treasury Market Practices Group, 2025). In practice, however, SOFR is more reflective of the later than the former. We can quickly validate this assertion by looking at regression statistics of daily changes in GC/SOFR, GC/TGCR, and GC/EFFR spreads. We have data going back to August 2014, including simulated SOFR and TGCR data provided by Bowman (2019) (formal index production began on April 2, 2018). Including all available data (August 2014 to March 2026), daily changes in GC/TGCR and GC/SOFR spreads have an $R^2 = 86\%$ and slope of 0.84; GC/SOFR and GC/EFFR spreads have an $R^2 = 27\%$ and slope of 0.24. Including only data from January 2021 to March 2026, daily GC/TGCR and GC/SOFR spreads have an $R^2 = 89\%$ and slope of 0.96; GC/SOFR and GC/EFFR spreads have an $R^2 = 45\%$ and slope of 0.41. This bias in the index fixing is a result of using a volume-weighted and clipped median in the context of a bi-modal distribution. Given the constituent rules, the triparty component of the distribution consistently dominates on a volume-weighted and and the SOFR index generally picks up that mode. That makes GC/SOFR spreads a good proxy for GC/triparty, or the bid/ask spread of matched-book repo intermediation.

Since the launch of SOFR in April 2018, the interest rate swaps market has also been transitioned to a predominantly SOFR-indexed market (Williams, 2019; Logan, 2018; Alternative Reference Rates Committee, 2023). This process began in earnest with a supervisory letter from the three main banking regulators in the United States setting a hard deadline for banks under their charge to suspend trading in Libor-indexed derivatives. It was then pushed forward more aggressively by the " Big Bang" discounting switch at the major derivatives CCPs (LCH Ltd., 2020). By 2022, the overwhelming majority of USD interest rates swaps were indexed to SOFR.

Swap spreads, in turn, have also transitioned to a SOFR standard.[9] That means swap spreads in recent years can be thought of as a GC/triparty proxy and excess returns reflect expectations for the bid/ask spread of matched-book repo intermediation rather than the relative cost of secured versus unsecured borrowings (i.e., GC/EFFR or GC/Libor). Trading swap spreads as a proxy for bid/ask in repo markets is a much cleaner expression of the underlying arbitrage and less exposed to orthogonal risks such as interbank credit

[9]We use EFFR-linked OIS in the above empirical analysis to ensure we have a smooth series going back as far as possible with a consistent underlying swap index. Although SOFR/EFFR can be volatile at times in overnight interst rates, differences in par rate between SOFR- and EFFR-linked OIS are much more stable.

or the nuances of the federal funds market (Afonso and Lagos, 2015; Afonso et al., 2011, 2019, 2023). It has also coincided with less volatility in intermediation costs, owing in large part to increased prevalence of cleared repo described in §6.1.

6.3 Cross-Margining and the Mitigation of Margin Spirals

One useful contribution of our model is that it naturally explains margin spiral in which rising volatility begets higher margin requirements, essentially increasing hedge fund tightness and forcing more de-levering. Unsurprisingly, our model isolates $d\gamma/d\nu$ as a key driver of such spirals. This logic formalizes an intuitive observation others have made previously: that migitating the volatility of margin requirements for fixed income relative value positions can improve the resilience of the Treasury market.

One key development towards this end is exanded access to cross-margining of Treasury futures basis positions. Cross-margining between the CME (a futures CCP) and the Fixed Income Clearing Corporation (FICC, a repo and cash CCP and a subsidiary of DTCC) involves resource-sharing arrangements that allow offsetting exposures on the two CCPs to be netting for the purposes of sizing margin on an overall portfolio. For relative value trades with a long and short leg, this reduces and stabilizes margin relative to separate arrangements (Younger, 2021; Yadav and Younger, 2025). The financial stability benefits cross-margining in equity markets—specifically between futures and options facing different CCPs—was in fact one of the primary recommendations by regulators after the 1987 Black Monday market crash (Presidential Task Force on Market Mechanisms, 1988; U.S. General Accounting Office, 1990). The CME/FICC program has been available for some time, but until recently was narrowly focused on direct members. Starting two years ago, it was expanded to include proprietary ("house") positions of joint CME/FICC clearing members and certain eligible affiliates. More recently, CME and FICC have sought to extend the same offering to customer positions(CME Group, 2026a; Fixed Income Clearing Corporation, 2025a; CME Group, 2025).

Historically, the main restrictions were legal and accounting-based. The existing cross-margining framework was designed for joint clearing members and certain affiliates because the CCPs needed visibility into their full set of exposures in the event of a default (Chicago Mercantile Exchange Inc. and Fixed Income Clearing Corporation, 2025; Fixed Income Clearing Corporation, 2025b). Extending that treatment to customer positions ran into the separation between securities and futures customer protection regimes: in particular, SEC Rule 15c3-3 and the broker-dealer customer protection framework on the securities side, and CEA customer segregation requirements on the futures side (Securities and Exchange Commission, 2026; Commodity Futures Trading Commission, 2025a). As a result, customer positions could not simply be folded into the proprietary cross-margining arrangement without exemptive relief and a new legal structure gov-

erning how the positions and collateral would be carried, pledged, and protected (Securities and Exchange Commission, 2026; Commodity Futures Trading Commission, 2025a; Chicago Mercantile Exchange Inc. and Fixed Income Clearing Corporation, 2025).

Regulators are now actively trying to address those frictions. On the SEC side, the Treasury clearing rules noted above are an important step (Uyeda, 2025; U.S. Securities and Exchange Commission, 2025b). Further, FICC and CME have applied for exemptive relief to permit certain customer positions and associated collateral to be held in a futures account structure for purposes of cross-margining, and FICC filed related rule changes to implement a customer cross-margining arrangement (Securities and Exchange Commission, 2026; Fixed Income Clearing Corporation, 2025b). The Commodity Futures Trading Commission (CFTC) has provided the limited exemptive relief needed to expand the CME–FICC cross-margining program to certain customers, explicitly as part of Treasury market reform and implementation of the SEC clearing mandate (Commodity Futures Trading Commission, 2025b,a).

Expanded cross-margining as proposed may include hedge funds, but only indirectly and subject to eligibility limits. Under the current proposal, customer cross-margining would be available to customers of joint FICC/CME clearing members that are dually registered as broker-dealers and futures commission merchants ("BD-FCMs") (Commodity Futures Trading Commission, 2025a; Securities and Exchange Commission, 2026). In practice, that includes all major securities dealers. The BD-FCM could then pass along the margin savings to their customers when and where appropriate (Fixed Income Clearing Corporation, 2025b).

That said, the current cross-margining program is focused on futures and Treasury securities and does not include cleared interest rate swaps (Chicago Mercantile Exchange Inc. and Fixed Income Clearing Corporation, 2025; Commodity Futures Trading Commission, 2025a). Therefore, while beneficial for cash–futures basis trading, cross-margining for swap spreads would require a separate process with considerable coordination, regulatory review, and approval to operationalize any program (Commodity Futures Trading Commission, 2025a; Securities and Exchange Commission, 2026). One recent and promising development is CME's establishment of CME Securities Clearing as a separate SEC-registered securities clearing agency. The stated goal of that program is to more seamlessly offer cross-margining against other products within the CME ecosystem, including interest rate swaps (CME Group, 2026b). That said, this process remains ongoing, and the timeline for the build-out itself as well as regulatory review and approvals is uncertain (CME Group, 2026b; Commodity Futures Trading Commission, 2025b).

6.4 Rethinking the Role of the SLR

This work also casts new light on the role of the SLR in Treausry market functioning. The SLR is perhaps the most prominent of hte various various mechanisms blamed for episodes of fragility. As early as 2016, Bill Dudley, President of the Federal Reserve Bank of New York, described the SLR as one of the "most important" changes to Treasury markets since the GFC (Dudley, 2016). Since they, numerous policy makers have pointed to the unintentional consequences of binding leverage constraints as a primary driver of dysfunction and a critical issue to address through regulatory reform (see e.g., Bowman, 2025).

To that end, in 2025 the Fed set about adjusting the SLR to ensure if was much less frequently a binding constraint (Powell, 2025). The result incorporated tailoring through linking minimum leverage ratios to other measure of systemic risk to ensure it remained a backstop (Board of Governors of the Federal Reserve System, 2025). This had the effect of reducing minimum ratios and significant increasing overall balance sheet capacity among the largest securities dealers.

The results were far from definitive, however. Swap spreads and other measures of relative value and intermediation capacity in Treasury markets barely reacted to the implementation of the new rule in 2026. That is arguably a cleanner test of the impact of leverage ratios than the temporary suspension of the SLR during the Covid pandemic (although those authors do come to that conclusion; e.g., Cochran et al., 2023; Chabot et al., 2024).

In our model, however, shadow costs for marginal dealer balance sheet allocated to Treasury relative value positions (i.e., κ) is but one of several mechanisms. As noted earlier, the key parameters determining the clearing price of risk associated with warehousing Treasury collateral represent a blend of both hedge funds and dealers. There are many scenarios in which $d\Pi_s/d\kappa$ is small compared to other sensitivities. Our empirical results suggest there is some connection, but the loading is much weaker in recent years that over the full time period. This is all to suggest that our model points towards a more fundamenetal source of frictions to arbitrage in the Treasury market the rising important of demand from levered investors in ensuring the market clears. That results should further temper hopes that targetted regulatory changes can restore the market to something resembling its pre-GFC (or even pre-2015) dynamics.

6.5 Tiering Remuneration of Reserves

Another area of focus in policy circles has been monetary policy implementaion. Since the Global Financial Crisis (GFC), interest rate control has been maintained primarily by the use of administered interest rates. The first, introduced in the fall of 2008, is interest on reserve balances (now referred to as IORB; previously interest on excess reserves, or IOER) which is paid to commercial banks and certain other eligible financial

institutions with deposits at Federal Reserve banks. The second is the rate at the Overnight Reverse Repo Facility (ON-RRP) which is paid to eligible MMMFs using SOMA holdings of Treasury securities as collateral. While the *de faco* policy implementation framework for more than a decade after 2008, this arrangement was formalized in 2019 as an ample reserves regime (see Hughes and Younger, 2026, and references therein).

Recently, there has been a fair amount of debate over the desirability of ample reserves, specifically the remuneration of bank deposits. Some of those commentaries discuss the political economy of IORB in particular as a source of value to U.S. commercial banks (Hughes and Younger, 2026). Others focus on the size of the Fed's balance sheet more broadly, with a goal of reducing both the market's reliance on the Fed as a source of demand for government debt and banks' over reliance on reserves as a source of liquidity (see e.g., Warsh, 2025; Bessent, 2025; Nelson, 2024; Nelson et al., 2026; Nelson, 2026).

The Fed and others have repeatedly warned that shrinking the balance sheet quickly or simply removing IORB would be highly disruptive to financial markets (English and Kohn, 2026, 2025; Reuters, 2025). One intermediate solution that has been proposed is tiering the remuneration of reserves. In this framework, some proportion of reserve balances would continue to earn IORB while the remainder would earn a lower rate (or be non-interest bearing). Those thresholds could be chosen by the Fed itself, or by the banks in close coordination with their supervisors in a process analogous to stress testing (Duffie et al., 2026; Hughes and Younger, 2026). Both would have the effect of rendering a portion of reserve balances non-interest bearing.

What would happen to those lower yielding reserves? The banks could lend more reserves directly via the repo market. They have, in fact, been quite active in doing so when repo rates are materially about IORB (Clouse et al., 2025; Gissler, 2025; Logan, 2025; Levy and McCormick, 2026). Were a significant proportion of their balances to be below the fully remunerated tier, they would be strongly incentivized to do so even at lower rates. Alternatively, banks could attempt to "push out" excess reserves, presumably to MMMFs and other non-banks offer cash alternatives. Those MMMFs would then likely deploy a significant fraction of those inflows in repo as well as short-dated Treasury securities (bills and aged coupon securities with less than eighteen months remaining maturity, consistent with SEC Rule 2a-7; see U.S. Securities and Exchange Commission, 2023, and references therein). Both would have the effect of increasing supply to the repo market (i.e., increasing its capacity at a fixed price) and supporting more stability in levered demand for Treasury securities. In other words, tiering can address the supply of cash to the repo market while other reforms (e.g., cleared repo) can address the cost and other frictions for intermediating that cash to hedge funds.

As an aside, recent history also shows that large banks are quite capable of pushing out deposits in response to regulatory incentives. A good case study to this point is the implementation of the Liquidity Coverage Ratio in the U.S. (LCR; Basel Committee on Banking Supervision, 2013; Board of Governors

of the Federal Reserve System et al., 2014). The LCR mandated large banks to hold high-quality liquid assets (HQLA)—including reserves as well as Treasury securities and government-backed mortgage-backed securities as well as other assets (subject to a haircut based on liquidity and credit quality)—to cover stressed outflows over a 30-day horizon. For each bank, those outflows are calculated based on the composition of their liabilties, with more runnable funding receiving a higher weight.in the final outflow calculation (Ihrig et al., 2017; Yankov, 2020). Among the various deposit types, non-operational wholesale deposits–meaning institutional balances not required for clearing, custody, or operational payment services (i.e., inactive cash)–were given a much higher weight than operational wholesale and retail deposits. Non-operational deposits also tend to be remunerated at a much higher rate than other deposit types–in other words, they have a higher deposit β (see Hughes and Younger, 2026, and references therein). To avoid having to holdg low-yielding HQLA against high-yielding non-operational deposits, U.S. banks were highly incentivized to simply push those deposits out to smaller banks which are not in scope for LCR or to MMMFs.

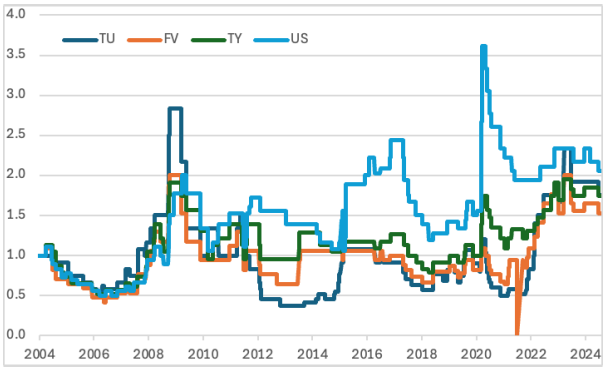
For the most part, they were successful in doing so. The banks themselves were, in fact, quite in doing so, with J.P. Morgan in particualrly taking a fairly heavy-handed approach (Rapoport and Rexrode, 2015; Glazer, 2015; Levine, 2015). Later research shows that they did manage to significantly reduce their exposure to non-operational deposits shortly after the rule became effective (Ihrig et al., 2017). The implication is that banks can and do react to regulatory incentives in structuring their liability stack, and would likely reduce their exposure to lower-value deposits to shed non-interest bearing reserves if remuneration were to be tiered.

6.6 Treasury Debt Management Strategy

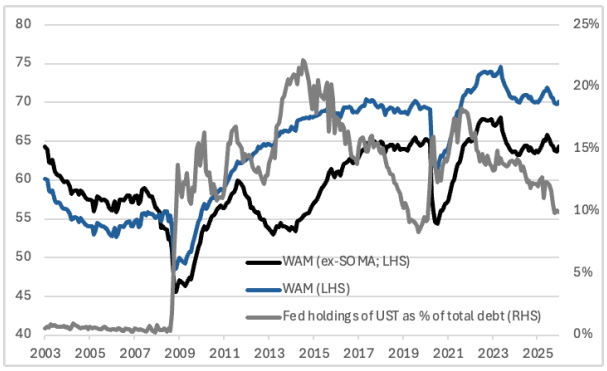
Finally, we turn to the Treasury debt management strategy. As noted above, the empirical results in §4 suggest that the maturity structure of Treasury debt is more impactful on swap spreads than its net supply. That should remain the case so long as repo market structure can supply sufficient leverage–which appears to be the case currently and could remain so over the medium term. The WAM, however, is another potentially potent policy lever for maintaining the resilience of the Treasury market.

As a quick review, our model suggests that hedge funds generally require greater compensation to hold Treasury collateral in relative value trades the price of which is more volatile. To the extent that they are the marginal price-setter, as appears to have been the case for some years now, the result is a steeper term structure of swap spreads. Further, long-dated swap spreads exhibit not only higher levels of volatility than shorter tenors but also higher volatility of volatiltiy ("vol-of-vol").

In other words, when overall volatility rises, it tends to rise proportionally more so in longer maturities.



(a) IM for various CME Treasury futures contracts (normalized to 1 as of Jan 2004)



(b) Treasury Debt WAM excluding and inclusive of SOMA holdings (months)

Figure 8: Margin volatility and Treasury debt WAM

That can, in turn, feed into more violent margin spirals in longer maturities. In the language of our model, $d^2\gamma/d\nu d\tau > 0$. We can see this in practice by using Treasury futures as an analogy (for which we have data from CME, and which, as mentioned earlier, follow a similar margining methodology to swaps). Taking the spring of 2020 and inflation as a case study, we find that margin on the Ultra-long Treasury futures contract (WN) increased much more so than then shorter maturities (i.e., TY and US versus TU and FV; Figure 8a).

The upshot of this is three-fold. First, Treasury pays a greater premium relative to derivatives when borrowing in longer tenors when its WAM is longer. That is, unsurprisingly, true in longer maturities. But by steepening the overall term structure of swap spreads, longer Treasury debt WAMs increase costs to the taxpayer across the curve. Second, longer maturity relative value positions are more at risk of rapid delevering and margin spirals. By implication, reducing the volume of collateral supply in longer maturities–i.e., reducing the WAM of the debt–the Treasury can reduce overall market exposure those more fragile exposures. Finally, the slope and intercept of the swap spread curve suggests that the market is relying ever more on maturity transformation facilitated by hedge funds. In other words, there is sufficient demand for collateral but not sufficient demand for duration to absorb Treasury debt. Increasing the proportion of the debt funded in Treasury bills–i.e., in cash equivalents–is one way to better align debt management with market needs.

7 Conclusion

This paper develops a framework for interpreting Treasury swap spreads as the equilibrium price of intermediary balance-sheet capacity in the U.S. Treasury market. The analysis yields three main results.

First, we present a tractable model linking swap spreads to the distribution of risk-bearing capacity across financial intermediaries. Treasury securities are absorbed by a combination of unlevered investors and leveraged intermediaries (incldluing hedge funds and securities dealers) who are subject to various constraints

including risk appetite, access to risk capital, margin requirements, and shadow balance sheet costs. Swap spreads therefore represent the compensation required for intermediaries to warehouse Treasury collateral in relative value structures that bear no outright interest-rate risk. In equilibrium, spreads reflect both the tightness of intermediary balance sheets and the reservation premia required for intermediaries to allocate scarce resources to Treasury relative-value trades.

Second, the model demonstrates a clear relationship between Treasury supply and the maturity structure of swap spreads. Absorbing additional supply requires leveraged investors to expand relative-value positions, but arbitraging longer-maturity spreads exposes those investors to greater risk. As a result, they demand greater compensation to warehouse Treasury collateral at longer maturities.

Third, we present empirical evidence to support the model. Using data from 2003–2025, the maturity slope of swap spreads is closely related to realized volatility, the maturity composition of Treasury debt, and measures of dealer balance-sheet capacity. Short-horizon issuance expectations, by contrast, have limited explanatory power for variation in the slope. These findings suggest that the resilience of the Treasury market depends less on the level of government debt itself than on the capacity of leveraged intermediaries to intermediate that supply.

Recent episodes of Treasury market stress illustrate these dynamics. During the market turmoil of March 2020, rapid deleveraging by hedge funds engaged in Treasury relative-value trades produced sharp dislocations, including both the cash–futures basis and swap spreads. More recently, the volatility surrounding the April 2025 "Liberation Day" tariff announcement generated a similar pattern as rising volatility tightened intermediary constraints and steepened the swap-spread curve. During both episodes, market dislocations reflected limits to the capacity of the financial system to warehouse Treasury risk.

Our results highlight the increasingly central role of leveraged intermediaries in clearing the Treasury market. They also illustrate that while regulatory constraints are an important driver and consideration, they are not the only factor. In fact, the average label and term structure of swap spreads is little changed since the implementation new regulations designed to reduce the impact of leverage constraints. Our model helps to explain why relaxing those constraints did little to change the pricing of Treasuries relative to derivatives, and likely did not significantly improve Treasury market resilience.

The framework developed in this paper suggests several implications for policymakers concerned with Treasury market resilience.

First, the maturity slope of swap spreads can serve as a forward-looking, market-based indicator of tightening intermediary capacity. Traditional liquidity measures—such as bid–ask spreads or price impact—often deteriorate only after market functioning has already weakened. Movements in the swap-spread curve can instead signal rising balance-sheet constraints before those constraints metastasize into broader market dys-

function.

Second, policies that influence the elasticity of leverage supply play an important role in determining how Treasury supply shocks are transmitted into financial markets. Repo market structure, the availability of central clearing, and the treatment of Treasury-related activities in bank capital and leverage regulations all affect the willingness of intermediaries to warehouse Treasury collateral.

Third, the maturity composition of Treasury issuance interacts with intermediary constraints. Because longer-duration securities expose intermediaries to greater mark-to-market risk, increases in the weighted average maturity of Treasury debt can raise the compensation required for leveraged investors to absorb supply. Longer maturity swap spreads are also more at risk to margin spirals. Debt management decisions therefore interact with the structure of financial intermediation in shaping Treasury market resilience.

Fourth, structural changes within the hedge fund industry may influence the stability of Treasury market intermediation. The growth of multi-manager hedge fund platforms with centralized risk allocation and mechanical de-risking rules may make hedge fund demand more sensitive to volatility shocks. When volatility rises, these institutions may reduce risk rapidly, reducing the elasticity of intermediary demand precisely when the market most needs it.

Taking a step back, this paper suggests that the maturity structure of swap spreads contains useful information about intermediary constraints and the current health of a Treasury market increasingly reliant on levered demand. When intermediary balance sheets remain elastic, increases in Treasury supply can be absorbed without large changes in expected returns across maturities. When volatility rises or balance-sheet costs become binding, however, the compensation required to warehouse Treasury collateral increases more rapidly at longer maturities, steepening the swap-spread curve. By implication, finding ways to restructure markets and provide regulatory incentives aimed at maintaining that elasticity is critical to the resilience of the Treasury market. And, along the way, the maturity structure of swap spreads is a good early warning indicator of fragility and the risk of dysfunction.

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