STAFF
REPORTS

NO. 1146
APRIL 2025

U.S. Treasury Market Functioning from the GFC to the Pandemic

Tobias Adrian | Michael Fleming | Kleopatra Nikolaou

FEDERAL RESERVE BANK *of* NEW YORK

U.S. Treasury Market Functioning from the GFC to the Pandemic

Tobias Adrian, Michael Fleming, and Kleopatra Nikolaou

Federal Reserve Bank of New York Staff Reports, no. 1146
April 2025
https://doi.org/10.59576/sr.1146

Abstract

This article examines U.S. Treasury securities market functioning from the global financial crisis (GFC) through the Covid-19 pandemic given the ensuing market developments and associated policy responses. We describe the factors that have affected intermediaries, including regulatory changes, shifts in ownership patterns, and increased electronic trading. We also discuss their implications for market functioning in both normal times and times of stress. We find that alternative liquidity providers have stepped in as constraints on dealer liquidity provision have tightened, supporting liquidity during normal times, but with less clear effects at times of stress. We conclude with a brief discussion of more recent policy initiatives that are intended to promote market resilience.

JEL classification: G12, G24, G28
Key words: intermediation, liquidity, regulation, market structure, Treasury securities

---

Fleming: Federal Reserve Bank of New York (email: michael.fleming@ny.frb.org). Adrian, Nikolaou: IMF (emails: tadrian@imf.org, knikolaou@imf.org). The authors thank Henry Dyer for excellent research assistance.

1. INTRODUCTION

US Treasury securities serve as a benchmark in global capital markets because of their exceptional creditworthiness and liquidity. The securities are used to manage interest rate risk, price other securities, collateralize financing transactions, implement monetary policy, and as a reserve asset. All these roles are foundational for global capital markets and depend on Treasury securities' high liquidity. Investors tend to pay a premium for Treasuries because of their liquidity, leading to lower yields and hence lower US government borrowing costs (e.g., Amihud & Mendelson 1991, Longstaff 2004, and Krishnamurthy & Vissing-Jorgensen 2012). Liquidity is a key attribute of US Treasury securities that is closely linked to the securities' pricing and popularity.

The US Treasury market's liquidity has been called into question by the 2007-09 global financial crisis (GFC), post-crisis regulatory changes, and the increasing role of principal trading firms (PTFs) in the market. Nguyen et al. (2020) characterize the liquidity disruptions in the most actively traded Treasuries during the GFC and Musto, Nini & Schwarz (2018) explore the unusual pricing discrepancies that arose among less actively traded securities. Adrian et al. (2017) describe the post-crisis regulatory changes and how they may have affected liquidity in dealer-intermediated markets such as the Treasury market. The Joint Staff Report (2015) on the US Treasury market examines the October 15, 2014 flash rally in the Treasury market and shows that PTFs now account for most activity in the so-called interdealer market.

Covid-19-related developments in March 2020 exacerbated concerns about US Treasury market functioning as massive customer selling (the so-called dash-for-cash) overwhelmed dealers' capacity to intermediate trades (Duffie 2020). Market liquidity deteriorated to its worst level since the GFC (Fleming & Ruela 2020) and pricing dislocations arose among Treasuries with similar cash flows and between cash Treasuries and Treasury futures (Duffie 2020, Schrimpf, Shin & Sushko 2020). The disruptions caused the Federal Reserve to initiate massive asset purchases – and to engage in a range of other initiatives – to restore market functioning (Vissing-Jorgensen 2021).

The Covid-related disruptions spurred calls by academics and policymakers to make the Treasury market more resilient (e.g., Duffie 2020, Liang & Parkinson 2020, Brookings 2021, and Group of Thirty 2021). Many of the policy efforts have been led by members of the Interagency Working Group on Treasury Market Surveillance (IAWG) and described in a series of annual reports (see IAWG 2021, 2022, 2023, and 2024). Significant steps to date to improve Treasury market resilience include the launch of a standing liquidity backstop, improved market transparency, and the approval of rules to promote increased central clearing of trades.

This paper assesses US Treasury market functioning given the recent market developments and associated policy responses. We first review the market's structure and some of the past work on the market's liquidity. We then describe factors that have meaningfully affected liquidity provision since the GFC and discuss the effects of these changes for market functioning in both normal times and times of stress. We conclude with a discussion of policy implications, including recent policy initiatives that are intended to promote market resilience.

2. MARKET STRUCTURE AND LIQUIDITY

2.1. Market Structure

US Treasury securities are sold in the primary market through single price auctions. While the auctions are open to all investors, primary dealers – dealers with a trading relationship with the Federal Reserve Bank of New York – play a special role. Some primary dealers are subsidiaries of bank holding companies, while others are non-bank security-broker dealers. These dealers have an obligation "to bid on a pro-rata basis in all Treasury auctions at reasonably competitive prices," thereby ensuring that the entire issue is sold at a reasonable price.[1] Other investors—including investment funds and foreign monetary authorities—participate in the auctions either directly, or indirectly through primary dealers as intermediaries.

Secondary trading in Treasury securities occurs in a multiple-dealer over-the-counter market. Trading takes place around the clock during the week, although most of the trading takes place during New York trading hours, roughly from 7:30 a.m. to 5:00 p.m. eastern time (Fleming 1997). The primary dealers are the principal market makers, buying and selling securities from customers for their own accounts at their quoted bid and ask prices. Dealer trading with customers occurs either directly via phone or instant messaging, or indirectly through request-for-quote (RFQ) platforms.

In addition to trading with their customers, the dealers trade among themselves, primarily through interdealer brokers (IDBs). The IDBs offer the dealers proprietary electronic screens or trading platforms that post the best bid and offer prices of the participating dealers, along with the associated quantities bid or offered (minimums are $5 million for bills and $1 million for notes and bonds). When a trade is executed, IDBs post the resulting trade price and size. IDBs thus facilitate risk transfer and information flows while providing anonymity to their clients.

A notable development in the market's structure is the migration of interdealer activity from voice-assisted brokerage to electronic platforms, which were introduced to the market in 1999 (Mizrach & Neely 2006). With voice-assisted brokerage, dealers post orders and execute trades by calling the brokers. In contrast, electronic platforms automate and speed up the trading process by matching buyers to sellers without human intervention. Nearly all interdealer trading of on-the-run securities occurs via these electronic platforms (Barclay, Hendershott & Kotz 2006).

Around 2005 the electronic platforms opened access to non-dealer participants, including hedge funds and PTFs. Table 3.3 (p. 59) in the Joint Staff Report (2015) shows that PTFs account for 56% of trading volume in the on-the-run 10-year note, compared to bank-dealers' share of 35%, with the remaining 9% split among non-bank dealers and hedge funds. PTFs trade for their own account, often using high-frequency, algorithmic trading strategies, and, unlike dealers,

[1] Primary dealers are also expected to "participate in open market operations consistently and competitively," "make markets for the New York Fed on behalf of its official accountholders," and "provide ongoing insight into market developments." Dealer expectations and requirements are posted on the New York Fed's website at https://www.newyorkfed.org/markets/primarydealers.html.

generally carry little inventory overnight.

While this paper's focus is on the functioning of the cash market for US Treasury securities, there is also a highly liquid sale and repurchase market (repo market) for Treasuries, where the securities are used as collateral to facilitate short-term borrowing, and a futures market, where the securities are traded for future delivery. The cash, futures, and repo markets are highly interconnected via arbitrage, which ensures price consistency across them, but which can also facilitate the transmission of shocks. In 2024, daily Treasury repo market financing averaged more than $5 trillion and daily US Treasury futures trading averaged about $775 billion in notional value, compared to roughly $900 billion of daily trading volume in the US Treasury cash market.[2]

2.2. Market Functioning

2.2.1. The primary market. Academic work on the functioning of the primary US Treasury market has focused on the relationship between primary and secondary market prices as well as on secondary market prices around auctions. Treasuries tend to be sold in the primary market at prices lower than the contemporaneous prices in the secondary, when-issued market, as documented by numerous studies including Cammack (1991), Spindt & Stolz (1992), and Simon (1994). Other research characterizes auctions as predictable supply shocks and shows how they cause secondary market prices of similar securities to decline in the days preceding auction and increase in the days thereafter (Lou, Yan & Zhang 2013).

Primary market functioning is also often assessed through various auction metrics, although they can be harder to interpret. The bid-to-cover ratio gauges the quantity of bids submitted relative to the offering amount, with a higher bid-to-cover suggesting greater demand. The auction tail — typically defined as the spread between the auction high and the median yield — provides a gauge of the dispersion of accepted yields and whether the Treasury Department needed to accept appreciably less competitive bids to sell the offered amount. The allocation of an issue across investor classes is also used as a proxy of auction strength, with higher dealer participation suggesting that other market participants were less willing to bid aggressively.

2.2.2. The secondary market. In the secondary market, the availability of transactions and order book data have allowed analysis of direct market liquidity measures, including bid-ask spreads,

[2] Cash market volume of $908 billion is calculated from data reported to TRACE and published in the Financial Industry Regulatory Authority's Daily Treasury Aggregate Statistics. Futures volume of $774 billion is calculated from numbers reported in the CME Group's Monthly Volume Report. Overall Treasury repo market financing is not known precisely but averaged $2.6 trillion in the tri-party/general collateral finance segment in 2024 based on data from the New York Fed and $2.0 trillion in the cleared delivery-versus-payment segment based on data from the Office of Financial Research (with the latter number including a small share of transactions with non-Treasury collateral). The preceding numbers exclude the sizable non-centrally cleared bilateral repo segment (see Hempel et al. 2022), suggesting an overall market size exceeding $5 trillion.

order book depth, and price impact. Several studies analyze price formation and liquidity around macroeconomic announcements (e.g., Fleming & Remolona 1999) or other events (e.g., Fleming & Krishnan 2012 and Fleming 2020). Other studies examine liquidity over time using order book data (e.g., Fleming 2003, Chordia, Sarkar & Subrahmanyam 2005, Nguyen et al. 2020, and Adrian et al. 2017). Adrian, Fleming & Vogt (2023) assess the evolution of Treasury liquidity using over 30 years of limit order book data.

Figure 1 plots the aggregated liquidity index of Adrian, Fleming & Vogt (2023) from 2005 to 2024.[3] The index is based on average daily bid-ask spreads, average daily order book depth at the inside bid and offer prices, and daily price impact measures for the on-the-run two-, five-, and ten-year notes. After taking the negative of log depth (so that higher values indicate worse liquidity for all series), the nine series are standardized to mean 0 and standard deviation 1 and then averaged. The figure plots the five-day moving average of the index, standardized for the plotted sample period.

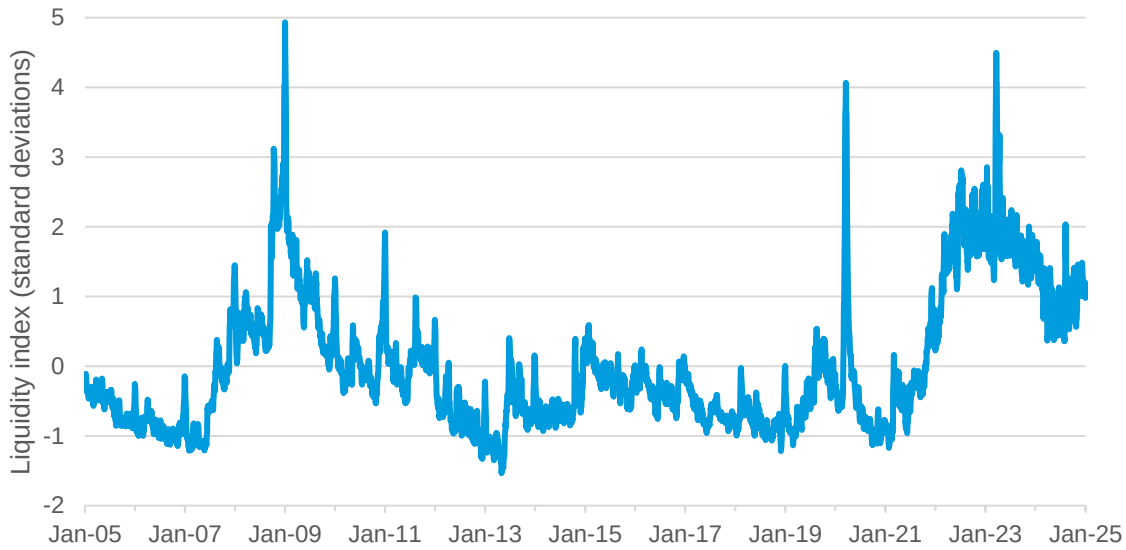

Figure 1
Evolution of Treasury market liquidity. This figure plots the aggregate Treasury market liquidity index of Adrian, Fleming & Vogt (2023) from January 2005 to December 2024. The index is based on average daily bid-ask spreads, average daily order book depth at the inside bid and offer prices, and daily price impact measures for the on-the-run two-, five-, and ten-year notes. After taking the negative of log depth (so that higher values indicate worse liquidity for all series), the nine series are standardized to mean 0 and standard deviation 1, and then averaged. The figure plots the five-day moving average of the index, standardized for the plotted sample period.

[3] The paper uses order book and transactions data from voice-assisted IDBs (via GovPX) from 1991 to 2000 and from a fully electronic IDB (BrokerTec) from 2001 to 2024. We plot the index for the shorter 2005-24 sample period here so that the plotted data are all from the same source (that is, without a series break) and because market coverage of the data source was less thorough in the 2001-04 period.

The index shows that market liquidity worsened markedly during the GFC. After recovering in the years after the crisis, liquidity deteriorated abruptly during the mid-2013 taper tantrum, when the Federal Reserve suggested that it might soon start reducing the pace of its asset purchases, and again following the October 15, 2014 flash rally. Liquidity then worsened to its worst levels since the GFC during the March 2020 dash-for-cash. Liquidity again deteriorated around the start of the Fed's policy rate tightening cycle in March 2022, and around the regional banking failures in March 2023.

Note that US Treasury market liquidity measures are typically calculated for on-the-run securities using data from the IDB market. This largely reflects data availability. Order book data are only available for the IDB segment of the market. Moreover, it is only the on-the-run notes and bonds that trade on the electronic IDBs. Off-the-run securities trade on the voice IDBs, directly between dealers, and in the dealer-to-customer market.[4] That said, the interdealer market "is critical to the intermediation process," "serves as an important source of price discovery in Treasuries" (Logan 2020), and accounts for roughly half of all activity in the market (Brain et al. 2018).

While order book data are not available for off-the-run Treasuries, the increased availability of transactions data makes the assessment of liquidity for such securities increasingly possible. Since the advent of Treasury TRACE in July 2017, transactions data for all Treasuries has been reported by dealers and available to the official sector. Duffie et al. (2023) show that liquidity measures generated from such data for off-the-runs are broadly consistent with measures calculated from order book data for on-the-runs. Moreover, indicative bid-ask spreads for off-the-runs seem informative, depending on their source, with Clarida, Duygan-Bump & Scotti (2021) showing that off-the-run indicative spreads widened more sharply than on-the-run firm (and indicative) spreads in March 2020, but exhibit a similar pattern over time.

Given the historical scarcity of data with which to measure Treasury market liquidity directly, liquidity proxies are often considered, including a yield curve noise measure (Hu, Pan & Wang 2013) and the on-the-run/off-the-run spread (e.g., Furfine & Remolona 2002). The noise measure captures the dispersion of market yields around a smoothed yield curve and is meant to gauge the quantity of arbitrage capital engaging in relative value trades. The on-the-run/off-the-run spread measures the yield difference between an on-the-run security and an off-the-run security with similar cash flows and captures the yield investors forego in order to hold the more liquid on-the-run issue, as well as any differences in security borrowing costs (e.g., Krishnamurthy 2002, Vayanos & Weill 2008, and Pasquariello & Vega 2009). While these proxies correlate with the liquidity index of Adrian, Fleming & Vogt (2023), there are some differences, particularly in times of stress.

[4] While off-the-run as well as on-the-run securities are hence analyzed in studies that use data from the voice IDBs via GovPX, including Elton & Green (1998), Brandt & Kavajecz (2004) and Pasquariello & Vega (2009), market coverage of the voice IDBs declined sharply around 2000 as the electronic IDBs gained market share.

2.2.3. The repo and futures markets. Measures for the repo and futures market segments are less widely used to gauge US Treasury market liquidity. Repos with Treasury collateral constitute the majority of repo trades, but the nature of the repo market as a funding market implies that tensions in this market are typically linked to liquidity shortages in the financial system (e.g., Afonso et al. 2021), rather than liquidity challenges in the U.S. Treasury market.

Moreover, data availability poses significant challenges to the understanding of repo market liquidity. Repo trades take part in different market segments, which are intermediated by dealers.[5] The largest segment, consisting of bilateral trades between dealers and asset managers or hedge funds, is the most opaque, although there are efforts underway to collect data for this segment as discussed in Section 5.3. Repo activity and price metrics are available for other segments, but provide an incomplete view into the workings of the overall market.

Finally, the U.S. Treasury futures market is linked to the cash and repo markets via arbitrage. Arbitrage strategies are often the focus of research when examining the resilience of the Treasury market. For example, the rise in arbitrage positions between the cash and the futures market prior to the pandemic was largely supported by hedge funds increasingly leveraged positions in the repo market and likely contributed to the tensions in the cash market during the pandemic (Barth & Kahn 2021; Kruttli et al. 2021; Banegas & Monin 2023). While the futures market offers good transparency in terms of data, the riskiness and dynamics of leveraged trades remain opaque as discussed in Section 3.3.3 (Barth, Kahn & Mann 2023).

3. DRIVERS OF INTERMEDIATION CHANGES

3.1 Postcrisis Regulatory Framework

3.1.1. Changes in the framework. The regulatory landscape for financial institutions tightened significantly in the aftermath of the GFC, with a focus on enhancing capital, liquidity, and transparency of financial institutions. Major US dealers, previously largely outside the regulatory perimeter, became bank holding companies (BHCs), or affiliated with BHCs through mergers. Major dealers were thus drawn into the regulatory frameworks of BHCs and their affiliates, including Basel III and the 2010 Dodd-Frank Act (DFA). The gradual tightening of prudential standards resulted in higher capital and liquidity of major bank-affiliated dealers, improving their resilience to adverse shocks. At the same time, the interplay of these regulatory changes and

[5] In the bilateral segment, dealers trade directly with each other and with clients, notably hedge funds, to source and fund specific securities. In contrast, the tri-party segment is a general collateral market in which dealers typically source liquidity using a broad range of securities, without specifying individual securities, as collateral. It is called tri-party because an agent facilitates and administers the settlement. The two segments are connected. Typically, dealers use the tri-party market to source funding from cash investors (such as money market funds) to finance other activities, such as purchases of Treasuries, or the financing of hedge funds. There is also a small interdealer market (General Collateral Finance – GCF) within the tri-party market, in which dealers source or provide liquidity, but most interdealer activity occurs in the bilateral repo segment.

changes in market structure and trading technology contributed to significant changes in the behavior of bank dealers and their role in providing market liquidity.

More specifically, the Basel Committee on Banking Supervision played a pivotal role in strengthening global banking standards aimed at enhancing the safety and soundness of banks and, more broadly, the stability of the financial system. In response to the vulnerabilities identified during the GFC, the committee introduced Basel III, building on the previous Basel II and Basel 2.5 frameworks. Introduced in 2011, Basel 2.5 aimed at upgrading the measurement and management of market risk exposures, particularly the adequacy of capital held by banks against such exposures. It introduced a stressed value at risk (VaR) measure to ensure that banks hold sufficient capital to cover potential losses arising from their trading activities. It also introduced an incremental risk charge to enhance requirements for banks' internal risk calculations and provide a more comprehensive measure of trading book risks.

Basel III further strengthened the regulation, supervision, and risk management of banks. It mandated three key changes that are crucial for Treasury market functioning: (i) It increased the minimum risk-based capital requirements for banks compared to Basel II, thereby increasing the cost of capital to banks of risk taking; (ii) it introduced the supplementary leverage ratio (SLR) to reduce the risk of excessive leverage, effectively making activities such as repo funding of Treasury collateral subject to prudential capital requirements for bank-affiliated dealers; (iii) it introduced the liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR), which enhance banks’ resilience to liquidity shocks and anchor banks’ maturity transformation more materially to retail deposits and other stable sources of debt financing. Short-term funding via repos with Treasury collateral is treated favorably under both the LCR and the NSFR. The tightening of capital requirements and the SLR were phased in between 2013 and 2015, while the LCR became effective in 2015 and the NSFR in 2018. Some final components, often referred to as Basel III endgame, are still to be implemented as of the time of writing.

In parallel to the global standards set by Basel, the DFA introduced a range of reforms aimed at increasing transparency and reducing systemic risk within the U.S. financial system. It required stress testing for large financial institutions and their affiliated dealers to monitor capital sufficiency and assess their resilience in stress times (DFAST). The assessment became a component of the Federal Reserve’s broader annual Comprehensive Capital Analysis and Review (CCAR), which uses stress tests to assess the capital adequacy and capital planning processes of large U.S. BHCs. As a result of the BHC CCAR, affiliated broker dealers may have to adjust their risk taking. Furthermore, the DFA tightened reporting and oversight requirements on derivatives markets.

A pivotal component of the DFA was the Volcker Rule, which constrained bank-affiliated dealers’ proprietary trading activities (that is, trading with their own capital to generate profits for the institution) and limited their investments in hedge funds and private equity funds. The rule went into effect in April 2014 and has been found by some studies to be associated with a reduction in the market-making activities of bank-affiliated dealers in the corporate bond market (Bao, O’Hara & Zhou 2018). In contrast, independent brokers, not subject to the rule, have more

flexibility in providing liquidity. The Volcker Rule was loosened to some extent in 2020 to mitigate its adverse effects on market making.

In complement to the capital, liquidity, and trading regulations resulting from Basel III and the DFA, the U.S. Securities and Exchange Commission (SEC) focused on operational readiness, market transparency, and conduct at the level of dealers. Rule 15c3-5, implemented in 2011, required brokers-dealers to have robust risk management controls and supervisory procedures to prevent excessive risk taking in their trading activities, aligning with the broader regulatory goals of Dodd-Frank and Basel III to ensure financial stability through stringent oversight and compliance. Additionally, after the GFC, the SEC adopted and amended several rules governing trade transparency for domestic and foreign transactions (Rule 605, Rule 606, Rule 17a-8). Additional SEC rules govern the code of conduct for dealers with their customers (Regulation Best Interest, Form CRS).

3.1.2. Impact of the changes

The Basel Committee on Banking Supervision evaluated the effects of the Basel III reforms and concluded that they coincided with improved capital and liquidity positions, particularly at banks with the weakest capital and liquidity ratios, enhancing bank resilience and reducing systemic risk (BCBS, 2022). The report does not find much evidence of negative side effects, finding that banks complying with Basel III lowered their costs of equity and debt, with more pronounced declines for banks with lower initial capital ratios. Moreover, the report finds no evidence that the reforms impaired the aggregate supply of credit to the economy.

That said, market participants report that post-crisis regulations have had broad implications for dealers' business models and market-making practices (CGFS 2014). Risk weights and credit risk charges have reportedly increased the costs associated with trading, particularly for corporate bonds and credit derivatives. Furthermore, the leverage ratio weighs on relatively lower risk activities, such as repo operations, thereby increasing financing costs. Market participants identify the Basel III leverage ratio and higher risk-weighted capital as being the most significant drivers of regulatory capital charges for sovereign bonds, whereas revisions to the market risk framework are considered the primary driver of regulatory charges for corporate bonds (CGFS 2016).

Ryan & Toomey (2021) argue that the SLR, in particular, can be a binding constraint for dealer intermediation in normal times, but especially during periods of stress, as dealers do not have the balance sheet capacity to absorb the associated customer flows. Cochran et al. (2023) similarly argue that for banks with large dealer affiliates "the SLR rule has implied higher capital requirements than risk-based capital rules in recent years, making it possible that the SLR may affect their willingness and ability to intermediate in Treasury markets, especially during periods of increased demand for intermediation."

A growing academic literature offers insights into the effects of regulations on dealer balance sheets and intermediation. Some studies find that the post-global GFC regulatory tightening increased dealers' balance sheet costs (e.g., Adrian et al. 2017 and Du, Hébert & Li 2023) and

attenuated liquidity provision (Gromb & Vayanos 2010; He & Krishnamurthy 2013; Breckenfelder & Ivashina 2023). Bräuning & Stein 2024 find that the relaxation of the SLR in 2020, when Treasuries and reserves were temporarily exempt, eased dealer constraints and improved Treasury market liquidity (also see Favara, Infante & Rezende 2022). Other studies, including Boyarchenko et al. (2018), Du, Hébert & Li (2023), and Wu & Jarrow (2024), explain how leverage ratios help explain negative swap spreads (swap rates lower than comparable maturity Treasury yields), which are an indication of an eroding US Treasury convenience yield and a proxy for increased dealer intermediation costs.[6] In contrast, a 2022 Financial Stability Board study concludes that the evidence of post-GFC regulatory reforms adversely impacting dealers' liquidity support is inconclusive.

It should be recognized that the macroeconomic environment, alongside regulation, can limit dealer willingness to provide liquidity. Adrian & Shin (2014) explain how dealers adjust their risk-taking behavior and balance sheet size in their normal course of business, highlighting that leverage is procyclical. Dealer risk taking evolves organically to adhere to risk-based regulatory requirements alongside broader developments in financial markets and the macroeconomy (Adrian et al. 2015b, Adrian et al. 2017, Adrian et al. 2013 for the GFC and 2012 crisis, and Chen et al. 2021 for the Covid-19 crisis). When market volatility increases, dealer funding constraints tighten, making intermediation more costly, which in turn can feed back into asset valuations. The Covid experience demonstrated such dynamics, with dealer risk-taking capacity becoming constrained in light of extreme market uncertainty (FSB 2022).

3.2. Changing Auction Participation

Amid the changes brought about by the post-crisis regulatory framework, an important question is whether dealer intermediation of new Treasury issuance has changed materially. As committed underwriters of Treasury auctions, primary dealers absorb issuance supply shocks using their balance sheets and redistribute supply to investors over time. How they manage this role amid balance sheet constraints in the context of fast-growing public debt has implications for the funding costs of the US Treasury. Duffie (2020, 2023) expresses the concern that tighter regulations, combined with the rapid growth in Treasury debt outstanding, mean that the market's size may have outgrown the capacity of dealers to safely intermediate the market on their own.

In fact, dealer purchases at auction have declined sharply in recent years, as shown in Figure 2. Dealers and brokers thus purchased 65% of new note and bond issuance in the years before the GFC (January 2005 to July 2007), but just 17% in recent years (January 2022 to December 2024). Over the same period, auction purchases by investment funds – a category that includes mutual funds, money market funds (MMFs), hedge funds, money managers, and investment

[6] The convenience yield measures the value that investors assign to the liquidity and safety attributes offered by Treasuries above and beyond those of securities of similar riskiness, such as AAA-rated corporate bonds (Krishnamurthy & Vissing-Jorgensen 2012). Higher Treasury debt outstanding tends to erode the convenience yield.

advisors – rose from 13% to 67%. Purchases by all other investors (including depository institutions, pension & retirement funds, insurance companies, and foreign & international accounts) declined from 22% to 15%.

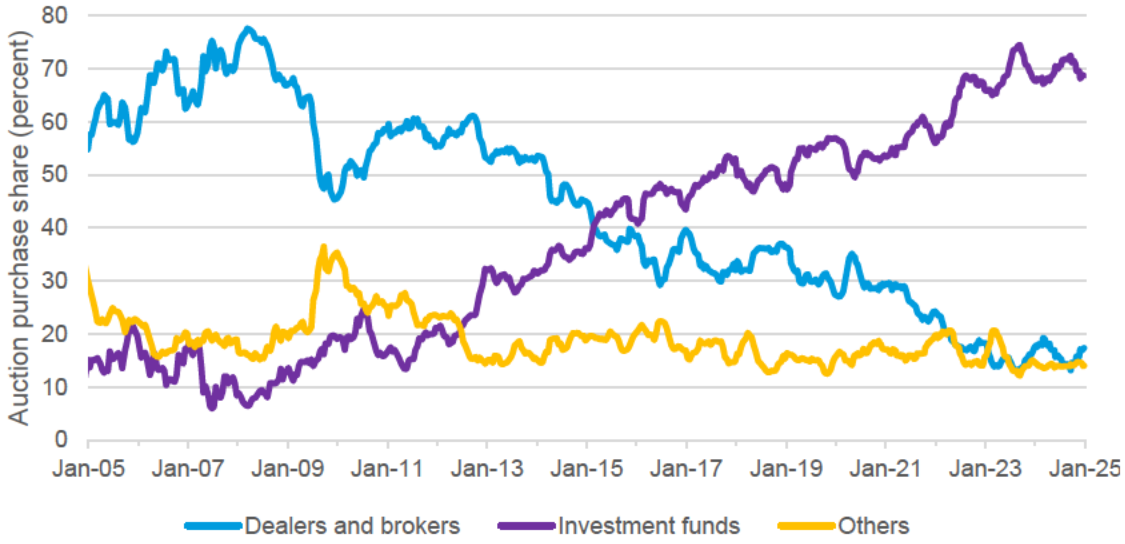

Figure 2
Treasury auction purchases by investor class. This figure plots the 13-week moving average of the share of weekly coupon security auction amounts purchased by dealers and brokers, investment funds, and other investor classes from January 2005 to December 2024. Federal Reserve purchases, which are "add-ons" to announced offering amounts, are excluded from the analysis. The investment funds category includes mutual funds, MMFs, hedge funds, money managers, and investment advisors. A similar figure appears in Fleming, Nguyen & Rosenberg (2024). Data are from the US Treasury Department.

Fleming, Nguyen & Rosenberg (2024) also document the decline in dealer auction purchases but show that compensation for liquidity provision at auction has, if anything, decreased. That is, the price pressure effects arising from auctions (previously documented by Lou, Yan & Zhang 2013) have moderated as dealer participation has declined. The authors note the increased participation of investment funds and conjecture that asset managers including hedge funds that used to demand liquidity provision around auctions are now competing with dealers in the provision of liquidity. These authors further show that participation by investment funds is associated with reduced price pressure effects on an auction-by-auction basis.

Table 1 presents a related analysis with consistent findings. It reports results from regressions of auction tails (the highest yield accepted minus the median yield of accepted bids) on dealer purchase shares and implied volatilities. Dealer purchase shares are measured as the deviations from the preceding six auctions (for the corresponding term) so as to gauge their innovation. The results show that the auction tail increases with dealer share for most securities, especially the longer-term ones for which uncertainty is higher. That is, higher dealer participation is associated with a weaker auction by this metric, consistent with the evidence that

higher participation from investment funds is associated with a well-intermediated auction. The results also show that the auction tail increases with volatility as expected.

Table 1: Treasury auctions and dealer intermediation

	2-Year	3-Year	5-Year	7-Year	10-Year	30-Year
Dealer share	-0.009	0.003	0.038	0.067***	0.073***	0.151***
	(0.016)	(0.016)	(0.024)	(0.025)	(0.018)	(0.042)
Volatility	0.021***	0.030***	0.023***	0.027***	0.028***	0.028***
	(0.004)	(0.003)	(0.006)	(0.005)	(0.005)	(0.006)
Constant	1.902***	1.625***	2.893***	2.932***	2.617***	3.573***
	(0.322)	(0.331)	(0.465)	(0.440)	(0.412)	(0.511)
Observations	216	186	216	185	209	194
Adjusted R^2	0.365	0.485	0.258	0.277	0.308	0.298

Notes: This table reports the results from regressing Treasury note and bond auction tails on primary dealer purchase shares and swaption implied volatilities. The auction tail equals the highest yield accepted minus the median yield of accepted bids (in basis points), the dealer share equals the primary dealer purchase share less the average purchase share from the previous six auctions for the corresponding term (in percent), and the volatility is the term-matched swaption implied volatility as of the previous day's market close (in basis points). The sample period generally runs from January 2007 to December 2024 but starts in February 2008 for the 30-year bond, July 2009 for the 3-year note, and August 2009 for the 7-year note due to data limitations. Newey-West standard errors are in parentheses. One. two, and three asterisks indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Data are from Bloomberg.

3.3. Changing Ownership Patterns

Aside from purchases at auction, changes in US Treasury security ownership generally have important implications for market intermediation. In this section, we first review developments involving foreign investors and foreign central banks given the significance of US Treasury securities as a global safe asset. We then discuss the increased presence of mutual funds and hedge funds in the Treasury market and the challenges this poses to dealers' ability to intermediate trading flows at times of stress.

3.3.1. Global demand. U.S. Treasury securities are a vital reserve asset for central banks worldwide, providing a liquid and highly creditworthy store of value during normal times and a safe haven at times of crisis. Arslanalp, Eichengreen & Simpson-Bell (2022, 2024) find that central banks' demand for U.S. dollars has remained broadly stable over the past 25 years, both reflecting and underpinning central banks' Treasury investments. To be sure, there has been a roughly 10 percentage point decline in the dollar's share of international reserves, from about 70 percent in 2000 to about 60 percent in 2024 (Figure 3). This shift reflects reserve diversification by central banks into alternative currencies, such as the Chinese renminbi, and the Australian

and Canadian dollars.[7] Despite this gradual decline, the U.S. dollar continues to be the dominant reserve currency, underscoring the crucial role of Treasury securities as a cornerstone of liquidity, safety, and stability.

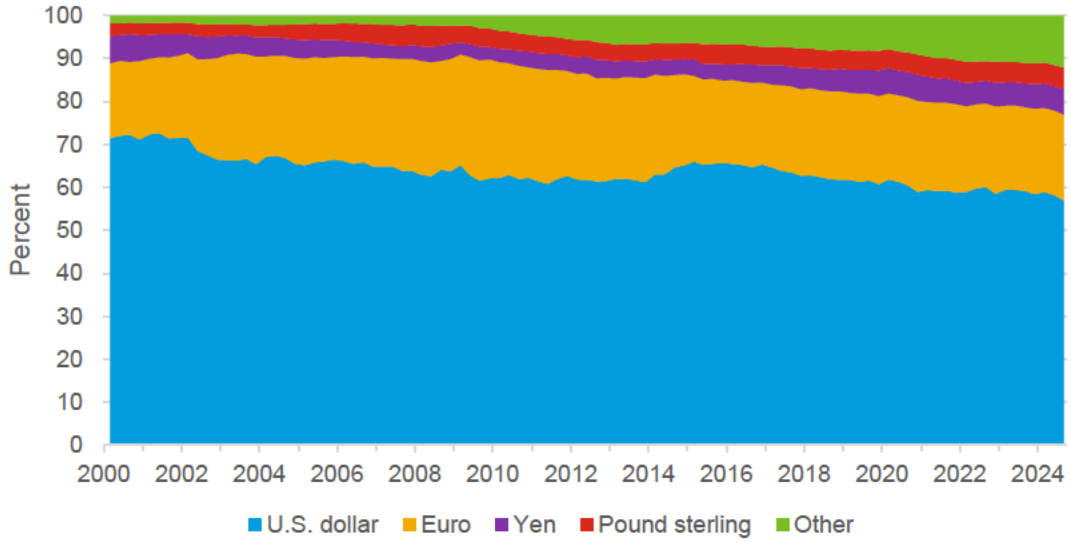

Figure 3
Currency composition of global foreign exchange reserves. This figure plots the currency composition of global foreign exchange reserves from 2000:Q1 to 2024:Q3. The four major reserve currencies are the US dollar, euro, Japanese yen, and British pound. Other reserve currencies include the Australian dollar, the Canadian dollar, and the Chinese renminbi. The data are from the International Monetary Fund's Currency Composition of Official Foreign Exchange Reserves. A similar figure appears in Arslanalp, Eichengreen & Simpson-Bell (2022, 2024).

The foreign official sector, primarily composed of central banks and sovereign wealth funds, holds a large stock of Treasuries, totaling just under $4 trillion at the end of 2024, accounting for nearly half of foreign investor holdings and around 15% of all Treasuries outstanding. Foreign official holdings have been relatively stable for more than a decade, implying a declining share of holdings as debt outstanding has increased. Conversely, foreign official reverse repos with the Federal Reserve have increased in recent years, totaling $415 billion at the end of 2024, up from $105 billion a decade earlier. Combined, these Treasury holdings and repo transactions with the Fed indicate continued strong demand for the dollar as a safe asset and highlight the importance of the foreign sector as a holder of US debt.

The dynamics of the foreign sector holdings can impact the Treasury market in various ways. As a consistently large buyer of Treasuries, the foreign official sector provides steady demand, supporting intermediaries' ability to offer market liquidity. This sector also typically engages in

[7] Such diversification reflected changes in liquidity management and was facilitated by growth in non-traditional currency markets and advancements in electronic trading that reduced transaction costs. Central bank currency swap lines further facilitated access to these currencies and liquidity backstops.

buy-and-hold strategies, and hence is less likely to employ trend-following tactics that could heighten volatility. That said, the sector holds the securities as a reserve asset and can draw down its holdings rapidly and sometimes in less-than-ideal market conditions. Such dynamics arose during the Covid-19 crisis when there was heavy selling of Treasuries from a wide range of investors, including the foreign official sector (see Duffie 2020 and Vissing-Jorgensen 2021). These selling pressures exacerbated market illiquidity, raising concerns about market stability.

3.3.2. Mutual funds. Mutual fund ownership of Treasuries increased from 8% of the outstanding stock (excluding holdings of the Federal Reserve) to over 20% over the past 20 years, as shown in Figure 4, and totaled $5.0 trillion as of December 31, 2024. This increase reflects the growth of mutual funds generally, as well as MMFs' shift in holdings from private credit to Treasury securities.

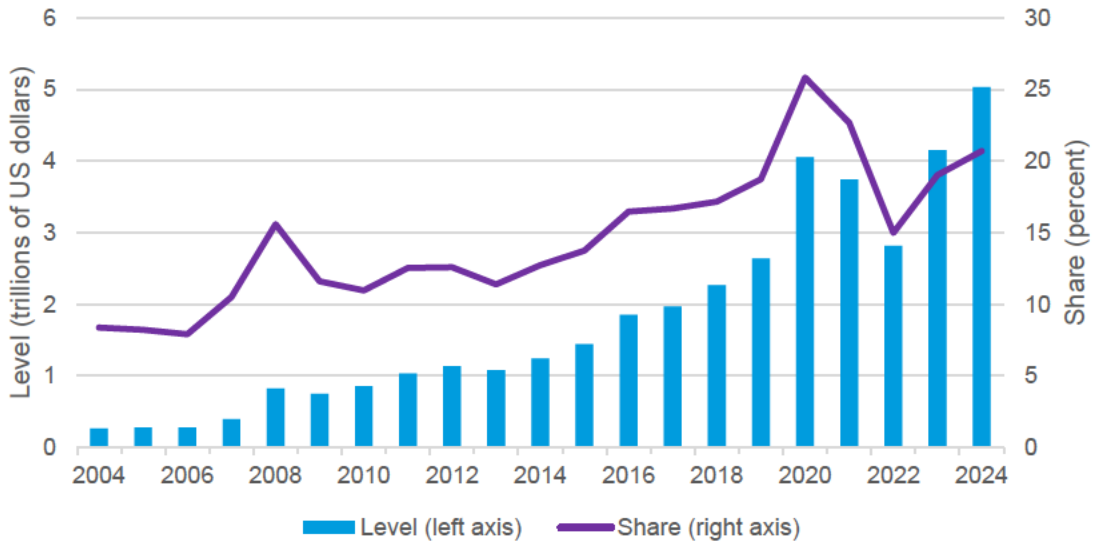

Figure 4
Treasury security holdings of mutual funds. This figure plots US Treasury security holdings of mutual funds (including exchange-traded funds, MMFs, and closed end funds) in levels and as a percent of US Treasury debt outstanding (excluding holdings of the Federal Reserve) from December 31, 2004 to December 31, 2024. Data are from the Financial Accounts of the United States and the US Treasury Department.

Regulatory changes to strengthen MMFs' liquidity management led to a significant shift in MMF holdings towards short-term Treasuries. MMFs experienced a run in September 2008 after the Reserve Primary Fund "broke the buck," leading to extraordinary government intervention to restore investor confidence.[8] These runs subsequently prompted regulatory changes that led to

[8] Specifically, for the MMF sector the U.S. Treasury Department established a temporary guarantee program for MMFs, and the Federal Reserve introduced the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility to provide liquidity to the market and restore investor confidence. These were part of broader market interventions during the GFC (PWG 2020).

a significant decline in assets-under-management (AuM) of prime MMFs (those investing primarily in non-Treasury securities) and a commensurate increase in the AuM of government- and Treasury-only MMFs, which invest primarily in Treasury bills and Treasury repo. As a result, during the March 2020 dash for cash, MMFs were not subject to runs, but rather received inflows, with redemption pressures focused on the relatively small set of prime MMFs (PWG 2020).

Mutual funds' increased ownership of Treasuries also raises concerns about redemption risks, especially at times of crisis. At such times, open-end mutual funds may need to meet end-investors' demand for same day or next day liquidity (redemptions) by selling portfolio assets. In fact, bond mutual funds suffered large redemption pressures at the onset of the pandemic. Ma, Xiao & Zeng (2022) find that open-end mutual funds sold $236 billion in Treasuries in the first quarter of 2020, accounting for about one-third of the total sales of Treasuries in that quarter. They also find that bond funds investing in more illiquid assets experienced greater outflows, that funds sold their most liquid securities first to meet redemptions, and that outflows contributed to the selling pressures in fixed income markets at the time.

Dealers play a crucial role in managing redemption pressures from mutual funds, facilitating the funds' sales of Treasuries and other securities. However, during periods of market stress, dealers' capacity to absorb and redistribute these securities can be strained, potentially worsening market volatility. Adrian et al. (2015a) highlight the challenges dealers face in absorbing selling pressure from bond funds during periods of stress, while Li, O'Hara & Zhou (2024) explain how strained dealer capacity in periods of crisis can exacerbate illiquidity in the municipal bond market following mutual fund redemptions.

More recently, there has been a growing concern about asset managers' strong demand for Treasury futures. As shown in Figure 5, asset managers have significantly increased their long futures positions over the past decade. Asset managers use futures to take directional positions on interest rate developments or to extend the duration of their higher-yielding portfolios, thereby tracking their benchmark index at a lower cost (Barth et al. 2024). This practice increases leverage and drives price discrepancies between futures and cash prices of Treasuries, creating profitable arbitrage opportunities, known as basis trades. These opportunities, as discussed below, have attracted hedge funds and bolstered their role in the Treasury market. Consequently, short futures positions of hedge funds have grown substantially over the past decade, albeit with some variation, alongside the opposing long positions of asset managers.

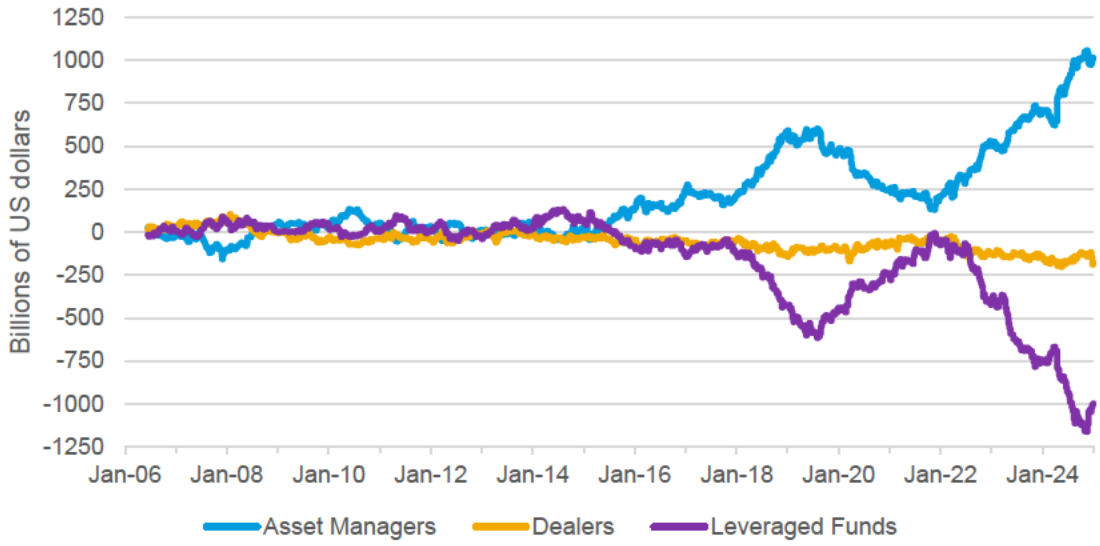

Figure 5

Net Treasury futures positions of asset managers, dealers, and leveraged funds. This figure plots the total net positions (long minus short) for 2-year, 5-year, 10-year, bond, and ultra bond futures traded on the Chicago Board of Trade, by category of trader, from June 13, 2006 to December 31, 2024. Data are from the Commodity Futures Trading Commission's Traders in Financial Futures report.

3.3.3. Hedge funds. Hedge funds have also become more important participants in the Treasury market, with parallel activity in all Treasury market segments. In particular, hedge funds stepped up Treasury purchases during both Federal Reserve balance sheet reduction periods, with their share of outstanding Treasuries net of the Federal Reserve's holdings increasing significantly (Cordes & Ferris 2024; IMF 2024a; IMF 2024b).[9] As mentioned, this increase was largely related to basis trades, an arbitrage trading strategy involving the cash, futures and repo markets that further extended hedge funds' footprint in the Treasury market.

Hedge funds' flexible investment mandates and limits on redemption allow them to provide liquidity when other investors or dealers cannot. During the 2014 flash rally, for example, hedge funds were the one group that traded against the apparent mispricing in aggregate. When dealers cannot, or choose not to, provide capital to intermediate flows overnight and/or take positions that will profit from (while also mitigating) pricing dislocations, hedge funds are the natural group to step in. As discussed, hedge funds have been important liquidity providers in the Treasury market in periods of increased net Treasury supply. They also engage heavily in arbitrage trades in Treasuries, such as the basis trade, more so than dealers. The increased role of investment funds in buying Treasuries at auction, discussed above, is likely due at least in part to hedge funds' primary market liquidity provision.

[9] The first balance sheet reduction period spanned 2017-19. The second one has been ongoing since 2022 and has coincided with heavy Treasury security issuance, leading to a considerable increase in the net supply of Treasuries.

However, hedge funds typically increase their holdings of cash Treasuries as part of leveraged trading strategies. The popular basis trade has attracted scrutiny because the strategy is associated with at least three vulnerabilities: First, it relies on leverage to be profitable, with hedge funds financing their Treasury cash purchases in the repo market, typically at low cost (involving zero or negative haircuts) and with overnight maturities. The increased volume of repo trades further adds to the demand for dealer balance sheet space. Second, these trades tend to be concentrated among a small number of institutions, adding to the vulnerabilities via concentration risk (Banegas & Monin 2023; IAWG 2023; IMF 2024a). Third, hedge fund cash positioning largely offsets mutual fund futures positioning, thus increasing financial system interconnectedess (Barth et al. 2024).

These vulnerabilities heighten broader deleveraging risks in times of crisis. At such times, increased market volatility can raise borrowing costs for hedge funds and render arbitrage trades unprofitable, forcing both hedge funds and mutual funds to unwind their Treasury positions. Calls for higher margins on Treasury futures positions can contribute to further deleveraging. Concentrated positioning by both hedge funds and asset managers can exacerbate the unwinding (IMF 2024a), while constraints on dealer intermediation may be binding. These factors converged during the onset of the pandemic, amplifying instability in the Treasury market (Schrimpf, Shin & Sushko 2020; Kruttli et al. 2021; Barth & Kahn 2021).

3.3.4. Implications for intermediation: The preceding discussion suggests that while mutual funds and hedge funds can support Treasury market liquidity in normal times, they may be forced to unwind positions in times of stress, potentially increasing liquidity demand. Such demand effects are exacerbated by the funds' increased holdings of Treasuries as issuance continues to grow. Moreover, dealers' intermediation capacity may be constrained at exactly those times that liquidity is most needed, worsening the intermediation challenge and raising concerns about Treasury market functioning and resilience.

The Covid crisis illustrated the challenges starkly. Duffie (2020) and Vissing-Jorgensen (2021) document that dealers were overwhelmed by extraordinary selling pressure in Treasuries by foreign official accounts, mutual funds, and hedge funds when the pandemic hit. While dealers bought Treasuries and other fixed income securities in huge quantities, their balance sheet constraints and internal risk limits prevented them from meeting the increased liquidity demand on typical terms, thereby amplifying volatility.[10] The ensuing market disruptions spurred an extraordinary policy response, including the Federal Reserve's market functioning purchases of Treasuries and agency MBS.

[10] Fleming et al. (2022) report that the increases in primary dealers' net Treasury note and bond and agency MBS holdings were the highest on record for the four weeks ending March 18. FSB (2022) reports that extreme uncertainty drove dealer VaRs higher, but aggregate risk limits did not change substantially, leading to growing reluctance to expand intermediation further.

3.4. Electronic Trading

Fully electronic IDB platforms launched in the US Treasury market in 1999 and 2000, as noted earlier, quickly gained market share (Mizrach & Neely 2006), and have generally improved market liquidity. Mizrach & Neely (2006) show that bid-ask spreads are narrower and price impact lower with electronic IDBs. Adrian, Fleming & Vogt (2023) show a decline in both the mean and variance of spreads, and an increase in order book depth, between the pre- and post-electronification periods. They also show that low latency trading is associated with better liquidity on a day-to-day basis, with narrower spreads, higher depth, and lower price impact. Electronic trading is also found to reduce trading costs, enhance competition, and promote price discovery in other markets (e.g., Domowitz 2002).

Despite evidence that electronic trading improves liquidity, there are concerns about "the potential for greater operational risk, disruptive market practices and trading strategies, and the risk of sharp, short-term disruptions to the Treasury securities market" (Treasury Market Practices Group 2015). In equity markets, for example, Knight Capital lost $440 million in 45 minutes in August 2012 due to a glitch in its electronic trading (BBC Magazine, August 11, 2012). In the US Treasury market, liquidity was adversely affected when a major clearing firm was hit by a cyberattack in November 2023 (Wall Street Journal, November 9, 2023). While the attack did not affect electronic trading directly, it illustrates the risks to the market generally, and to electronic trading especially, through the clearing channel (which is a point raised in Bank of England 2019).

Some concerns about electronic trading relate to PTFs in particular. The electronic IDBs opened to PTFs around 2004 and by the time of the October 15, 2014 flash rally, such firms accounted for most activity in the IDB market (Joint Staff Report 2015). As noted earlier, PTFs trade for their own account, often using algorithmic trading strategies, and generally carry little inventory overnight. Low latency is typically a key element of their trading strategies, so that the firms are virtually absent from the parts of the market that are not fully electronic. Their tendency to close out positions by the end of each trading day means that PTFs are effectively providing intraday liquidity, but not the sometimes-needed inter-day liquidity that dealers can provide.

During the 2014 flash rally, the 10-year Treasury yield dropped 16 basis points and then rebounded, without a clear cause, in a narrow 12-minute window. Federal Reserve Chair Jerome Powell, then a Board governor, noted that such episodes, "threaten to erode investor confidence" and that investors need "to have full faith in the *structure and functioning* of Treasury markets themselves." (Powell 2015). While the interagency staff report did not identify a single cause of the events that day, it did identify notable changes in Treasury market structure, including PTFs' prominent role in the IDB segment. PTFs' share of activity was also found to increase during the event window, with some PTFs trading against the apparent mispricing even as others traded with it.

The role of PTFs at times of crisis is also of concern, as illustrated by developments during the pandemic. PTFs increased their level of activity sharply in late February and early March 2020 as overall trading volume surged, but then decreased both their level and share of activity in

mid-March 2020 (Fleming et al. 2022). The high volatility, illiquidity, and unpredictability of flows caused PTFs to reduce their intermediation capacity relative to dealers and hence PTFs' share of trading activity to decline. Reduced liquidity in the interdealer market in turn exacerbated dealers' challenges in intermediating customer flows.

4. BROKER-DEALER INTERMEDIATION AND TREASURY MARKET LIQUIDITY

To this point, we have discussed how Treasury market ownership changes and growth have increased intermediation needs, particularly at times of crisis, even as regulatory changes have constrained dealers' intermediation capacity. These conflicting forces have raised concerns that dealers may not have the capacity to effectively intermediate the market at all times, especially given the market's continued rapid growth (Duffie 2020, 2023). In this section, we present evidence on the intermediation capacity of broker dealers across time, and we quantify the relationship between intermediation capacity, Treasury market volatility, and Treasury market liquidity.

Indicative of dealers' intermediation capacity is their gross Treasury positions, which sum across short and long positions, and their estimated market-making positions, both plotted in Figure 6.[11] Both measures plunged during the GFC, whether measured in dollar terms or as a percent of Treasury debt outstanding. There was some recovery in the years immediately following the GFC, but the measures have trended down as a percent of debt outstanding since 2011 (in dollar terms there's been some increase in recent years, especially since the pandemic).

Limits on intermediation capacity reflect dealers' concerns about risk exposures. In stress periods, heightened volatility increases the risk that dealers face in intermediating markets and causes associated risk measures such as value at risk (VaR) to rise sharply. Internal risk management processes developed to ensure compliance with regulations limit the ability of dealers to respond, just as the demand for intermediation services intensifies. A negative feedback loop can ensue between volatility and dealer behavior, leading to markedly worse liquidity outcomes.

[11] Market-making positions are estimated by summing the *minimum* of the long and short positions for each security type, maturity bucket, and dealer. The idea is that if a dealer is both long and short similar securities, the smaller of these positions may largely reflect dealer market making. In contrast, dealers' net Treasury positions may not be very informative about their willingness to make markets as such positions are determined jointly with dealers' other positions in line with their broader interest rate strategies. Dealers' net positions in Treasuries flipped from negative to positive after the GFC (e.g., Fleming, Nguyen & Rosenberg 2024), likely reflecting dealers' reduced need to hedge their reduced net corporate positions.

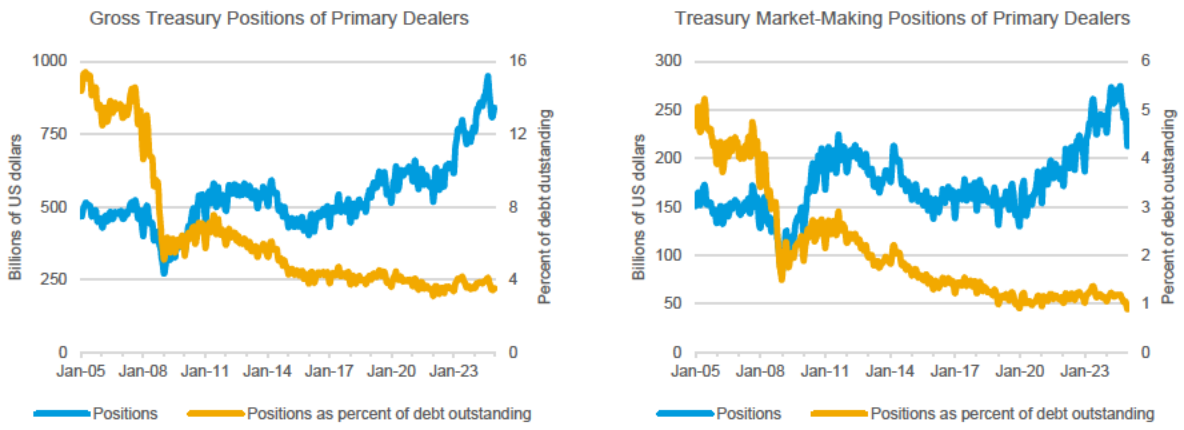

Figure 6

Primary dealer gross and estimated market-making positions. This figure plots four-week moving averages of primary dealers' gross and estimated market-making positions in US Treasury bills, coupons, Treasury Inflation Protected Securities, and floating rate notes. Gross positions are the sum of long and short positions aggregated across security types, maturity buckets, and dealers. Market-making positions are estimated by summing the minimum of the long and short positions for each security type, maturity bucket, and dealer. Debt is the total marketable US debt, excluding holdings of the Federal Reserve, linearly interpolated from monthly to weekly data. A similar figure appears in the Joint Staff Report (2015). Data are from the Federal Reserve (FR 2004 statistical release) and the US Treasury Department.

As a result, the VaR has historically been strongly correlated with Treasury market volatility and liquidity. The strong correlation is not surprising as these measures all reflect risk, with unit VaR—the ratio of VaR to total assets—being the firms' own assessment of risk and market volatility being the market's assessment of risk. In turn, more volatile markets are associated with an increased risk of executing transactions and therefore a deterioration in various market liquidity metrics.[12] Figure 7 shows that the VaR measure correlates strongly with both US Treasury liquidity and volatility.[13]

The riskiness of dealer balance sheets may help explain changes in liquidity beyond those explained by volatility as shown in Duffie et al. (2023) and supported by our analyses below. Duffie et al. (2023) use dealer positions, trading flows, and VaR measures to construct proxies

[12] Volatile markets correlate with wider bid-ask spreads, reduced depth, and an increased price impact of trades. Early studies showed that spreads are positively related to stock market volatility as risk averse dealers charge higher spreads to compensate for inventory risks, the lack of diversification, or asymmetric information (Stoll 1978, Amihud & Mendelson 1980; Glosten & Milgrom 1985). More recent studies showing a tight link between Treasury market liquidity and interest rate volatility include Nguyen et al. (2020), Adrian, Fleming & Vogt (2023), Duffie et al. (2023), and Meldrum & Sokolunskiy (2023).

[13] During the inflation episode of 2021-23, interest rate volatility rose, while equity and credit implied volatility remained contained, breaking the historical relationship between interest rate volatility and VaR, at least temporarily.

of dealer balance sheet capacity constraints and show that when capacity constraints become binding, liquidity worsens beyond what can be explained by volatility alone. They suggest that volatility and balance sheet constraints may be endogenously magnified and that balance sheet constraints matter more when illiquidity is at extreme high levels.

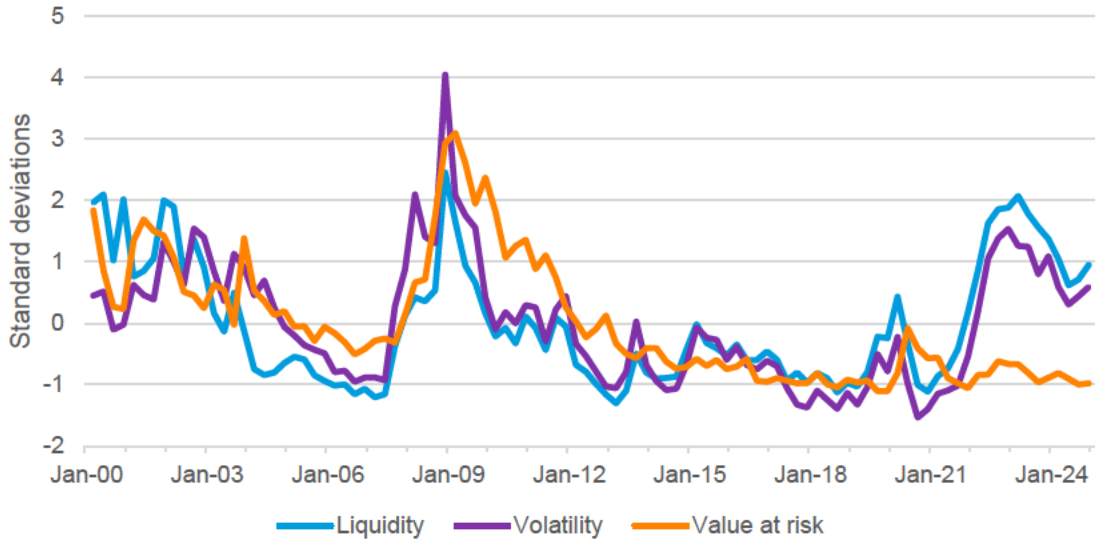

Figure 7
Treasury market liquidity, volatility, and value at risk. This figure plots the Treasury market liquidity index from Adrian, Fleming & Vogt (2023), implied Treasury market volatility as measured by the MOVE index, and unit VaR based on Adrian & Shin (2014) from January 2000 through December 2024. The MOVE index is an average of implied volatilities from a basket of at-the-money call and put options on US Treasury bonds. The unit VaR is the asset-weighted average of the standardized ratios of VaR to total assets for eight large commercial and investment banks: Bank of America, Citibank, JP Morgan, Bear Stearns, Goldman Sachs, Lehman Brothers, Merrill Lynch, and Morgan Stanley. Liquidity and volatility are averaged by quarter and plotted against quarter-end VaR. All variables are standardized to mean 0 and standard deviation 1 for the plotted sample period. Volatility and VaR data are from Bloomberg.

As a first step in exploring the role of dealer capacity here we regress liquidity on volatility and unit VaR and report the results in Table 2. According to Adrian & Shin (2014), the unit VaR reflects the risk environment of the recent past, which weighs on a firm's decision as to how much risk exposure to take on. The firm can cut back its exposure when the environment becomes riskier by reducing its balance sheet size, mainly via reduced leverage.

Results of the first specification show that volatility is a significant driver of liquidity, consistent with the evidence of numerous prior papers. The second specification reveals also the VaR as a significant driver of liquidity, with substantial explanatory power. The third specification further shows that unit VaR has additional explanatory power for liquidity beyond volatility. In particular, a one standard deviation increase in the VaR results in an 0.25 standard deviation worsening of liquidity. Dealer capacity does seem to affect liquidity above and beyond the effects of volatility on liquidity, as shown in Duffie et al. (2023).

Table 2: Treasury market liquidity, volatility, and value at risk

	(1)	(2)	(3)
Volatility	0.665***		0.595***
	(0.055)		(0.074)
Value at risk		0.587***	0.255*
		(0.127)	(0.133)
Observations	96	96	96
Adjusted R^2	0.533	0.198	0.562

Notes: This table reports the results from regressing (in year-to-year changes) the Treasury market liquidity index from Adrian, Fleming & Vogt (2023) on implied Treasury market volatility as measured by the MOVE index, and unit VaR based on Adrian & Shin (2014) from January 2000 through December 2024. The MOVE index is an average of implied volatilities from a basket of at-the-money call and put options on US Treasury bonds. The unit VaR is the asset-weighted average of the standardized ratios of VaR to total assets for eight large commercial and investment banks: Bank of America, Citibank, JP Morgan, Bear Stearns, Goldman Sachs, Lehman Brothers, Merrill Lynch, and Morgan Stanley. All variables are measured at quarter-end and standardized to mean 0 and standard deviation 1. Volatility and VaR data are from Bloomberg. Newey-West standard errors are in parentheses. One. two, and three asterisks indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

We further examine the relationship between liquidity and risk taking using quantile regressions, similar to the approach taken by Duffie et al. (2023). The objective is to understand how market liquidity depends on dealer risk constraints not only on average (as shown in Table 2), but also at both the higher and lower tails of the market liquidity spectrum. Quantile regressions are an effective tool for this, as they allow us to quantify how market liquidity varies with dealer risk constraints across the entire conditional liquidity distribution.

We map the conditional distribution of liquidity using a quantile regression of liquidity as a linear function of volatility and the VaR. We plot the estimated coefficients for volatility and the VaR over a range of quantiles in Figure 8. The findings indicate that volatility and dealer risk taking can provide additional explanatory power for extreme quantiles.

The left panel of Figure 8 shows a strong nonlinear dependence of market liquidity on volatility. The slope coefficient rise sharply with higher quantiles (when illiquidity is higher), suggesting a higher impact of market volatility when liquidity is low. Specifically, higher volatility is associated with more illiquid markets, and this relationship becomes even stronger as market volatility increases. The difference in how market illiquidity responds to market volatility between the lower and upper quantiles is statistically significant, as shown in the figure.

A similar pattern of nonlinearity emerges in the dealer VaR regressions as shown in the right panel of Figure 8. The slope coefficient again rises with higher quantiles and turns positive at the upper quantiles. Up to that point, market illiquidity is negatively correlated with dealer VaR,

suggesting that periods of adequate liquidity can correlate with lower dealer intermediation. In contrast, in the upper quantiles the relationship becomes strongly positive, supporting the interpretation that increased perceived dealer risk in stressed or illiquid conditions can lead to reduced market-making activity and amplify episodes of market illiquidity. Our findings are broadly consistent with the analysis by Duffie et al. (2023), which examines a shorter time sample, and illustrates the economic mechanism highlighted by Adrian & Shin (2014).

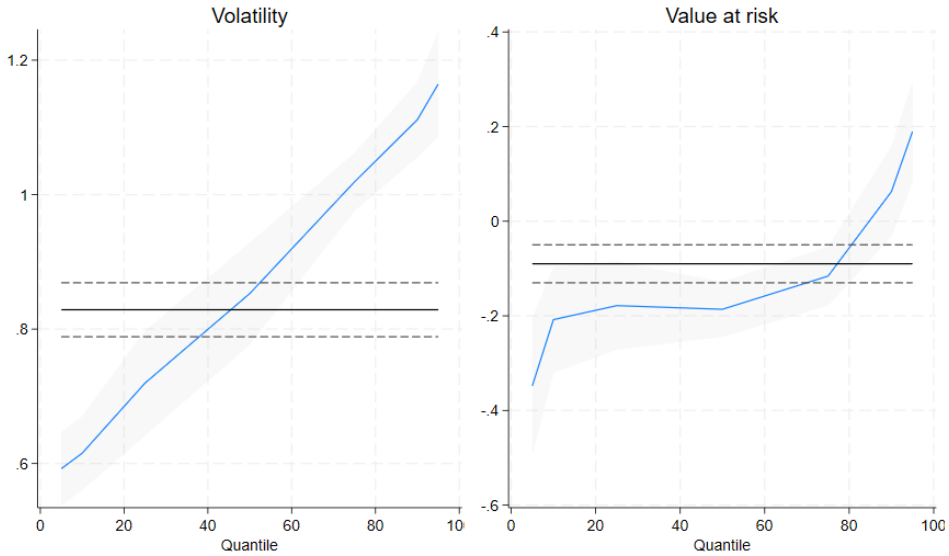

Figure 8

Quantile regressions of Treasury market liquidity on volatility and value at risk. This figure plots the conditional distribution slope coefficients for the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles from regressions of the Treasury market liquidity index of Adrian, Fleming & Vogt (2023) on implied Treasury market volatility as measured by the MOVE index and unit VaR based on Adrian & Shin (2014) from January 2000 through December 2024. The left panel plots the coefficients for the MOVE index. The right panel plots the coefficients for the unit VaR. The ordinary least squares coefficients are reported as solid lines with the shaded areas indicating the 95% confidence intervals. The MOVE index is an average of implied volatilities from a basket of at-the-money call and put options on US Treasury bonds. The unit VaR is the asset-weighted average of the standardized ratios of VaR to total assets for eight large commercial and investment banks: Bank of America, Citibank, JP Morgan, Bear Stearns, Goldman Sachs, Lehman Brothers, Merrill Lynch, and Morgan Stanley. All variables are measured weekly, with liquidity and volatility averages of daily values and VaR interpolated from quarter-end values. All variables are standardized to mean 0 and standard deviation 1 before estimation. Volatility and VaR data are from Bloomberg.

In sum, the empirical results presented in this section reveal a significant deterioration in market liquidity dynamics when dealers face challenges in intermediation. These shifts underscore the substantial transformations within the US Treasury market following the GFC and emphasize the inherent vulnerabilities still present in the Treasury market, particularly during crises when demand for dealer intermediation can increase dramatically.

5. POLICY INITIATIVES

The intermediation challenges discussed in the preceding sections culminated with the pandemic-induced disruptions of March 2020 and the unprecedented policy response. These events led to calls by academics and policymakers to make the Treasury market more resilient, particularly given the market's continued rapid growth (e.g., Duffie 2020, Liang & Parkinson 2020, Brookings 2021, and Group of Thirty 2021). Policymakers have since responded, with numerous measures taken by members of the Interagency Working Group on Treasury Market Surveillance (IAWG): the SEC, the Treasury Department, the Federal Reserve, and the Commodity Futures Trading Commission (CFTC). These efforts, described in a series of annual reports (see IAWG 2021, 2022, 2023, and 2024), focus on improving market structure, transparency, and the resilience of participants, and fall broadly into five areas:[14]

5.1. Improving Resilience of Market Intermediation

An important policy development in recent years to promote the resilience of Treasury market intermediation was the Fed's establishment of the Standing Repo Facility in July 2021. The facility is available daily to primary dealers and certain depository institutions to provide liquidity against securities eligible for open market operations. The facility helps address pressures in money markets, thereby supporting monetary policy implementation, and it provides a liquidity alternative to sales, helping prevent fire sales of Treasuries (e.g., in the case of an extreme demand for cash), which could in turn disrupt other financial markets.

A key feature of a standing repo facility is the range of eligible counterparties. There are many practical reasons why a central bank limits its counterparties, but too narrow a set can preclude liquidity from reaching those who need it in a crisis situation. Liang & Parkinson (2020) and Group of Thirty (2021) suggest access for a broad range of dealers, whereas Brookings (2021) suggests access for dealers and other market participants, including asset managers and PTFs. The Federal Reserve's SRF counterparties are thus somewhat narrower than those recommended by many commentators. In contrast, other central banks allow for a broader group of counterparties in similar facilities.[15]

Another important policy action in this area was the Treasury Department's May 2024 launch of a security buyback program to support Treasury market liquidity and enhance Treasury's cash management capabilities. Focusing on liquidity support, the program gives market participants the opportunity to sell less frequently traded off-the-run securities to the Treasury, which should increase the willingness of intermediaries to make markets in these securities. The operations

[14] Our grouping is similar but not identical to the grouping used in the IAWG reports.

[15] The Bank of England recently opened a Contingent Non-Bank Financial Institution Repo Facility which will lend to participating insurance companies, pension schemes and liability driven investment funds during episodes of severe gilt market dysfunction (Bank of England 2025). Similarly, the Bank of Canada has established the Contingent Term Repurchase Facility (CTRF), which allows financial institutions subject to financial sector/market regulations to access funding from the central bank against government collateral in case of a systemic crisis.

may also boost market liquidity by serving as a focal point for trading activity, thereby increasing liquidity around buybacks, and by freeing up dealer balance sheet space that can then be used for additional market making. As of late 2024, the Treasury was conducting weekly liquidity support operations for buybacks of up to $30 billion per quarter.

5.2. Expanding Central Clearing

Another key policy proposal culminated with the SEC's adoption of rules in December 2023 that would expand central clearing of U.S. Treasury securities transactions. While central clearing is extensively used in financial markets to reduce risk and improve efficiency, large shares of U.S. Treasury cash and repo market transactions are not subject to the practice. The approved rules will require central clearing of cash transactions that are intermediated by IDBs as well as repos and reverse repos for which a central counterparty (CCP) participant is a counterparty. Certain transactions are exempt from the rules, including those in which a counterparty is a central bank.

Central clearing brings risk management and netting efficiencies that should promote market stability more broadly. The risk management benefits come from the CCP's standardized, robust, and transparent risk management practices, including margin requirements. CCP margin requirements may be greater than those currently applied in certain market segments, such as that for non-centrally cleared bilateral repo, and better reflect transactions' underlying risk. Better risk management should make the market more resilient to shocks.

A CCP also nets transactions across participants, reducing firms' settlement obligations and associated exposures prior to settlement.[16] Settlement netting could reduce the balance sheet space dealers need to make markets and increase dealers' market making capacity. This is particularly relevant for repos, because unsettled cash trades can already be netted for accounting purposes. To be sure, balance sheet netting outside a clearing house is a practice that dealers already apply extensively with their customers (Bowman, Hu & Infante 2024).[17] However, data reported by primary dealers show a recent increase in the share of Treasury repo trades that are centrally cleared, especially at quarter- and year-ends, when dealer balance sheet space becomes more limited.[18] While most repo trades with customers remain uncleared, the trend toward increased central clearing is expected to continue in light of the SEC's mandate.

---

[16] Fleming & Keane (2021), for example, estimate that central clearing of all trades (which is broader than what would result from the SEC's approved rules) could lower dealers' settlement obligations in the cash market by up to 70%.

[17] Bowman, Hu & Infante (2024) estimate modest balance sheet benefits of expanded central clearing due to already widespread balance sheet netting and limits on the eligibility of repos for central clearing.

[18] Primary dealers report their repo financing to the New York Fed, broken down by market segment and clearing method, among other metrics. The data suggest an increased share of trades in the cleared segments of the market since January 2022, when reporting of these breakdowns started.

An additional benefit of expanded central clearing is that it could allow for the emergence of direct trading between non-dealer buyers and non-dealer sellers (Duffie 2019). That is, by assuming members' trade obligations, the CCP reduces the credit risk associated with bilateral transactions. Direct trading between non-dealers reduces the need for dealers to intermediate every trade, freeing dealer balance sheet space. Academics and policymakers have hence argued since the events of March 2020 that expanded central clearing could allow for all-to-all trading and thereby ease dealers' intermediation constraints and promote Treasury market resilience (Duffie 2020, Liang & Parkinson 2020, Group of Thirty 2021, Chaboud et al. 2025).

5.3. Increasing Data Availability and Transparency

Additional initiatives are aimed at increasing the quality and availability of data to the public and the private sectors. Timely information on positions and transactions can help the public sector both identify and address market vulnerabilities. In March 2020, for example, data gaps and lags made it difficult for the official sector to evaluate the drivers of the selling pressures in the Treasury market in real time (IAWG 2021). For the private sector, data availability can facilitate better informed decision making, support market functioning and liquidity, and enhance financial stability.

In the cash market, where transactions data has been reported by dealers and available to the official sector since the start of Treasury TRACE reporting in July 2017, public transparency has steadily increased. The Financial Industry Regulatory Authority started releasing aggregated volume data on a weekly basis in March 2020 and then, in February 2023, on a daily basis, along with trade counts and average prices for on-the-run notes and bonds. In March 2024, it started releasing data on individual transactions for on-the-run notes and bonds (at the end of each day and with trades sizes capped).

In the repo market, there has long been a dearth of data on non-centrally cleared bilateral repos for both the official and private sectors. In May 2024, the OFR adopted a rule to establish an ongoing data collection for such repos, with daily reporting starting by December 2024, to complement the transaction-level data already available to the official sector for the triparty and centrally cleared segments. The rule builds on outreach and a data collection pilot that began in mid-2022 and follows an earlier 2015 pilot data collection exercise (see Baklanova et al. 2016 and Hempel et al. 2023).

Additional steps taken to improve the official sector's understanding and oversight of hedge funds and mutual funds are discussed in Section 5.5.

5.4. Leveling the Regulatory Playing Field

Other policy initiatives are intended to ensure consistency across markets, and within the Treasury market, in how trading platforms are regulated. In September 2020, the SEC proposed a rule that would apply operational transparency, investor protection, and regulatory oversight provisions to platforms that facilitate trading in government securities. The rule change would remove an exemption that exists for such platforms, applying provisions already

applicable to platforms trading corporate debt or equity securities. The proposal was re-proposed in January 2022, reflecting public comments received on the 2020 proposal.

Also in January 2022, the SEC proposed to amend the definition of "exchange" to include platforms such as request-for-quote platforms, which bring together buyers and sellers. The proposal is intended to require such platforms to comply with the same securities laws and regulations applicable to other platforms, and hence provide the same investor protection and fair and orderly market principles. The comment period for the exchange definition proposal was reopened in April 2023, and as of late 2024, the SEC was continuing to consider comments received in response to the proposal.

5.5. Mitigating Liquidity Risks

A further set of initiatives has focused on the entities that demand liquidity. As discussed earlier, ownership patterns have shifted towards mutual funds, which may need to meet end-investors' demand for same day or next day liquidity (redemptions) by selling portfolio assets, and hedge funds, which may be forced to unwind levered positions when volatility spikes. In the March 2020 dash-for-cash, selling by mutual funds, hedge funds, and foreign investors overwhelmed dealers' capacity to smoothly intermediate these flows, exacerbating market volatility.

One step to address these selling pressures was the Federal Reserve's launch of the FIMA Repo Facility in March 2020 -- a repo facility for foreign and international monetary authorities. The facility allowed foreign central banks to enter into repurchase agreements with the Federal Reserve, thereby temporarily exchanging their US Treasury securities for US dollars. This arrangement thereby reduced foreign central banks' incentives to sell Treasuries in the open market. The facility saw relatively little take-up, but provided confidence to FIMA investors that funding would be available when needed (IAWG 2021). The initially temporary facility was made a permanent standing facility in July 2021.

Another step toward improving buy-side resilience was the re-establishment of the Hedge Fund Working Group by the Financial Stability Oversight Council (FSOC). The aim of that interagency working group was the monitoring of financial stability risks from hedge funds. The working group noted gaps in the availability of data related to hedge funds and vulnerabilities associated with the low or zero haircuts common for repos in the non-centrally cleared bilateral repo market. This triggered policy efforts to require more timely reporting, thus improving systemic risk monitoring.[19]

The FSOC also created the Open-End Funds Working Group to consider risks to financial

[19] In May 2023 the SEC adopted amendments to Form PF to require, among other things, that large hedge fund advisers file a current report within 72 hours of the occurrence of specified events with respect to their qualifying hedge funds. In February 2024, the SEC and the CFTC jointly adopted changes to Form PF to improve the FSOC's ability to monitor systemic risk and bolster the SEC's investor-protection efforts and oversight of private fund advisers.

stability arising from open-end fund liquidity and redemption features. In July 2023, the SEC adopted amendments to reduce the risk of investor runs on MMFs during periods of market stress by removing MMFs' ability to temporarily suspend redemptions and removing the tie between liquidity fees and weekly liquid asset thresholds. The amendments also provide a more substantial liquidity buffer in the event of rapid redemptions by increasing the minimum liquidity requirements for MMFs. In August 2024, the SEC adopted enhanced reporting requirements for open-end funds that require information on funds month-end portfolio holdings, with publicly available quarterly filings.

6. CONCLUSION

The market for US Treasury securities has evolved considerably since the GFC. Post-crisis regulatory changes bolstered the resilience of financial institutions and the broader financial system. This helped precipitate changes in ownership and in the entities that buy Treasuries at auction, with investment funds at least partially displacing dealers. The advent of electronic trading also led to the entry into the interdealer market of PTFs, which engage in high-speed cross-market arbitrage.

We argue that these changes have on balance promoted market functioning and liquidity. Dealers have reduced their footprint in the primary market, but increased participation by investment funds has ensured that auction metrics have not deteriorated. Dealers also account for a much smaller share of activity in the IDB market, but entry of PTFs and the increased activity of asset managers has helped ensure that the market remains highly liquid. To be sure, there are questions about non-dealer intermediation in times of stress given the potential pull-back of PTFs and the redemption pressures faced by asset managers, but the post-GFC regulatory changes help ensure that dealers remain highly resilient.

That said, market disruptions since the GFC and the market strains in March 2020 triggered by the onset of the Covid-19 pandemic renewed concerns about the Treasury market's resilience, particularly given the continued growth in debt outstanding. Mutual funds, hedge funds, and foreign central banks sold massive quantities of Treasuries in the dash-for-cash. Dealers stepped in as counterparts, but were overwhelmed by the trading flows, leading to pricing dislocations and unusually poor illiquidity. The Federal Reserve subsequently initiated asset purchases at an unprecedented speed and scale to restore market functioning.

Policymakers have since pursued changes to the Treasury market's structure to reduce the chances of future disruptions. Notable changes to date include the launch of a standing repo facility, the approval of rules to increase the share of trades that are centrally cleared, and the release of transactions data for the most actively traded Treasuries. Additional efforts have sought to promote the transparency of investment funds, consistent treatment of market participants and infrastructure, and an understanding of the barriers to a market structure that does not rely so much on dealers. These changes, and increased data availability, suggest that work on Treasury market liquidity will remain a fruitful area of research in the years to come.

Literature Cited

Adrian T, Fleming M, Goldberg J, Lewis M, Natalucci F, Wu J. 2013. Dealer balance sheet capacity and market liquidity during the 2013 selloff in fixed income markets. Federal Reserve Bank of New York Liberty Street Economics, October 16.

Adrian T, Fleming M, Shachar O, Vogt E. 2015a. Redemption risk of bond mutual funds and dealer positioning. Federal Reserve Bank of New York Liberty Street Economics, October 8.

Adrian T, Fleming M, Shachar O, Vogt E. 2017. Market liquidity after the financial crisis. Annual Review of Financial Economics 9:43-83.

Adrian T, Fleming M, Stackman D, Vogt E. 2015b. What's driving dealer balance sheet stagnation. Federal Reserve Bank of New York Liberty Street Economics, August 21.

Adrian T, Fleming M, Vogt E. 2023. The evolution of Treasury market liquidity: Evidence from 30 years of limit order book data. Federal Reserve Bank of New York Staff Reports no. 827, January.

Adrian T, Shin HS. 2014. Procyclical leverage and value-at-risk. Review of Financial Studies 27(2):373–403.

Afonso G, Cipriani M, Copeland A, Kovner A, La Spada G, Martin A. 2021. The market events of mid-September 2019. Federal Reserve Bank of New York Economic Policy Review 27(2).

Amihud Y, Mendelson H. 1980. Dealership market: Market making with inventory. Journal of Financial Economics 8(1):31-53.

Amihud Y, Mendelson H. 1991. Liquidity, maturity, and the yields on U.S. Treasury securities. Journal of Finance 46(4):1411-25.

Arslanalp S, Eichengreen B, Simpson-Bell C. 2022. The stealth erosion of dollar dominance and the rise of nontraditional reserve currencies. Journal of International Economics 138:103656.

Arslanalp S, Eichengreen B, Simpson-Bell C. 2024. Dollar dominance in the international reserve system: An update. IMF Blog, June 11.

Baklanova V, Caglio C, Cipriani M, Copeland A. 2016. The U.S. bilateral repo market: Lessons from a new survey. OFR Brief Series 16-01, Office of Financial Research, US Department of the Treasury, January 13.

Banegas A, Monin P. 2023. Hedge fund Treasury exposures, repo, and margining. FEDS Notes. Board of Governors of the Federal Reserve System, September 8.

Bank of England. 2019. Does the reliance of principal trading firms on banks pose a risk to UK financial stability? Bank Overground. August 9.

Bank of England. 2025. Bank of England opens new contingent non-bank lending facility for applications. News Release. January 28.

Bao J, O'Hara M, Zhou X. 2018. The Volcker Rule and corporate bond market making in times of stress. Journal of Financial Economics 130(1):95–113.

Barclay MJ, Hendershott T, Kotz K. 2006. Automation versus intermediation: Evidence from Treasuries going off the run. Journal of Finance 61(5):2395-2414.

Barth D, Kahn RJ. 2021. Hedge funds and the Treasury cash-futures disconnect. Working Paper 21-01, Office of Financial Research, US Department of the Treasury.

Barth D, Kahn RJ, Mann R. 2023. Recent developments in hedge funds' Treasury futures and repo positions: Is the basis trade "back"? FEDS Notes. Board of Governors of the Federal Reserve System, August 30.

Barth D, Kahn RJ, Monin P, Sokolinskiy O. 2024. Reaching for duration and leverage in the Treasury market. Finance and Economics Discussion Series 2024-039. Board of Governors of the Federal Reserve System.

Basel Committee on Banking Supervision (BCBS). 2022. Evaluation of the impact and efficacy of the Basel III reforms. Bank for International Settlements, December 14.

Bowman D, Huh Y, Infante S. 2024. Balance-sheet netting in U.S. Treasury markets and central clearing. Finance and Economics Discussion Series 2024-057. Board of Governors of the Federal Reserve System.

Boyarchenko N, Gupta P, Steele N. Yen J. 2018. Negative swap spreads. Federal Reserve Bank of New York Economic Policy Review 24(2):1–14.

Brain D, De Pooter M, Dobrev D, Fleming M, Johansson P, Jones C, Keane F, Puglia M, Reiderman L, Rodrigues T, Shachar O. 2018. Unlocking the Treasury market through TRACE. Federal Reserve Bank of New York Liberty Street Economics, September 28.

Brandt, MW, Kavajecz KA. 2004. Price discovery in the U.S. Treasury market: The impact of order flow and liquidity on the yield curve. Journal of Finance 59(6):2623–54.

Bräuning F, Stein H. 2024. The effect of primary dealer constraints on intermediation in the Treasury market. Federal Reserve Bank of Boston Research Department Working Papers no. 24-7, July.

Breckenfelder J, Ivashina V. 2023. Bank balance sheet constraints and bond liquidity. Working paper. September.

Brookings, 2021, Report of the task force on financial stability, June.

Cammack, E. 1991. Evidence on bidding strategies and the information in Treasury bill auctions. Journal of Political Economy 99(1):100-30.

Committee on the Global Financial System (CGFS). 2014. Market-making and proprietary trading: industry trends, drivers and policy implications. CGFS papers no. 52, November.

Committee on the Global Financial System (CGFS). 2016. Fixed income market liquidity. CGFS papers no. 55, January.

Chaboud A, Correia Golay E, Cox C, Fleming M, Huh Y, Keane F, Lee K, Schwarz K, Vega C Windover C. 2025. All-to-all trading in the US Treasury market. Federal Reserve Bank of New York Economic Policy Review 31(2).

Chen J, Liu H, Rubio D, Sarkar A, Song Z. 2021. Did dealers fail to make markets during the pandemic? Federal Reserve Bank of New York Liberty Street Economics, March 24.

Chordia T, Sarkar A, Subrahmanyam A. 2005. An empirical analysis of stock and bond market liquidity. Review of Financial Studies 18(1):85–129.

Clarida, RH. Duygan-Bump B, Scotti C. 2021. The COVID-19 crisis and the Federal Reserve's policy response. Finance and Economics Discussion Series 2021-035, Board of Governors of the Federal Reserve System.

Cochran P, Infante S, Petrasek L, Saravay Z, Tian M. 2023. Dealers Treasury market intermediation and the supplementary leverage ratio. FEDS Notes. Board of Governors of the Federal Reserve System, July 28.

Cordes L, Ferris E. 2024. Who buys Treasuries when the Fed reduces its holdings. FEDS Notes. Board of Governors of the Federal Reserve System, June 14.

Domowitz I. 2002. Liquidity, transaction costs, and reintermediation in electronic markets. Journal of Financial Services Research 22(1-2):141-57.

Du W, Hébert B, Li W. 2023. Intermediary balance sheets and the Treasury yield curve. Journal of Financial Economics 150(3):103722.

Duffie D. 2019. Report in Support of Class Plaintiffs' Motion for Class Certification, In re Interest Rate Swaps Antitrust Litigation. 16-MD-2704 (S.D.N.Y.), originally filed under seal on February 20, 2019, and filed in redacted form on March 7, 2019 (Dkt. No. 725-2).

Duffie D. 2020. Still the world's safe haven? Redesigning the U.S. Treasury market after the COVID- 19 crisis. Hutchins Center Working Paper 62, Brookings Institution, June.

Duffie D. 2023. Resilience redux in the U.S. Treasury market. Jackson Hole Symposium, Federal Reserve Bank of Kansas City, August.

Duffie D, Fleming M, Keane F, Nelson C, Shachar O, Van Tassel P. 2023**.** Dealer capacity and U.S. Treasury market functionality. Federal Reserve Bank of New York Staff Reports no. 1070, October.

Elton EJ, Green TC. 1998. Tax and liquidity effects in pricing government bonds. Journal of Finance 53(5):1533-62.

Favara G, Infante S, Rezende M. 2022. Leverage regulations and Treasury market participation: Evidence from credit line drawdowns. Working paper. December.

Financial Stability Board (FSB). 2022. Liquidity in Core Government Bond Markets. October 20.

Fleming M. 1997. The round-the-clock market for U.S. Treasury securities. Federal Reserve Bank of New York Economic Policy Review 3(2):9–32.

Fleming M, 2020. Treasury market liquidity and the Federal Reserve during the COVID-19 crisis. Federal Reserve Bank of New York Liberty Street Economics, May 29.

Fleming M. 2003. Measuring Treasury market liquidity. Federal Reserve Bank of New York Economic Policy Review 9(3):83–108.

Fleming M, Keane F. 2021. The netting efficiencies of marketwide central clearing. Federal Reserve Bank of New York Staff Reports no. 964, April.

Fleming M, Krishnan N. 2012. The microstructure of the TIPS market. Federal Reserve Bank of New York Economic Policy Review 18(1):27-45.

Fleming M, Liu H, Podjasek R, Schurmeier J. 2022. The Federal Reserve's market functioning purchases. Federal Reserve Bank of New York Economic Policy Review 28(1):210-41.

Fleming M, Nguyen G, Rosenberg J. 2024: How do Treasury dealers manage their positions? Journal of Financial Economics 158:103885.

Fleming M, Remolona EM. 1999. Price formation and liquidity in the U.S. Treasury market: The response to public information. Journal of Finance 54(5):1901–15.

Fleming M, Ruela F. 2020. Treasury market liquidity during the COVID-19 crisis. Federal Reserve Bank of New York Liberty Street Economics, April 17.

Furfine, CH, Remolona E. 2002. What's behind the liquidity spread? On-the-run and off-the-run U.S. Treasuries in autumn 1998. BIS Quarterly Review, June.

Glosten L, Milgrom P. 1985. Bid, ask and transaction prices in a specialist market with heterogeneously informed traders. Journal of Financial Economics 14(1):71-100.

Gromb D, Vayanos D. 2010. Limits of arbitrage. Annual Review of Financial Economics 2:251-75.

Group of Thirty. 2021. U.S. Treasury markets: steps toward increased resilience. July.

He Z, Krishnamurthy A. 2013. Intermediary asset pricing. American Economic Review 103(2):732–70.

Hempel SJ, Kahn RJ, Mann R, Paddrik M. 2023, Why Is so much repo not centrally cleared? Lessons from a pilot survey of non-centrally cleared repo data. The OFR Blog, Office of

Financial Research, US Department of the Treasury, May 12.

Hu, GX, Pan J, Wang J. 2013. Noise as information for illiquidity. Journal of Finance 68(6):2341–82.

IAWG. 2021. Recent disruptions and potential reforms in the U.S. Treasury market: A staff progress report. U.S. Department of the Treasury, Board of Governors of the Federal Reserve System, Federal Reserve Bank of New York, U.S. Securities and Exchange Commission, and U.S. Commodity Futures Trading Commission, November 8.

IAWG. 2022. Enhancing the resilience of the U.S. Treasury market: 2022 staff progress report. U.S. Department of the Treasury, Board of Governors of the Federal Reserve System, Federal Reserve Bank of New York, U.S. Securities and Exchange Commission, and U.S. Commodity Futures Trading Commission, November 10.

IAWG. 2023. Enhancing the resilience of the U.S. Treasury market: 2023 staff progress report. U.S. Department of the Treasury, Board of Governors of the Federal Reserve System, Federal Reserve Bank of New York, U.S. Securities and Exchange Commission, and U.S. Commodity Futures Trading Commission, November 6.

IAWG. 2024. Enhancing the resilience of the U.S. Treasury market: 2024 staff progress report. U.S. Department of the Treasury, Board of Governors of the Federal Reserve System, Federal Reserve Bank of New York, U.S. Securities and Exchange Commission, and U.S. Commodity Futures Trading Commission, September 20.

International Monetary Fund (IMF). 2024a. Global Financial Stability Report: Steadying the Course: Uncertainty, Artificial Intelligence, and Financial Stability. October.

International Monetary Fund (IMF). 2024b. Global Financial Stability Report: The Last Mile: Financial Vulnerabilities and Risks. April.

Joint Staff Report. 2015. The U.S. Treasury market on October 15, 2014. U.S. Department of the Treasury, Board of Governors of the Federal Reserve System, Federal Reserve Bank of New York, U.S. Securities and Exchange Commission, and U.S. Commodity Futures Trading Commission, July 13.

Krishnamurthy, A. 2002. The bond/old-bond spread. Journal of Financial Economics 66(2-3):463–506.

Krishnamurthy A, Vissing-Jorgensen A. 2012. The aggregate demand for Treasury debt. Journal of Political Economy 120(2):233–67.

Kruttli MS, Monin PJ, Petrasek L, Watugala SW. 2021. Hedge fund Treasury trading and funding fragility: Evidence from the COVID-19 crisis. Finance and Economics Discussion Series 2021-038, Board of Governors of the Federal Reserve System.

Li Y, O'Hara M, Zhou X. 2024. Mutual fund fragility, dealer liquidity provision, and the pricing of municipal bonds. Management Science 70(7):4167-92.

Liang N, Parkinson P. 2020. Enhancing the liquidity of U.S. Treasury markets under stress. Brookings Institute, December 16.

Logan LK. 2020. Treasury market liquidity and early lessons from the pandemic shock. Remarks at Brookings-Chicago Booth Task Force on Financial Stability meeting, October 23.

Longstaff FA. 2004. The flight-to-liquidity premium in U.S. Treasury bond prices. Journal of Business 77(3):511–26.

Lou D, Yan H, Zhang J. 2013. Anticipated and repeated shocks in liquid markets. Review of Financial Studies 26(8):1891–1912.

Ma Y, Xiao K, Zeng Y. 2022. Mutual fund liquidity transformation and reverse flight to liquidity. Review of Financial Studies 35(10):4674-711.

Meldrum A, Sokolinskiy O. 2023. The effects of volatility on liquidity in the Treasury market. Finance and Economics Discussion Series 2023-028. Board of Governors of the Federal Reserve System.

Mizrach B, Neely C. 2006. The transition to electronic communications networks in the secondary Treasury market. Federal Reserve Bank of St. Louis Review 88(Nov/Dec):527-41.

Musto DK, Nini G, Schwarz K. 2018. Notes on bonds: Illiquidity feedback during the financial crisis. Review of Financial Studies 31(8):2983–3018.

Nguyen G, Engle RF, Fleming MJ, Ghysels E. 2020. Liquidity and volatility in the U.S. Treasury market. Journal of Econometrics 217(2):207-29.

Pasquariello P, Vega C. 2009. The on-the-run liquidity phenomenon. Journal of Financial Economics 92(1):1–24.

Powell JH. 2015. The evolving structure of U.S. Treasury markets. Speech. October 20.

President's Working Group (PWG). 2020. Report of the President's Working Group on Financial Markets: Overview of Recent Events and Potential Reform Options for Money Market Funds. December.

Ryan P, Toomey R. 2021. Improving capacity and resiliency in US Treasury markets: Part II: Proposals for reforming US Treasury markets. Pennsylvania + Wall (SIFMA blog). March 30.

Schrimpf A, Shin HS, Sushko V. 2020. Leverage and margin spirals in fixed income markets during the Covid-19 crisis. BIS Bulletins 2, Bank for International Settlements.

Simon DP. 1994. Markups, quantity risk, and bidding strategies at Treasury coupon auctions. Journal of Financial Economics 35(1):43-62.

Spindt PA, Stolz RW. 1992. Are U.S. Treasury bills underpriced in the primary market? Journal of Banking and Finance 16(5):891-908.

Stoll H. 1978. The supply of dealer services in securities markets. Journal of Finance 33(4):1133-51.

Treasury Market Practices Group. 2015. Automated trading in Treasury markets. White paper. June.

Vayanos, D, Weill P-O. 2008. A search-based theory of the on-the-run phenomenon. Journal of Finance 63(3):1361-98.

Vissing-Jorgensen A. 2021. The Treasury market in spring 2020 and the response of the Federal Reserve. Journal of Monetary Economics 124(November):19-47.

Wu D, Jarrow RA. 2024. The Treasury -SOFR swap spread puzzle explained. Working paper. August.