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What Drives U.S. Treasury Re-use?*

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Abstract

We study what drives the re-use of U.S. Treasury securities in the financial system. Using confidential supervisory data, we estimate the degree of collateral re-use at the dealer level through their *collateral multiplier*: the ratio between a dealer's total secured funding and their outright holdings financed through secured funding. We find that Treasury re-use increases as the supply of available securities decreases, especially when supply declines due to Federal Reserve asset purchases. We also find that non-U.S. dealers' re-use increases when profits from intermediating cash are high, U.S. dealers' re-use increases when demand to source on-the-run Treasuries is high, and both types of dealers' re-use can alleviate safe asset scarcity. Finally, we document a sharp drop in Treasury re-use at the onset of the COVID-19 pandemic, with a subsequent reversal after the Federal Reserve's intervention to support market functioning.

Keywords: re-use, dealer, Treasury, collateral, rehypothecation, safe assets

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1 Introduction

In today's financial markets, the re-use of U.S. Treasuries as collateral in securities financing transactions (SFTs) is a widespread practice that enhances market functioning.[1] For example, re-use—defined as the use of collateral borrowed through an SFT—allows dealers to intermediate secured lending from risk-averse lenders to less creditworthy borrowers. Re-use also allows dealers to source and distribute specific securities that may be in high demand, improving underlying market liquidity. From a more conceptual perspective, Treasury re-use allows for the efficient distribution of their safe asset benefits, and has the potential to reduce the costs associated with safe asset scarcity.

Although Treasury re-use is beneficial for market functioning, it also has important financial stability implications, as it increases the total amount of leverage in the financial system. Treasury re-use also increases the interconnectedness of the financial system, as one security can be used in multiple transactions, creating so-called "collateral chains." These collateral chains can increase financial fragility because the failure of one counterparty to deliver re-used collateral may affect the soundness of others in the chain. When financial intermediaries re-use counterparties' securities, it can create uncertainty around who is entitled to the security in case of default. These problems may be amplified if the activity involves counterparties under jurisdictions with different regulatory treatments. Furthermore, high levels of collateral re-use can contribute to pro-cyclicality. When market conditions deteriorate, market participants become more reluctant to extend secured loans, reducing the amount of collateral available, and intensifying the contraction in securities financing activity.[2] These financial stability implications highlight the importance of measuring collateral re-use and better understanding the motivations behind it.

Despite the prevalence of U.S. Treasury re-use, its importance for market functioning, and the financial stability risks it poses, the empirical literature on what drives re-use is scant. Moreover, many existing studies that attempt to characterize re-use in the United States rely on aggregate data and make significant assumptions to measure the activity. In this paper, we fill the gap

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[1] SFTs include repo, securities lending contracts, and collateral swaps.

[2] See FSB (2017*b*) for more details on policymakers' concerns surrounding collateral re-use.

by using confidential supervisory data to measure and study what drives Treasury re-use at the individual dealer level. Following Infante, Press and Saravay (2020), we construct a dealer-level measure of Treasury re-use, called the collateral multiplier. Conceptually, the collateral multiplier is akin to a money multiplier: it measures SFTs (deposits) as a multiple of the total Treasuries (reserves) owned financed through SFTs (deposits). Intuitively, the Treasury collateral multiplier measures the amount of liabilities backed by Treasuries that dealers create, relative to how much they hold. And, under some conditions, the Treasury collateral multiplier can also be interpreted as the average length of collateral chains backed by U.S. Treasury securities.

We provide two conceptual frameworks to illustrate how the collateral multiplier captures re-use, and then, under these frameworks, assess how different factors affect the level of re-use. We first show that changes in Treasury supply should change the degree of re-use. Intuitively, if there are more Treasuries available, the need to re-use them is lower. We then discuss three economic incentives for dealers to adjust their level of Treasury re-use, proposed by Infante, Press and Saravay (2020). The first is the intermediation of cash from risk-averse lenders to less creditworthy dealers through SFTs. The second is the intermediation of specific Treasury securities that may be in high demand, such as on-the-run Treasuries, which tend to be the most traded and most liquid Treasury securities. And the third is the distribution of U.S. Treasuries' safe asset status by lending high-quality collateral to counterparties and giving them discretion to use it for their own purposes.

We use different versions of the collateral multiplier to explore how the factors outlined in the previous paragraph affect re-use. We first average each firm-level collateral multiplier across dealers to get a market-wide measure. We then separate between U.S. and non-U.S. dealers, as firms' motivations to participate in secured funding markets may differ across jurisdictions, either because of different regulatory restrictions or different business models. We also consider two different versions of the collateral multiplier that include different types of contracts. Specifically, we calculate a multiplier for all outgoing SFTs and repo separately, as repo is more flexible than other contract types and may be more sensitive to particular economic drivers.[3]

We test the insights from our conceptual framework in the time series, using cross sectional

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[3] Infante et al. (2018) show that the vast majority of SFTs using Treasury securities are through repo.

averages of the collateral multiplier, and also in simultaneous equation specifications, to exploit individual dealer-level data. Both specifications yield similar results. Our most robust result is that an increase in Treasury supply corresponds to a decrease in Treasury re-use. Importantly, we find that changes in the Federal Reserve's (Fed's) holdings of Treasury securities have a stronger, longer-lasting effect on re-use than Treasury issuance. This result suggests that the central bank has powerful tools to influence re-use, balancing the trade offs between market functioning and financial stability related to re-use.

Interestingly, we find that dealers' incentives to re-use Treasury securities differ depending on their jurisdiction. Non-U.S. dealers' re-use increases with higher profits from borrowing and lending cash across different secured funding markets. This sensitivity is higher for the repo CM, underscoring dealers' incentive to intermediate funds between different segments of U.S. repo markets. In contrast, U.S. dealers' re-use responds to an increase in demand to source on-the-run Treasury securities, measured through repo specialness. This result is consistent with the notion that dealers increase re-use to distribute specific securities, allowing dealers to deliver them to those that demand them most.

We then fine tune our empirical strategy to see if the demand for safe assets alters dealers' incentives to re-use Treasuries. Using an empirical strategy similar to Infante (2020), we use changes in the total outstanding amount of short-term T-bills as an exogenous shock to the the supply of safe assets to capture the sensitivity of the demand for safe assets. This analysis provides robust evidence that U.S. firms, and to a lesser degree non-U.S. firms, increase Treasury re-use in response to an increase in safe asset demand. Similar to the incentive to intermediate securities, as the demand for safe assets increases, dealers increase re-use, distributing the safety of Treasuries to others. From this perspective, the collateral multiplier does in fact capture the "multiplication" of safe assets whenever they're in high demand.

Using these insights, we study the patterns of Treasury re-use during the market disruption triggered by the COVID-19 outbreak. We find that prior to the Federal Reserve's interventions, Treasury re-use reached its lowest point on record. This drop in re-use is consistent with the narrative that dealers' holdings of Treasuries became notably elevated as they absorbed Treasuries sold by outside investors. While we find evidence that dealers also expanded their secured lending, the drop in the multiplier suggests that this expansion was not commensurate to the increase in outright holdings. In this sense, dealers' financing of counterparties' levered positions was not enough to support normal market functioning. The lack of secured lending is consistent with the notion that dealers were reluctant to increase the size of their balance sheet. We show that once the Fed announced an increase in their asset purchases, Treasury re-use returned to levels seen earlier in the year.

Our findings show that changing the Fed's holdings of Treasuries is an important tool to adjust the level of re-use, and thus, its associated financial stability risks and market functioning benefits. In particular, these results show that the Fed can alter the length of collateral chains that contribute to interconnectedness of the financial system. In terms of economic significance, we find that a one standard deviation increase in weekly Fed purchases results in a 0.38 standard deviation decrease in the average collateral multiplier. Put differently, a \$33 billion dollar increase in weekly Fed purchases leads to a 0.21 increase in the length of the collateral chain. From this perspective, if policymakers are concerned about the level of leverage and interconnectedness in the financial system, shrinking the Fed's balance sheet is an effective tool to decrease the average length of collateral chains.

All of these insights have important implications for market functioning and financial stability, and are a starting point to formulate a cost-benefit analysis of Treasury re-use. Our results show that the government can influence the financial system's re-use activity by changing the supply of Treasuries, particularly through central bank interventions. This insight is in line with Krishnamurthy and Vissing-Jorgensen (2015), Greenwood et al. (2015), and others who highlight the crowding out effect of government debt, but it underscores the importance of central bank actions. Moreover, our results show the differential role domestic and foreign dealers play in securities financing markets, underscoring the importance of their different business models and motivations to participate in re-use. Finally, our results show that dealers' re-use also plays a role in alleviating the costs associated with safe asset scarcity.

The rest of the paper is structured as follows. The next part of the introduction gives a brief literature review. Section 2 provides the conceptual framework to understand our measure. Section 3 contains the main empirical analysis. Section 4 provides a brief description of our measure amid Treasury the market turmoil of March 2020 caused by the COVID-19 outbreak.

Literature Review:

This paper contributes to the literature that characterizes how dealers re-use securities as collateral and the financial stability risks associated with this activity. A growing literature has studied financial firms' role in intermediating cash and securities through SFTs. Gottardi et al. (2019) shows how the intermediation of secured financing by creditworthy dealers may arise endogenously to overcome counterparty credit concerns. Infante (2019) studies the different contracting terms that can emerge when dealers intermediate cash and securities through repos, and Infante and Vardoulakis (2021) show how this activity can introduce a new source of fragility: a run from collateral providers. Using different data sources, Gorton, Metrick and Ross (2020) highlight the role intermediaries play across different segments of the repo market, and underscore the need to improve data collection efforts to understand the overall financial stability concerns of these markets. In this paper, we build on these insights to empirically explore the hypothesis of Infante, Press and Saravay (2020), and posit other incentives for firms to re-use Treasuries, beyond intermediating cash and securities.

Singh (2011) is among the first papers to empirically document the degree of collateral re-use using quarterly Securities and Exchange Commission filings. That paper proposes a measure of re-use, coined "collateral velocity," which is the ratio between aggregate collateral received through SFTs to aggregate collateral firms can access. In this paper, we use granular supervisory data to construct precise, firm-level measures of the amount of collateral dealers distribute relative to how much they own, which can be thought of as a "collateral multiplier." FSB (2017*a*) propose several collateral re-use metrics at the global and national level, some of which are closely related to our measure.[4] Fuhrer et al. (2016) and Jank and Moench (2020) measure re-use at the security level in the Swiss and European repo market, respectively. These papers empirically show significant scarcity effects, especially from central bank interventions: fewer securities leads to more re-use.

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[4] A discussion of the relationship between their proposed metrics and our collateral multiplier is in section 3.1.1.

Our firm-level analysis in the U.S. confirms the same type of scarcity effect, but also allows us to study how firms' incentives to re-use high quality collateral differ across jurisdictions and markets.

This paper is related to the literature on repo specialness and its role in Treasury market functioning. Duffie (1996) first documents how repo rates can trade below prevailing market rates when the economic incentive to enter the repo contract is to source a specific security. Krishnamurthy (2002) empirically confirm the no arbitrage relationship between specialness and the price of the on-the-run Treasury. Vayanos and Weill (2008) theoretically show that search frictions cause the more liquid security to trade special and Huh and Infante (2021) show how, in the time series, an increase in specialness corresponds to a decrease in liquidity for non-dealers. These two observations together imply that the more liquid security is relatively more illiquid across time when specialness is high. Keane (1996) documents that repo specialness tends to increase with the Treasury auction cycle as more on-the-run Treasury securities are held by long-only investors that typically do not lend securities. In addition, D'Amico et al. (2018) and Corradin and Maddaloni (2020) show how central bank purchases can create scarcity, resulting in an increase in repo specialness in U.S. and European markets, respectively. These papers prove that asset scarcity increases repo specialness. However, Graveline and McBrady (2011) shows that, controlling for Treasury supply, specialness also increases as the demand to hedge interest rate risk increases. Put together, these insights indicate that specialness captures more broadly the need to intermediate specific securities.[5] In our analysis we show that, controlling for Treasury supply, an increase in specialness corresponds to an increase in re-use implying that dealers provide more specific securities though re-use when needed.

Our findings contribute to the growing literature on safe assets and the interaction between publicly and privately produced safe assets. Nagel (2016) shows that the safe asset convenience yield depends on the level of interest rates. Krishnamurthy and Vissing-Jorgensen (2015), Greenwood et al. (2015), and Sunderam (2014) show that an increase in the demand for safe assets prompts private agents to create more short-term debt, making the financial system more fragile. Infante (2020) shows that this sensitivity depends on the safe asset status of the collateral backing that

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[5] The additional increase in specialness may be driven by an increase in hedging demand, shorting demand, or search frictions. In this paper we are agnostic as to what drives the level of specialness.

short-term debt, as an increase in the demand for safe assets leads investors to hold longer-term safe assets directly, rather than use them as repo collateral. In this paper we find evidence that both sensitivities are at play: as the demand for safe assets increases, our collateral multiplier increases, suggesting that dealers create more private safe assets through SFTs with the remaining Treasuries they own, and they distribute more Treasuries directly to investors that demand them.

From a historical perspective, Gorton, Laarits and Muir (2020) document that forcing short-term debt to be backed by safe public assets does not necessarily reduce financial fragility. However, Infante and Ordoñez (2020) theoretically show that the use of Treasuries as collateral increases risk sharing when future macroeconomic volatility increases, demonstrating that using public assets as collateral produces a positive externality. In our analysis we find that an increase in the demand for safe assets increases Treasury re-use, increasing interconnectedness and leverage, but with safe collateral; thus, the overall impact on financial stability is less clear.

Our analysis is complimentary to Correa et al. (2020) who use the same data to study how U.S. banks provide global liquidity. Correa et al. (2020) find that U.S. dealers' repo remains unchanged with Treasury issuance, which is consistent with our finding that increased Treasury issuance increases dealers' positions relative to their repo, or in other words, decreases their re-use. In this paper, we also study the behavior of non-U.S. dealers to underscore their different incentives to participate in short-term funding markets. [6] Importantly, our focus is on dealers' distribution of collateral, rather than their funding.

Finally, our study of Treasury re-use following the COVID-19 outbreak is related to He et al. (2020) and Duffie (2020). These papers highlight that restrictions on dealers' balance sheets reduced their capacity to intermediate the market, which severely affected market functioning. These insights are consistent with our observation that dealers' Treasury long positions increase more than their reverse repo, resulting in a large drop in Treasury re-use.

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[6] Correa et al. (2020) implicitly recognizes different behavior across jurisdictions by focusing on quarter-end dates. We focus on dealers' activity outside of their window dressing incentives.

2 Conceptual Framework

Traditionally, measuring Treasury re-use has been difficult given the lack of available data. Our measure of collateral re-use is the ratio of a firm's total amount of SFTs to the amount of securities they hold that are financed by SFTs. This measure, which we call the collateral multiplier, is similar to a money multiplier. While the money multiplier measures deposits as a multiple of total reserves owned, the collateral multiplier measures SFTs as a multiple of total Treasuries owned.

There are important differences between the collateral multiplier and the money multiplier. Perhaps the most relevant is that the assets backing deposits in the money multiplier can be anything, while the assets backing SFT liabilities in the collateral multiplier have to be SFTs themselves. However, the money and collateral multipliers are similar in that they measure the way in which reserves and Treasuries pass through financial firms as they create new private deposits and repo, respectively.

In this section we provide two stylized illustrations to interpret how the collateral multiplier captures re-use, and how different drivers may affect re-use. The first assumes re-use is concentrated *within the dealer sector*; and the other assumes dealers solely intermediate cash and collateral circulates *between investor types* through dealers. We view these stylized illustrations as two extreme examples: one in which all Treasuries are distributed within the dealer sector and another where Treasuries are intermediated between different sectors through dealers. In practice, dealer re-use is likely a combination of the two. While in both illustrations, Treasuries are finally posted to cash investors who "hold" Treasuries in the form of SFTs; the way securities are sourced and distributed differ.

2.1 Re-use Within the Dealer Sector

Figure 1 gives a stylized illustration of how the collateral multiplier measures the amount of Treasuries dealers make available to other dealers, or put differently, the amount of Treasuries dealers "multiply". The green diamond on the left represents all of the Treasuries available to dealers T. Each T-account to the right represents an individual dealer, with the dealer furthest to the right being the largest. The blue rectangle on the liability (right) side of dealer i represents its secured borrowing R_i, and the blue rectangle on the asset (left) side of each dealer represents its secured lending. Dealers also directly hold Treasuries, represented by the smaller green diamonds P_i. The largest dealer furthest to the right obtains secured funding outside the dealer community. However, for the remaining dealers, all of their borrowing comes from another dealers' lending. In the stylized setting of Figure 1, if every dealer has the same collateral multiplier $CM = CM_i = R_i/P_i$, then the total sum of all secured funding $\sum R_i$ is equal to the multiplier CM times the total amount of Treasuries available to dealers T, that is, $\sum_i R_i = CM \times T$. In other words, dealers are creating CM times more liabilities than there are assets, which can be interpreted as dealers "multiplying" the total amount of Treasuries available.[7]

[Insert Fig. 1 Here]

We interpret CM as measuring dealers' intermediation of securities. Specifically, if CM is large (small), then dealers are distributing many (few) Treasuries to clients/counterparties, affecting clients'/counterparties' ability to trade in the Treasury cash market. The collateral multiplier depends on the total volume of Treasuries in the market and dealers' ability and/or willingness to intermediate the Treasury market.

The multiplier as shown in Figure 1 can also be interpreted as the average amount of times a security is used as collateral through SFTs, that is, the average length of the collateral chain. This interpretation has financial stability implications, as a longer collateral chain is associated with higher leverage and more interconnectedness.[8] Specifically, longer collateral chains increase both the probability and the magnitude of disruptions that propagate throughout the financial system. These events are commonly known as "daisy chains" (see (Fleming and Garbade, 2007)). In the stylized setting of Figure 1, if every dealer has the same collateral multiplier CM, then the average chain length is

$$\sum_i i \frac{P_i}{T} = CM$$

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[7] This stylized view of dealer balance sheets illustrates how one collateral class is used and re-used. In reality, dealer balance sheets have other types of assets (e.g., holding of different collateral classes) and liabilities (e.g., equity).

[8] Specifically, FSB (2017*b*) highlight the financial stability implications of large collateral chains. Chang (2019) theoretically studies how collateralized dealer networks that take into account counterparty risk can create contagion.

That is, the volume-weighted average length of the chain is CM. From this perspective, a higher CM increases the likelihood and severity of a "daisy chain" event.

2.2 Re-use Between Investor Types

Figure 2 gives a simpler interpretation of the collateral multiplier, by considering a consolidated dealer sector that intermediates funds and collateral between cash investors and a leveraged investor sector (e.g., hedge funds), which is similar to the market structure modeled in He et al. (2020). [9] Under this view, the collateral multiplier measures the amount of Treasuries dealers post to cash investors relative to how many they hold directly. In this case, the total amount of Treasuries available is held by dealers and other leveraged investors. The upper green diamond on the left represents all of the Treasuries available to dealers T, and the lower green diamond on the left represents all of the Treasuries available to levered investors T'. The T-account to the right represents the consolidated dealer sector. The blue rectangle on the liability (right) side represents the sectors' total secured borrowing R from cash investors, and the blue rectangle on the asset (left) side represents the sectors' total secured lending RR to levered investors. That is, the multiplier satisfies $R = P \times m = P + RR$, and on aggregate, $R = T + T'$.

[Insert Fig. 2 Here]

From this perspective, the CM indirectly captures what fraction of funds are used to buy securities and what fraction of funds are use to support levered investors. A larger CM entails improved market liquidity, as there is more financing available to levered investors, but decreased financial stability, as there is more leverage in the financial system.

The following subsections describe various drivers that we expect would affect collateral re-use, along with how we should expect the collateral multiplier to respond to changes in these drivers under both stylized illustrations. First, we explain how system-wide re-use should be affected by changes in the supply of Treasury securities, whether caused by Treasury issuance or changes in the Fed's holdings of Treasuries. Following Infante, Press and Saravay (2020), we also explore three

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[9] We thank Quentin Vandeweyer for encouraging us to include this stylized example.

dealer-specific incentives that motivate dealers to change their degree of collateral re-use: 1) the intermediation of cash through SFTs, 2) the efficient re-distribution of U.S. Treasuries that are in high demand, and 3) the distribution of U.S. Treasuries' safe asset status.

2.3 Supply Effects

From the perspective of Figure 1, we can see that, keeping the total amount of SFTs constant, an increase in the total amount of Treasuries should decrease the collateral multiplier. Intuitively, a larger supply of Treasuries reduces the need to re-use them. From the perspective of Figure 2, the effect depends on whether the newly issued securities are held by dealers or other investors; that is, whether T or T' increases. To the extent that dealers take-up more Treasury securities relative to other investors as supply increases, we would expect the collateral multiplier to decrease.

These insights lead to two empirical predictions. First, the collateral multiplier will decrease with U.S. Treasury issuance. Second, the collateral multiplier will increase with Treasury purchases by the Fed. Fed purchases reduce the amount of Treasuries available to dealers, resulting in a higher multiplier.[10]

2.4 Dealer-Specific Incentives Behind U.S. Treasury Re-use

Infante, Press and Saravay (2020) point to three possible incentives dealers may have to re-use Treasuries.[11] It is important to note that we would expect many of these dealer-level incentives to be concentrated in different segments of U.S. repo markets. For example, the intermediation of cash is likely to occur between the tri-party and bilateral repo market, as large, creditworthy dealers access both of these markets to intermediate funds between risk-averse cash lenders and less creditworthy cash borrowers.[12] The intermediation of securities is likely concentrated in the bilateral repo market, where counterparties can specify the underlying collateral used in each repo transaction, allowing dealers to source and distribute securities that may be in high demand. Unfortunately, the

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[10] These frameworks are silent on the potential effect of an increase in bank reserves.

[11] Infante, Press and Saravay (2020) characterize these incentives as "drivers." In this paper we expand the concept of drivers to include supply effects, and characterize firm-level incentives to re-use Treasuries as "dealer-specific incentives."

[12] Bowman et al. (2017) show that a large fraction of trades used to calculate SOFR come from the bilateral repo market, indicating its increased importance for dealers to raise funds.

FR 2052a data cannot accurately distinguish whether a dealer's repo is in the bilateral or tri-party repo market, but the repo collateral multiplier accurately measures each dealer's repo across both segments of U.S. repo markets. [13] However, the differences across markets inform us on which spreads are more likely to capture dealers' different incentives to re-use securities, which we discuss in section 3.1.

Below, we detail each of these dealer-specific incentives and present an empirical strategy to test their relationship with re-use.

2.4.1 Intermediation of Cash

In the U.S., large dealers stand between the two largest segments of the repo market, intermediating cash from relatively risk-averse cash lenders to less creditworthy cash borrowers. This activity, often referred to as matched book repo, is the simplest form of rehypothecation. If the intermediation of cash is an important economic driver to re-use collateral, an increase in the profitability of matched book repo would lead dealers to participate more heavily in this activity, thereby increasing the collateral multiplier. Empirically, as the spread between the repo rate of cash borrowers and the repo rate of cash lenders increases, matched book repo becomes more profitable, incentivizing dealers to increase their volume of reverse repo and repo.

In particular, from the perspective of Figure 1, an increase in repo borrowing from cash investors will translate into an increase in R_1.[14] As more of these funds are distributed to other dealers (i.e., larger R_i with $i > 1$), we would expect an increase in $\sum_i R_i$, which causes an increase in the collateral multiplier. From the perspective of Figure 2, higher intermediation profits would incentivize dealers to increase their borrowing and lending, that is, R and RR; which would put upward pressure on the collateral multiplier.

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[13] Previous versions of this paper did show results splitting the data by these two dimensions, but a more detailed comparison of the data with other tri-party repo data sources shows that for some firms the classification in our data is inaccurate. For some firms, the correlation between tri-party repo volumes in FR 2052a and and those in other data sources is between .5 and .6, indicating that these classifications are unreliable.

[14] Note that R_1 represents the "end-of-the-line" of collateral re-use, consistent with the idea that cash lenders in the non-GCF portion of the tri-party market rarely re-use securities.

2.4.2 Intermediation of Specific Treasury Securities

Dealers rely heavily on SFTs to source and distribute Treasuries that are in high demand. This can result in long collateral chains, as search frictions may cause one security to move between many dealers before it reaches the ultimate user. From the perspective of Figure 1, if the intermediation of specific Treasury securities is an important economic driver, an increase in demand to source securities would increase the average length of collateral chains, thereby increasing the collateral multiplier. Empirically, when the need to intermediate specific Treasury securities is particularly acute, repo specialness—the spread between a general collateral repo rate and the specific issue repo rate—will be large.[15] Thus, when specialness is high we would expect the average length of collateral chains to increase, resulting in an increase in the collateral multiplier.

From the perspective of Figure 1, an increase in the demand for specific securities will translate into an increase in $\sum_i i \frac{P_i}{T}$, as more dealers look to source securities, lengthening the collateral chain. This would put upward pressure on the collateral multiplier. From the perspective of Figure 2, there is no direct prediction as to how the multiplier should change with demand for specific securities. In this framework, Treasuries are only distributed to cash investors, who, in general, do not care about the specific security within a collateral class.

2.4.3 Distribution of Treasuries Safe Asset Benefits

U.S. Treasuries play a special role as one of the most sought after safe assets in today's financial markets. These securities provide benefits above and beyond their risk-adjusted return. In addition, existing literature has shown that there is a term structure of the aforementioned benefits.[16] Through Treasury re-use, dealers can source and distribute the benefits of long-term safety for short periods of time. In this sense, dealers can "multipy" the safe asset benefits of U.S. Treasuries.

From the perspective of Figure 1, an increase in the demand for safe assets would result in an increase in the the volume-weighted length of the collateral chain, $\sum_i i \frac{P_i}{T}$. This effect is similar

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[15] Specialness can capture search frictions, increases in hedging demand, or overall asset scarcity; all of which increase the need to intermediate securities. See the literature review for a discussion on the link between asset scarcity and specialness.

[16] For example, Krishnamurthy and Vissing-Jorgensen (2012) and van Binsbergen et al. (2020) shows that investors value long- and short-term safety differently.

to that of sourcing specific Treasury securities, but in this case, counterparties only care about sourcing any type of Treasury securities. From the perspective of Figure 2, given the sensitivities documented by Infante (2020), the prediction is unclear. On the one hand, an increase in the demand for safe asset *reduces* the amount of repo available to cash investors (decrease in R), as non-dealer decide to hold Treasuries directly. On the other hand, the increase in non-dealers' direct holdings implies a reduction in the total amount of Treasuries held by dealers (decrease in P). Thus, from this perspective, the net effect is unclear.[17]

3 Empirical Analysis

The conceptual framework of section 2.1 and, in part, section 2.2, leads to the following empirical predictions:

* **Prediction 1**: An increase in the supply of U.S. Treasuries, caused either by an increase in Treasury outstanding or a reduction in the Fed's Treasury holdings, leads to reduced Treasury re-use. That is, an increase in Treasury supply decreases the collateral multiplier.

* **Prediction 2**: An increase in the profitability of repo cash intermediation leads to increased Treasury re-use. That is, an increase in the spread between dealers' reverse repo rate and dealers' repo rate increases the collateral multiplier.

* **Prediction 3**: An increase in demand for specific Treasury securities leads to increased Treasury re-use. That is, an increase in repo specialness increases the collateral multiplier.

* **Prediction 4**: An in increase in the demand for safe assets leads to increased Treasury re-use. That is, an increase in the safe asset convenience yield increases the collateral multiplier.

3.1 Data

To estimate dealers' collateral re-use, we use data from the FR 2052a Complex Institution Liquidity Monitoring Report, which is collected by the Federal Reserve Board in order to obtain a

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[17] Empirically, we will show that the decrease in direct holdings outweighs the decrease in SFTs, resulting in an increase in the collateral multiplier, consistent with the perspective in Figure 1.

comprehensive view of banking organizations' liquidity profiles. The largest domestic bank holding companies (BHCs) and foreign banking organizations (FBOs) report FR2052a daily, while smaller BHCs and FBOs report monthly. Reporting entities are required to submit data for the parent company, as well as any subsidiaries with a material presence in the U.S., allowing us to identify the dealer entities of large BHCs. The data detail secured borrowing and lending transactions, wholesale financing transactions, unencumbered asset positions, and various other activities relevant to overall firm liquidity.

This analysis centers on the U.S. Treasury financing activities of the nine largest primary dealer subsidiaries of Globally Systemically Important Banks (G-SIBs).[18] We focus on primary dealer subsidiaries because secured borrowing and lending activities are primarily located in the dealer entity, and because of the particular importance of primary dealers' activities in the U.S. Treasury market.[19] In addition, we limit our sample to external transactions, because dealers' internal transactions with affiliated entities may be motivated by idiosyncratic factors and are subject to different regulatory constraints. The period of analysis is between January 14, 2016, and April 17, 2020.

The FR2052a data allow us to track the flows of collateral at the individual dealer level, including information about the type of contract and the settlement venue. [20] In addition to the contract type, we can see whether dealers have labelled incoming collateral as encumbered or outgoing collateral as rehypothecated.[21]

Figure 3 illustrates how SFTs (blue rectangles) and cash trades (green diamonds) would appear on a dealer's balance sheet, highlighting what constitutes encumbered or rehypothecated collat-

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[18] Our sample is limited to primary dealer entities who report daily without any lapses over one month. These firms are Bank of America, Barclays, Citigroup, Credit Suisse, Deutsche Bank, Goldman Sachs, JP Morgan, Morgan Stanley, and Wells Fargo.

[19] Primary dealers are the main counterparties of the Federal Reserve Bank of New York and are active participants in U.S. Treasury markets. For example, they are expected to bid in all Treasury auctions at reasonably competitive prices.

[20] Contract types include reverse repos, collateral swaps, securities borrowing, and margin loans for collateral inflows transactions, and repo, firm shorts, collateral swaps, customer shorts, and securities lending for collateral outflow transactions.

[21] Incoming collateral is defined as encumbered if it is simultaneously used in a collateral outflow transaction or the firm is legally, contractually, or operationally restricted from recirculating it. Outgoing collateral is defined as rehypothecated if it was sourced through an incoming SFT. In this paper, "re-use" and "rehypothecation" are used interchangeably.

eral.[22] On the asset side, incoming collateral can be unencumbered, meaning the collateral is still available for re-use, or encumbered, meaning the collateral has already been re-used or it is restricted from re-use. Unencumbered assets are financed by unsecured debt or equity (yellow ovals). On the liability side, outgoing collateral can be non-rehypothecated, meaning the collateral was sourced from a long position, or rehypothecated, meaning the collateral was sourced from an incoming SFT. Importantly, the FR2052a data does not report encumbered long positions, but non-rehypothecated outgoing SFTs can serve as a proxy, since by definition they are sourced from encumbered long positions.[23]

[Insert Fig. 3 Here]

[Insert Fig. 4 Here]

Figure 4 shows the total flows of U.S. Treasury collateral for the dealers in our sample. About 85 percent of incoming Treasuries are re-used in outgoing transactions. Infante et al. (2018) show that dealers predominantly re-use Treasuries through repurchase agreements (repos), underscoring the importance of repo for U.S. Treasury intermediation. This importance is likely driven, in part, by the limited restrictions on dealers to re-use repo collateral, the high degree of leverage that can be taken through repos, and the seniority of repos in bankruptcy.

Figure 5 shows the total amount of outgoing Treasury SFTs and the total amount of Treasuries owned but financed through SFTs, labeled as non-rehypothecated Treasuries. That is, the figure shows the cross-sectional sum of the numerator and denominator of all dealers' collateral multiplier in our sample. From these aggregate numbers, we see that the total amount of SFTs backed by Treasuries is an order of magnitude larger than the total amount of Treasuries actually owned. In addition, both series exhibit abnormally large dips at a steady frequency. These dips are on quarter-end, which is associated with firms' incentives to window dress on regulatory reporting dates. This incentive is well documented by Munyan (2017), and quarter-ends are one of the main areas of focus of Correa et al. (2020). Given that in this paper we want to understand the economic

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[22] This stylized dealer balance sheet represents transactions involving a single collateral class, allowing us to match up assets and liabilities that use the same collateral.

[23] The identification of non-rehypothecated outgoing SFTs as long positions financed by SFTs has been used in the Federal Reserve's Financial Stability Report.

drivers behind re-use, the bulk of the analysis eliminates quarter-end dates. In section 3.6 we explore how the collateral multiplier changes throughout quarter-end.

[Insert Fig. 5 Here]

Following the conceptual framework described in section 2, the collateral multiplier is the ratio of outgoing collateral to non-rehypothecated outgoing collateral. We first calculate the measure at the dealer level and then take an average across dealers. Because primary dealers lie at the core of collateral circulation, averages of our firm-level measures are valid proxies for estimating re-use at the system-wide level. We also measure the level of re-use by U.S. and non-U.S. dealers, by taking the average multiplier across these separate samples. As mentioned previously, we calculate different versions of the multiplier to measure the degree to which dealers re-use collateral through particular contract types. [24] Figure 6 shows the level of the aggregate and repo collateral multipliers for U.S. Treasuries, which exhibit similar time series variation. The aggregate collateral multiplier shows that primary dealers can create up to seven times as many private liabilities backed by Treasury securities as they own. The figure also shows a sharp drop in both collateral multipliers towards the end of our sample period, which coincides with the market turmoil in Treasury markets in March 2020.

We test our framework's predictions on different versions of the collateral multiplier, as we would expect some predictions to be more salient for different contract types. We first consider the all contracts (aggregate collateral multiplier, AC), and then, isolate the changes in repo (repo collateral multiplier, RP) given that repo is the most prevalent and flexible contract that uses Treasury collateral.

We denote these different versions of the collateral multiplier by CM_{jpt}, which is the average collateral multiplier for j dealers, where $j \in \{All, US, non\text{-}US\}$, using p contracts, where $p \in \{AC, RP\}$, at time t.[25]

[Insert Fig. 6 Here]

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[24] When calculating the multiplier for a specific transaction type, the numerator is limited to that specific transaction type, while the denominator is always total amount of non-rehypothecated collateral, which represents the total amount of collateral available for re-use.

[25] The data file for these series are part of the accessible materials associated with this FEDS Working Paper.

To measure supply effects, we use auction results published by TreasuryDirect to construct time series of the changes in outstanding T-bills, $\Delta log(TbillsOut_t)$, and Treasury notes and bonds, $\Delta log(USTnotesOut_t)$, to proxy for issuance.[26] We also use the Federal Reserve H.4.1 Statistical Release to calculate changes in the Fed's holdings of Treasury securities in the System Open Market Account Holdings (SOMA) portfolio, $\Delta log(SOMA_t)$.[27] Figure 7 shows the daily log changes in Treasury bills outstanding and notes and bonds outstanding, along with daily log changes of the Fed's Treasury holdings. Log changes in T-bills are larger, given that their total outstanding is much smaller than for notes and bonds. Moreover, we see a sharp increase in SOMA holdings of U.S. Treasuries, followed by a large increase in T-bills outstanding towards the end of our sample. These sharp changes in total outstanding available to the public correspond to the official sector's response to the Treasury market turmoil caused by the COVID-19 pandemic.[28]

[Insert Fig. 7 Here]

We rely on spreads to measure dealers' incentives to re-use collateral. The degree of cash intermediation in the repo market, $(GCF-TPR)_{t-1}$, is measured by the spread between overnight Treasury DTCC GCF Repo Index rate and the BNY Tri-Party Repo Index, downloaded from the The Bank of New York Mellon's website. Large dealers typically lend in the GCF Repo market and borrow from the general tri-party repo market, making the spread between the two a measure of dealers' incentives to intermediate cash. Our measure of specialness, $(SOFR - RPSpecial)_{t-1}$, is the spread between the SOFR rate, downloaded from the Federal Reserve Bank of New York's Treasury Repo Reference Rate website, and a trade-weighted on-the-run Treasury repo rate in the specific issue repo market, which is calculated using data provided by the repo interdealer broker community. Finally, the convenience yield for holding safe assets, $(OIS - Tbill)_{t-1}$, is measured by the yield difference between a contract with a risk-free payoff that does not imply physical ownership of an asset and a risk-free safe asset (e.g., T-bills).[29] In the data, we use the one-month

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[26] We would like to thank staff in the Division of Monetary Affairs at the Federal Reserve Board for downloading, organizing, and updating the data from TreasuryDirect.

[27] The data file for these series are part of the accessible materials associated with this FEDS Working Paper.

[28] See section 4 for more details.

[29] Of note, in this paper the empirical measurement of the convenience in has the opposite sign as that of Infante (2020).

overnight indexed swap rate (OIS) for the risk-free rate, downloaded from Bloomberg and the four-week T-bill rate for the safe asset rate, downloaded from the Federal Reserve H.15 Statistical Release. Figure 8 shows all the spreads we use to capture dealers' incentives to re-use Treasuries.

[Insert Fig. 8 Here]

Table 1 shows the summary statistics of our main variables of interest: changes in dealer average collateral multipliers, changes in U.S. Treasury supply, and the relevant spreads capturing dealers' different incentives to re-use Treasuries.

[Insert Table 1 Here]

Table 2 shows the correlation matrix between the 1-day log changes of different versions of the multiplier. As discussed previously, we expect dealers to adjust their re-use activity differently across jurisdictions and contract types. From the table, we can see that the correlation between U.S. and non-U.S. dealers' collateral multipliers is relatively small, suggesting that dealers' participation in SFT markets depends on their jurisdiction. We can also see that the aggregate and repo collateral multiplier are highly correlated, consistent with Infante et al. (2018) who document that dealers conduct the vast majority of Treasury SFT activity through repo. [30]

[Insert Table 2 Here]

3.1.1 Relationship with Other Measures of Collateral Re-use

To understand our re-use measure, it's instructive to compare it to other measures proposed in the literature. For example, FSB (2017*a*) proposes a collateral re-use measure that relates the amount of collateral received to all of the collateral that can be accessed, scaled by the amount of collateral posted. From the perspective of Figure 3, this measure captures the blue squares on the assets side divided by the sum of the blue squares and the entirety of the green diamond on the asset side; times all outgoing collateral on the liability side.[31] One drawback of this measure is that the

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[30] The correlation matrix of 5-day log changes gives qualitatively similar insights.

[31] There is a small amount of incoming collateral on the asset side that would be restricted from re-use for contractual reasons, and therefore would not be included in the FSB measure. The amount of this contractually encumbered collateral, which can be measured as the difference between encumbered collateral and rehypothecated collateral, is relatively small, as shown in Figure 4.

amount of re-use depends on the size of the dealer's SFT activities. This means that the re-use activity of one large dealer may dwarf the activity of others. FSB (2017*a*) resolve this issue by proposing a scale free measure of re-use,

$$reuse_i^{rate} = \frac{collateral_i^{posted}}{collateral_i^{received} + assets_i^{own}},$$

which is the $collateral_i^{reused}$ divided by the amount of collateral received. This normalizes the measure relative to each individual dealer's size.

However, relative to our collateral multiplier, this measure has another drawback. Namely, $reuse_i^{rate}$ takes into account all of the dealer's asset holdings, both those financed through SFTs and those financed through unsecured liabilities. In contrast, the collateral multiplier only takes into account securities financed through SFTs. This distinction is important to capture the degree of re-use. For example, if a dealer were to raise equity and use those proceeds to redeem a large fraction of the SFTs backing their direct asset holdings, an ideal measure of re-use would increase. In this case, the securities that are now financed by unsecured debt aren't being used at all, and thus, they should not be included in a measurement of re-use. By redeeming outstanding SFTs with unsecured debt, in relative terms, the dealer is increasing their amount of re-use, and thus, we should expect an accurate measure of re-use to increase. In this example, the $reuse^{rate}$ is constant while the CM increases.

Despite these differences, these measures are closely related. Specifically, in a stylized case when a firm does not use any unsecured liabilities to finance either their direct asset holdings or incoming SFTs, these measures are related by the following equation

$$CM_i = \frac{1}{1 - reuse_i^{rate}}.$$

3.2 Aggregate and Repo Collateral Multiplier

In this section, we test the empirical predictions derived from our conceptual framework, outlined at the start of section 3. Specifically, we run the following regression

$$\begin{aligned}\Delta\log(CM_t) &= \alpha + \sum_l \eta_l \Delta\log(CM_{t-l}) \\ &\quad \gamma Spreads_{t-1} + \beta\Delta\log(Gov_t) + \theta X_{t-1} + \epsilon_t \qquad (1)\end{aligned}$$

where CM_t is CM_{jpt}, the different versions of the collateral multiplier described in section 3.1. For each collateral multiplier, we take daily log changes as the dependent variable and include four lags as independent variables to control for serial autocorrelation. We consider averages across different samples of dealers, as collateral re-use may depend on dealers' regulatory jurisdictions. We also winsorize every version of $\Delta\log(CM_t)$ at the 1% and 99% to eliminate the abnormal impact of outliers. In addition, we remove quarter-end dates, ±2 days around each quarter-end, to avoid picking up the effects of window dressing. In equation (1), $\Delta\log(Gov_t)$ capture the government supply variables and $Spreads_{t-1}$ capture the incentive spreads, both described in Section 3.1. We also include lagged financial variables as controls X_{t-1}, which includes: $(10yr - 2yr)_{t-1}$, the yield difference between the 10- and 2-year U.S. Treasury yield curve; $10yrVIX_{t-1}$, the derivative implied volatility of the 10-year U.S. Treasury bond; VIX_{t-1}, the derivative implied volatility of the S&P index; $MedianDealerCDS_{t-1}$, the median CDS of all the dealers in our sample; and an indicator for mid-March 2020 to capture a possible structural change amid the COVID outbreak.

[Insert Table 3 Here]

Table 3 shows the results for the specification in equation (1) for the aggregate and repo collateral multipliers. The coefficients on the change in the government variables are consistent with prediction 1: an increase in the supply of Treasury securities, either by a reduction of Treasury supply or an increase the Fed's Treasury holdings, increases the collateral multiplier. The result is present across all specifications. These effects are statistically and economically significant.[32] The sensitivity to changes in SOMA appears to be stronger: a 1 standard devia-

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[32] In an alternate specification, we estimate equation (1) including a dummy variable equal to one on the Treasury

tion change in $\Delta log(SOMA_t)$ corresponds to approximately a 0.28 standard deviation change in $\Delta log(CM_{All,All\,Contracts,t})$, whereas $\Delta log(USTnotesOut_t)$ and $\Delta log(TbillsOut_t)$ only correspond to approximately a 0.13 and 0.1 change, respectively.[33]

The results in table 3 also show that the incentive to intermediate cash only affects the collateral multiplier of non-U.S. dealers and the incentive to intermediate securities only affects U.S. dealers. The cash intermediation effect on non-U.S. dealers is stronger for repo, likely because of dealers' flexibility to expand and contract their repo book. The securities intermediation effect on U.S. dealers is stronger for the aggregate collateral multiplier, which also includes firm and client short activities. These results are consistent with the notion that the incentives to participate in U.S. collateral markets differ across jurisdictions. In all specifications of equation 1, the collateral multiplier does not show a statistical relationship to the demand for safe assets, measured through the convenience yield. However, in the following section we fine tune our empirical exercise to isolate the effect of the demand for safe assets on Treasury re-use.

3.3 Closer Inspection of the Demand for Safe Assets

The analysis in section 3.2 does not indicate that Treasury re-use is sensitive to the demand for safe assets, proxied by $(OIS - Tbill)_{t-1}$, our measure of the convenience yield. There may be confounding factors that prevent the previous specifications from capturing this sensitivity. For example, Treasury issuance may capture the impact of changes in short-term T-bills, confounding the effect of safe asset demand. However, following Infante (2020), there is a valid instrument to isolate the sensitivity of investors' demand for safe assets: changes in short-term T-bills outstanding, specifically those with a maturity less than one month, denoted by $\Delta \log(ShTbillsOut_t)$. Because the four-week T-bill rate is lower than prevailing overnight Treasury repo rates, it is unlikely that dealers would finance shorter-maturity T-bills with general collateral repo. Figure 9 shows

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auction settlement date (not shown). In that specification, the point estimate on Treasury issuance is still statistically significant, but somewhat smaller than the estimates in Table 3. This result indicates that while there may be a mechanical component to the effect of Treasury issuance on re-use due to the Treasury auction cycle, the effect of issuance itself is still statistically and economically meaningful.

[33] To calculate the regression coefficients in terms of standard deviation changes for each independent variable, we multiply the regression coefficient by the standard deviation of the independent variable and divide by the standard deviation of the log change in the collateral multiplier.

that the four-week T-bill rate is generally lower than the overnight Treasury repo rate (SOFR), even without accounting for the difference in maturity.[34] Therefore, if dealers funded short-term T-bills with overnight repo they would have negative carry, making it very unlikely they would engage in such a trade. Thus, changes in short-term T-bills outstanding only affect cash investors' demand for safe assets. Specifically, changes in the total supply of short-term public instruments isolate changes in cash investors' investment opportunity set, and thus, their demand for safe assets.[35] Importantly, changes in T-bills outstanding are typically known a day in advance, and the Treasury does not respond to opportunistic changes in rates, making changes in short-term T-bills outstanding largely exogenous. These observations imply that the change in short-term T-bill supply is a good instrument to capture changes in the demand for safe assets.

[Insert Fig. 9 Here]

This empirical strategy leads to the following specification

$$\begin{aligned}(OIS-Tbill)_{t-1} &= \alpha_1+\varphi_1\Delta\log(ShTbills_{t-1})+\sum_l \eta_{1t-l}\Delta\log(CM_{t-l})+ \\ &\quad \gamma_1 Spreads_{t-1}+\beta_1\Delta\log(Gov_{t-1})+\theta X_{t-1}+\epsilon_{t-1} \qquad (2)\\ \Delta\log(CM_t) &= \alpha_2+\varphi_2\widehat{(OIS-Tbill)}_{t-1}+\sum_l \eta_{2t-l}\Delta\log(CM_{t-l})+ \\ &\quad \gamma_2 Spreads_{t-1}+\beta\Delta\log(Gov_{t-1})+\theta X_{t-1}+\epsilon_t \qquad (3)\end{aligned}$$

where in this case $Spreads_{t-1}$ are $(GCF-TPR)_{t-1}$ and $(SOFR-RPSpecial)_{t-1}$, $\Delta\log(Gov_{t-1})$ are $\Delta\log(USTnotesOut_{t-1})$ and $\Delta log(SOMA_{t-1})$, and X_{t-1} are financial data controls used in Table 3. Note that in this empirical exercise, we use lagged government supply variables to make the first stage regression time consistent.[36] As in the baseline regression, four lags of changes in the collateral multiplier are included to control for serial autocorrelation.

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[34] There are notable differences before FOMC meetings, where monetary policy expectations of rate cuts push the longer-maturity T-bill rate lower.

[35] Krishnamurthy and Vissing-Jorgensen (2012), Infante (2020), and Vandeweyer (2019) study the different sensitivity from changes in long- and short-term government bonds.

[36] To understand the impact of issuance on the CM, we also estimate equation (1) including lagged issuance controls (not shown). That specification shows that while lagged issuance variables reduce the economic impact of lagged spreads, they are still statistically and economically significant.

[Insert Table 4]

[Insert Table 5]

Tables 4 and 5 show the results of the empirical strategy in equations (2) and (3) for the all contract and repo collateral multipliers. The coefficient on the convenience yield in the first stage is negative and statistically significant across all specifications. Moreover, all F-statistics of the first stage are greater than 10, reducing any concerns of weak instruments.

Turning to the sensitivity of the convenience yield itself, we find that across all empirical specifications, an increase in the demand for safe assets corresponds to an increase in the U.S. dealers' collateral multiplier. This sensitivity is likely caused by the dealer sector holding fewer Treasuries as outside investors demand more of them, which is consistent with previous literature. In addition, if dealers need to extend the length of collateral chains to distribute safe assets as demand increases, that would put further upward pressure on the multiplier.

The coefficient on non-U.S. dealers only exhibits weak statistical significance for the repo collateral multiplier, however the analysis in section 3.4, which exploits our dealer-level data even further, provides evidence that our measure of average dealer activity may not be fully capturing all of individual dealers' incentives.

3.4 Simultaneous Equation Regressions

The analysis so far has concentrated on changes in cross-sectional averages of dealers' collateral multipliers. In this section we exploit the granularity of our data to use information from firm-level activity. Because the cross-sectional sample size is low, we cannot rely on pooled regressions to give us efficient estimates. However, we can run simultaneous equation regression, which takes into account firm-level behaviour.

3.4.1 Baseline Estimation of Simultaneous Equation Regressions

In this section we estimate the simultaneous equation counterpart of our baseline formulation expressed in equation (4). Specifically, we estimate the following model:

$$\begin{aligned}\Delta \log(CM_{it}) \quad &= \quad \alpha + \sum_{l} \eta_l \Delta \log(CM_{it-l}) \\ &\quad\ \gamma Spreads_{t-1} + \beta \Delta \log(Gov_t) + \theta Z_{t-1} + \theta Z_{it-1} + \epsilon_{it} \qquad (4)\end{aligned}$$

where CM_{it} is dealer i's collateral multiplier at time t, Z_{t-1} are lagged aggregate financial variable controls (i.e., slope of the yield curve, 10-year Treasury VIX, and the S&P VIX), and Z_{it-1} are lagged individual dealer financial variable controls (i.e., dealer CDS). We estimate the model using the two-step GMM method with a heteroskedasticity and autocorrelation consistent (HAC) residual covariance structure with 21 lags, employing a Newey-West kernel.

To understand the differential impact of dealers' incentives to re-use Treasuries across jurisdictions, we run two specifications: One in which all dealers are forced to have the same coefficient on spreads (i.e., γ) and another in which we allow for the coefficients to differ between U.S. and non-U.S. dealers (i.e., $\gamma^{US}, \gamma^{nonUS}$).

Table 6 shows the results of both specifications, across the two types of collateral multipliers. We first observe that coefficients on the supply effects for the all contracts and repo collateral multipliers are very similar to those in the average-level analysis. An increase in aggregate supply, whether from Treasury issuance or a decrease in Federal Reserve holdings, results in a decrease in the collateral multiplier. Similar to the average-level analysis, the simultaneous analysis implies that the effects of change in SOMA are stronger than Treasury supply, indicating that central bank action has more of an impact on dealers' response to asset scarcity.

In terms of dealers' individual incentives, Table 6 confirms the insights from the average-level analysis. First, non-U.S. dealers' repo collateral multipliers are particularly sensitive to intermediation spreads, highlighting their incentive to intermediate cash. Second, U.S. dealers' collateral multipliers are sensitive to the level of specialness, across all specifications. We also see that non-U.S. dealers exhibit a statistically significant sensitivity to specialness, albeit smaller in magnitude than for U.S. dealers.

3.4.2 Safe Asset Demand Estimation of Simultaneous Equation Regressions

In this section we estimate the simultaneous equation counterpart of our instrumental variable specification expressed in section 3.3. Specifically, we estimate the following model:

$$\begin{aligned}\Delta\log(CM_{it}) &= \alpha+\varphi(\widehat{Tbill-OIS})_{t-1}+\sum_{l}\eta_{t-l}\Delta\log(CM_{t-l}) \\ &\quad +\gamma Spreads_{t-1}+\beta\Delta\log(Gov_{t-1})+\theta Z_{t-1}+\theta Z_{it-1}+\epsilon_{it} \qquad (5)\end{aligned}$$

where, as in section 3.3 we use changes in short-term T-bills outstanding as an instrument for the demand for safe assets. Table 7 shows the results of both specifications, across the two types of collateral multipliers. The results are consistent with those in section 3.3, which show that U.S. dealers' collateral multiplier increases as the demand for safe assets increases. In addition, we find that non-U.S. dealers also increase their collateral multiplier as the demand for safe assets increases.

3.5 Weekly Analysis

To understand the longer-term impact of the drivers behind Treasury re-use, we repeat the analysis of section 3.2 at a weekly frequency using overlapping data. Specifically, we estimate the same empirical model in (1) using 5-day changes in the collateral multiplier $\Delta^5\log(CM_t)$ and government outstanding $\Delta^5\log(Gov_t)$, and use 5-day lagged spreads $Spreads_{t-5}$. For this analysis, we include two lags of $\Delta^5\log(CM_t)$ to control for serial autocorrelation, 5-day lagged financial variable controls X_{t-5} used in section 3.2, and eliminate quarter-end dates ± 2 days around quarter-end.

[Insert Table 8 Here]

Table 8 show the results for the weekly frequency analysis. The results are broadly consistent with the results in section 3.2. The supply effects are concentrated on changes in the SOMA portfolio. These results underscore that changes in Fed asset purchases have a strong, longer-lasting impact on how dealers re-use Treasuries. We interpret this as central bank action having a direct effect on the length of the collateral chain, consistent with what Jank and Moench (2020) find in the European market.

In terms of economic magnitude, the coefficients in Table 8 show that a 1 standard deviation of increase in $\Delta^5 log(SOMA_t)$ results in a .38 increase in collateral multiplier for all contracts.[37] Given that the average size of the Fed's Treasury holdings during our sample is approximately \$2.4 trillion and the average length of the chain is 7.1, this implies that a \$ 33 billion dollar increase in SOMA Treasury holdings corresponds to a 0.21 increase in the all contracts collateral multiplier. From these results, we conclude that the Fed can have a strong, longer-lasting effect on dealers' re-use, underscoring the central bank has the ability to alter the overall leverage of the financial sector.

The weekly frequency analysis also shows that U.S. dealers are more sensitive to repo specialness, underscoring their role in distributing collateral. In addition, while statistically weaker, the results also show that non-U.S. dealers are more sensitive to repo intermediation spreads, highlighting their role in distributing funds.

3.6 Quarter-end Behavior

So far our empirical analysis has excluded quarter-end dates, ± 2 days around quarter-end. On those dates, firms' activity is driven by considerations unrelated to the economic drivers studied in this paper, namely window dressing. Because of different regulatory reporting frequencies across jurisdictions, some non-U.S. firms have incentives to reduce the regulatory balance sheet size on quarter-end dates (see section 3.1 for more details). Our re-use measure can provide additional insights into how these firms window dress.

Figure 10 shows the repo collateral multiplier for U.S. and non-U.S. firms near quarter-end dates. The figures depict the average series across all quarter-end dates in our sample. Consistent with existing studies, Figure 10 shows that non-U.S. firms' repo collateral multiplier decreases significantly, indicating a contraction in their repo borrowing. However, given that the multiplier decreases, as does the the total amount of SFTs (see Figure 5), on quarter-end dates we can infer that this contraction is concentrated in rehypothecated repo. That is, in relative terms non-U.S.

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[37] The standard deviation of $\Delta^5 \log(CM_{All,AC,t})$ and $\Delta^5 log(SOMA_t)$ are 0.077 and 0.014, respectively.

dealers choose to reduce their lending rather than sell their Treasury positions.

Interestingly, Figure 11 shows that the all contracts collateral multiplier of non-U.S. firms is flat around quarter-end. The difference between multipliers suggests that these dealers are substituting other types of SFTs for repo. A closer look shows that dealers' multiplier for collateral swaps tends to increase sharply on quarter-end dates. This behavior is consistent with firms' incentives to window dress, as dealers can net out their collateral swap positions, resulting in a smaller regulatory burden. In effect, swaps can be thought of as simultaneous repo and reverse repo with the same counterparty, making them eligible for regulatory netting rules (FIN 41).[38]

Consistent with existing studies, we find that non-U.S. dealers reduce borrowing from cash rich investors. Additionally, we find that this reduction in borrowing comes at the cost of a reduction in lending (i.e., reducing matched book repo) and that their activity migrates to contracts that have a reduced regulatory burden.

4 COVID-19

In this section, we discuss how the collateral multiplier responded to the volatility in financial markets related to the outbreak of COVID-19 in the U.S. during March 2020.

During the first two weeks of March, there were numerous reports of illiquidity in the Treasury cash market. Market participants described the decrease in market liquidity to be driven, in part, by clients' increased selling of Treasuries, which increased dealers' positions and hindered their market making abilities.[39] Amid these liquidity problems, both rehypothecated and non-rehypothecated Treasury SFT volumes increased notably, as dealers financed their new positions and those of their counterparties (see Figure 12). The increase in non-rehypothecated Treasury is consistent with Kruttli et al. (2021), who find that during March 2020 hedge funds borrowed more Treasury repo from large dealers associated with bank holding companies relative to smaller ones. However,

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[38] Dealers can offset exposures for regulatory purposes if trades 1) are with the same counterparty, 2) have the same maturity, and 3) settle on the same platform.

[39] For more detail on the Treasury market liquidity problems caused by the COVID-19 crisis, see Michael Fleming and Francisco Ruela, "Treasury Market Liquidity during the COVID-19 Crisis," Federal Reserve Bank of New York Liberty Street Economics, April 17, 2020. Consistent with market commentary, Barth et al. (2020) also provide evidence of increased selling pressures in the Treasury market caused by hedge funds unwinding their cash-futures basis trades.

during that time, the collateral multiplier decreased significantly, reaching its lowest level in our sample period during the week when market participants reported the most challenging liquidity conditions (see Figure 13). These patterns indicate that while dealers' expanded their balance sheet to support levered investor positions, the increase in lending was not commensurate to the increase in outright positions. The repo collateral multiplier followed a similar trend.

The significant decline of the collateral multiplier in early March demonstrates that as dealers' Treasury positions increased, they did not increase their rehypothecated repo proportionally. From this analysis, it is unclear why a dealer would prefer to increase their outright positions relative to their rehypothecated repo. It could be driven by differences in expected payoffs between Treasury cash and repo markets, making one market more attractive than the other.[40] It could also be driven by an overall increase in counterparty credit risk, which would reduce dealers' incentives to invest in reverse repo.

If instead dealers had increased the amount of rehypothecated repos relative to long positions, re-use would have "normalized." Specifically, the expansion of rehypothecated repo would have backed reverse repos, in part, for speculative investors such as hedge funds to take on levered long positions. Dealers' unwillingness to increase the amount of reverse repos was likely driven, in part, by balance sheet constraints. He et al. (2020) and Duffie (2020) suggest that the supplementary leverage ratio (SLR), a regulatory initiative which is particularly onerous for Treasury market intermediation, restricted dealers from participating, resulting in the market disruption. Specifically, He et al. (2020) argues that regulatory balance sheet costs reduced dealers' incentives to both take on more Treasuries and provide repos to speculative investors, which decreased the price of Treasury securities further than maturity-matched OIS rates. In that model, the allocation between direct holdings and reverse repo depends on the marginal risk adjusted return of holding a levered position in Treasury securities and the return of engaging in a matched book repo to intermediate funding, coupled with the shadow cost of leverage restrictions that disincentivize balance sheet growth.[41] And Duffie (2020) suggests that broader clearing mandates for the U.S. Treasury market

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[40] In equilibrium, the risk adjusted return of holdings Treasuries directly should equal the risk adjusted return of intermediating funds between repo markets. To the extent one strategy becomes more attractive than another, we would expect firms to rebalance their positions accordingly.

[41] In the context of a microstructure model, Huh and Infante (2021) also model the SLR as a size constraint on

would limit its reliance on a subset of dealers that are subject to many internal and regulatory constraints.

In the second half of March, emergency actions by the Fed to improve liquidity conditions in the Treasury market coincided with an increase in both the total and repo collateral multipliers. In effect, Figure 13 shows that the aggregate collateral multiplier changed course on March 12th, when the Fed announced a significant expansion of its repo program (March 12th) and asset purchases (March 13th). The figure shows that dealers' total SFTs peaked around the same time. As noted by Infante, Saravay et al. (2020), this suggests that dealers were able to fund their Treasury holdings, but were more reluctant to finance counterparties' Treasury holdings.

The relationship between developments in the Treasury market and movements in the collateral multipliers during March 2020 can be easily appreciated from the lens of our conceptual framework in section 2.1. All else equal, increased client selling causes an increase in the aggregate supply of Treasuries held by dealers—similar to an increase in Treasury issuance.[42] From the perspective of 1, the green diamond T would increase, resulting in a decrease in the collateral multiplier. Along the same lines, all else equal, Fed purchases of longer-dated Treasuries cause a decrease in the aggregate supply, the green diamond, resulting in an increase in the collateral multiplier. Our conceptual framework also gives a simple interpretation of how the take-up in the Fed's repo program may affect the collateral multiplier. Specifically, an increase in takeup would result in an increase in the total amount of SFTs, the right-most blue rectangle, putting upward pressure on the collateral multiplier. Finally, from our framework the SLR can be interpreted as a restriction on the size of dealers' balance sheet. From this perspective, the rule would have limited the total amount of SFTs to the dealer sector, even if funding were readily available. While this rule would not affect the collateral multiplier of an individual dealer directly, it would limit the amount of re-use for a fixed supply of Treasury securities.

Our empirical results suggest that the Fed's asset purchases had a particularly strong impact on collateral re-use during the COVID-19 outbreak period. To assess the effect of the Fed's actions

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dealers' balance sheet, highlighting in interaction between cash and different segments of the repo market.

[42] However, it is important to note that most of the selling was reportedly in off-the-run Treasuries, which are less liquid than on-the-run Treasuries created from new issuance.

taken during the crisis period on the collateral multiplier, we included $1_{\text{MidMarch2020}}$, an indicator variable equal to one after March 15th, 2020. On this date, the Federal Reserve expanded its asset purchase program, committing to purchase $500 billion dollars of U.S. Treasuries over the coming months in order to "support the smooth functioning of markets for Treasury securities."[43]

From our conceptual framework, we would expect that this date would be associated with an increase in dealers' collateral multiplier. The empirical results in section 3.2 include a dummy variable to capture the change in the Fed policy. However, the results show an insignificant, or even opposing effect. This result suggests that the sharp increase in the collateral multiplier after mid-March was primarily driven by the increase in the Fed's SOMA holdings during that period. In effect, as shown in figure 7, the increase in the Fed's SOMA portfolio was the most significant factor affecting the supply of Treasuries during the second half of March. The decrease in aggregate SFTs, along with the increase in the collateral multiplier, both seen in Figure 13, indicate that as the Fed increased its purchases of Treasury securities, dealers' funding of Treasuries decreased, but their holdings decreased proportionally more, resulting in an increase in the multiplier. That is, the Fed alleviated pressures in the market by taking Treasuries directly off dealers' inventories. In table 9, we repeat the empirical analysis reported in table 3, but exclude changes in the SOMA portfolio. The results show that the coefficient on $1_{\text{MidMarch2020}}$ is positive and statistically significant, indicating that the policy change on that day had a unique effect on dealers re-use of Treasuries. We interpret the increase in the collateral multiplier as an indication that market functioning improved after the intervention, reaching levels seen earlier in the year.

[Insert Fig. 13 Here]

5 Concluding Remarks

In this paper, we provide a conceptual framework to understand the main drivers behind Treasury re-use and use confidential supervisory data to explore their empirical relevance. Using a firm-level measure of collateral re-use called the collateral multiplier, we detail how re-use should change with

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[43] FOMC statement: `https://www.federalreserve.gov/newsevents/pressreleases/monetary20200315a.htm`.

Treasury supply, and explore dealer-specific incentives to adjust re-use, including the intermediation of funds, specific securities, and safe assets. The collateral multiplier can be interpreted as the number of times one security is used for multiple transactions—the length of the collateral chain.

Our empirical work shows that, similar to other jurisdictions, changes in the overall supply of Treasuries have a significant impact on Treasury re-use: an increase in Treasury supply leads to a decrease in Treasury re-use. We also find that the effects of central bank interventions are stronger and persist at lower frequencies. These observations combined suggest that the central bank can effectively reduce the interconnectedness of the financial system by reducing the size of its balance sheet.

We also show that incentives to re-use Treasuries have a differential impact on dealers, depending on their jurisdiction. Non-U.S. dealers' Treasury re-use is correlated with yield spreads between different segments of the repo market, indicative of their role as intermediaries of cash. In contrast, U.S. dealers' Treasury re-use is correlated with on-the-run repo specialness, indicative of their role as intermediaries of specific securities. Identifying dealers' differential roles in Treasury re-use allows regulators to monitor market functioning and measure financial resiliency more effectively.

Importantly, we find that dealers also engage in more Treasury re-use when the demand for safe assets is high. This activity alleviates some of the costs associated with safe asset scarcity, as Treasury re-use distributes safe assets to counterparties that need them most. However, it also increases leverage and interconnectedness with safe asset collateral, which raises other possible sources of risk, such as collateral runs. The overall stability implications of safe asset re-use are an important area of future research.

Finally, we show how re-use was affected by the Treasury market disruptions in March 2020 amid the COVID-19 outbreak. Re-use dropped dramatically as dealers took on more Treasury inventory, at a time when market liquidity was severely strained. We show that re-use rebounded to pre-outbreak levels following the Federal Reserve's announcement of further asset purchases, demonstrating again central banks' important role in curbing or prompting Treasury re-use.

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Figure 1: Stylized Illustration of U.S. Treasury Re-use *Within the Dealer Sector*
The green diamond on the left represents all of the Treasuries available to dealers T, the blue rectangle represent dealer i's funding, and the small green diamonds represents dealer i's direct Treasury holdings. Dashed arrows represent the purchase of a security, while solid arrows represent SFTs.

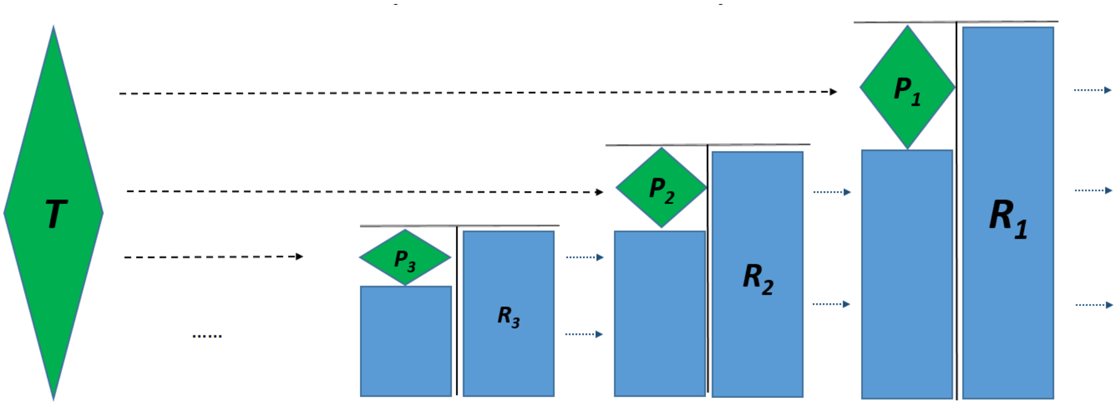


Figure 2: Stylized Illustration of U.S. Treasury Re-use *between Investors Types*
The large green diamond on the upper left represents all of the Treasuries available to dealers T, the large green diamond on the lower left represents all of the Treasuries available to leveraged investors T', the blue rectangles represents dealers' SFTs, and the small green diamond represents dealer's outright holdings. The orange shape represents the levered investor sector which raises SFTs from dealers.

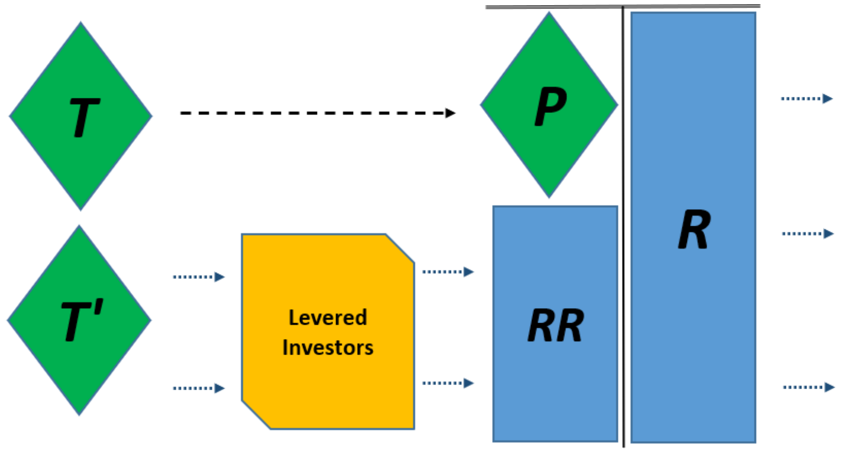


Figure 3: Stylized Illustration of Dealer's Balance Sheet
This figure depicts how SFTs and cash positions would appear on a theoretical dealer's balance sheet for a single collateral class. On the asset side, collateral can be encumbered, meaning it has been re-used or is restricted from re-use, or unencumbered, meaning it is available for re-use. On the liability side, collateral can be rehypothecated, meaning it was sourced from an incoming SFT, or non-rehypothcated, meaning it was sourced from an asset position.

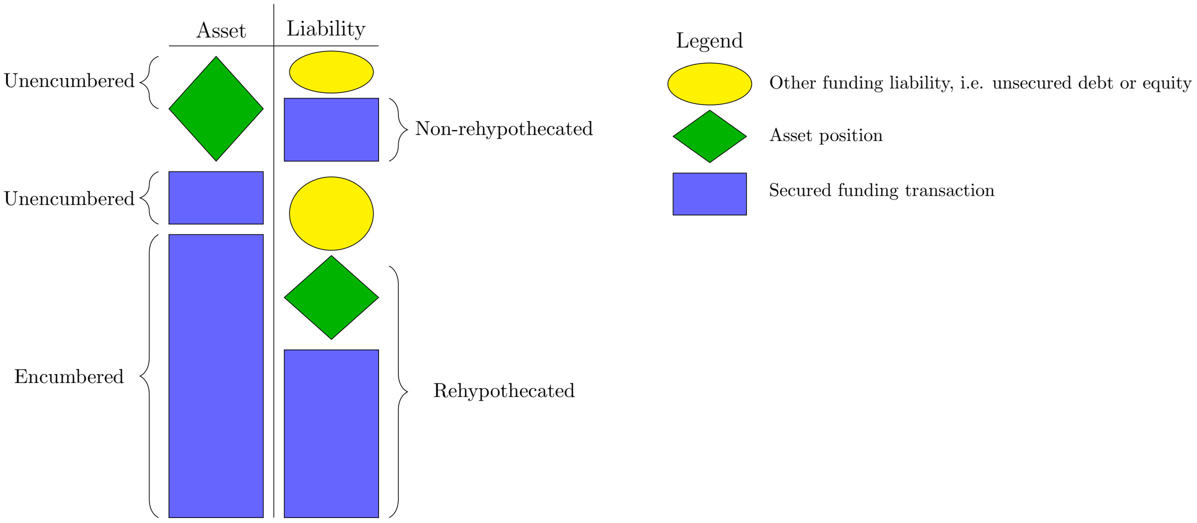
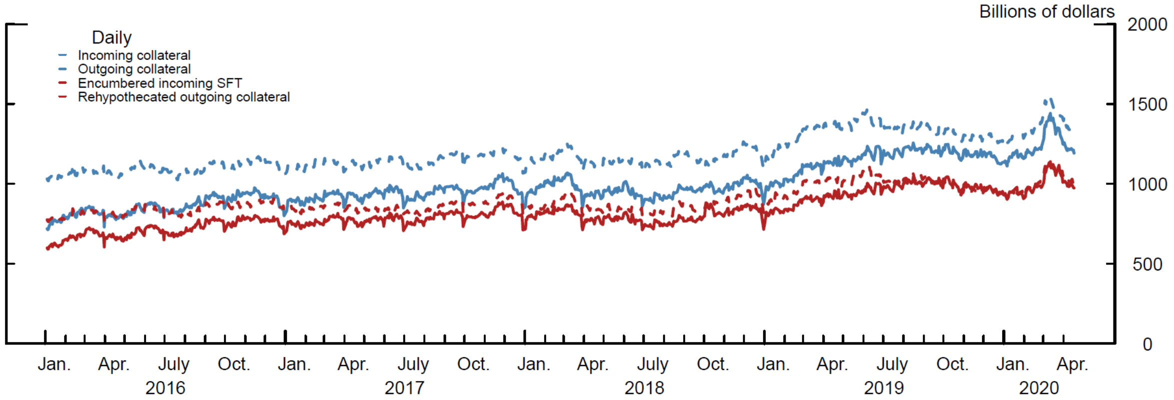
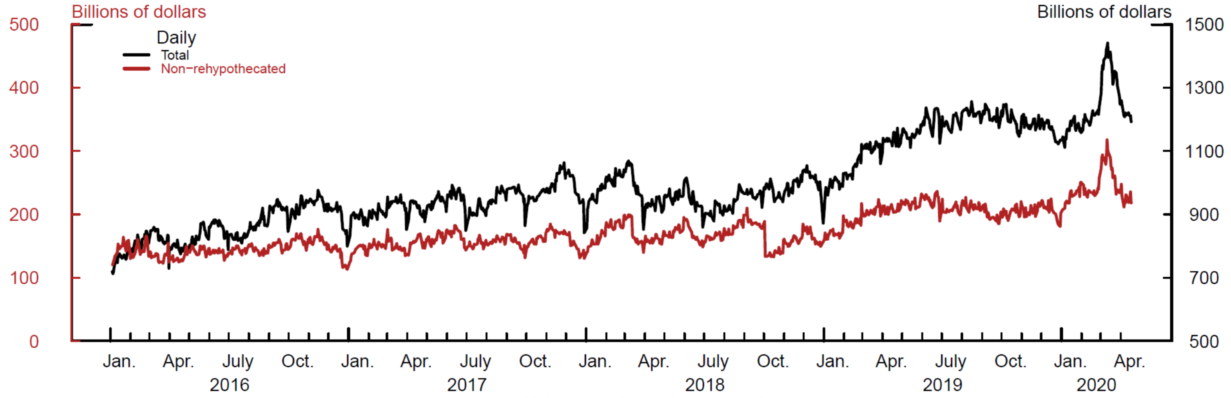


Figure 4: U.S. Treasury Incoming and Outgoing Collateral Volumes
This figure shows the total volumes of incoming and outgoing U.S. Treasury collateral for the dealers in our sample, as well as the amount of encumbered incoming transactions and rehypothecated outgoing transactions.



Source: Federal Reserve Board, Form FR 2052a, Complex Institution Liquidity Monitoring Report.

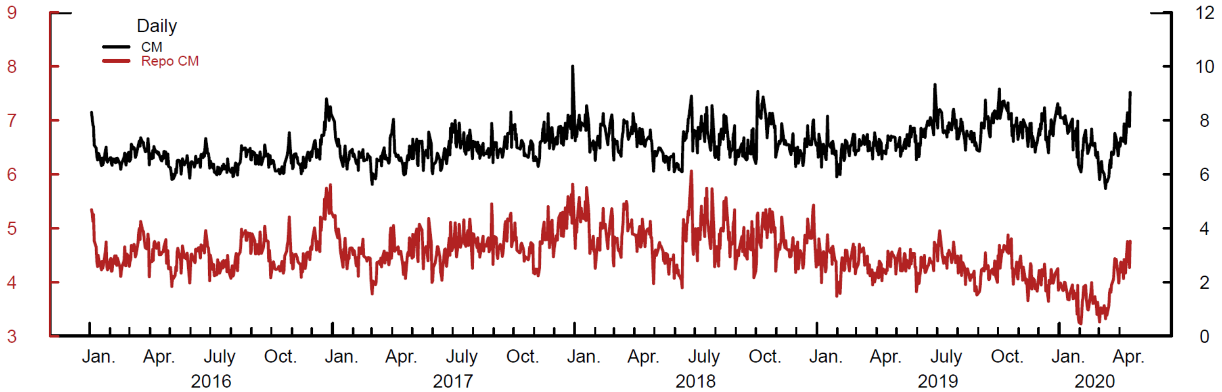
Figure 5: U.S. Treasury Outgoing Securities Financing Transactions
This figure shows the total volume of U.S. Treasury SFTs for the dealers in our sample, as well as the volume that is non-rehypothecated, meaning it was sourced from a firm's holdings. The series depicted in this figure are used at the firm level to calculate the collateral multiplier, which is the ratio between the black line and the red line.



Source: Federal Reserve Board, Form FR 2052a, Complex Institution Liquidity Monitoring Report.

Figure 6: Collateral Multiplier for Treasury Collateral

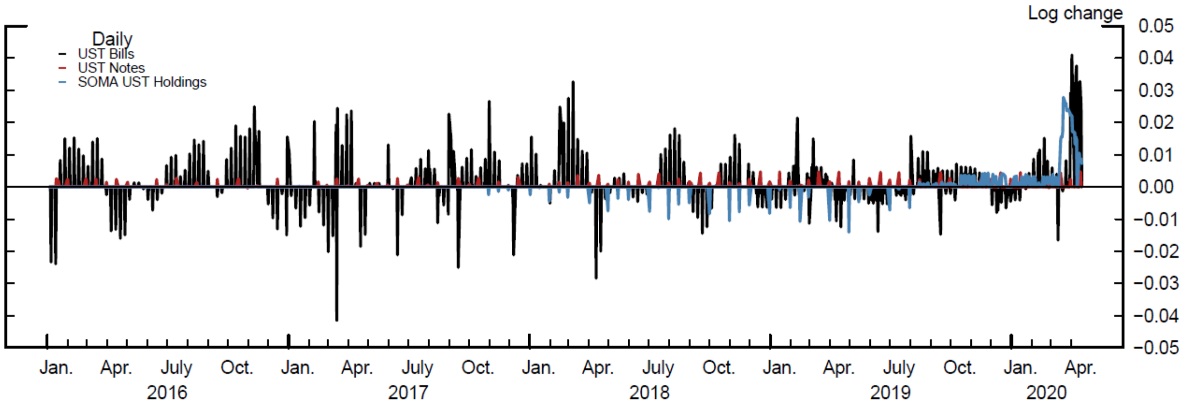
This figure shows the aggregate and repo collateral multiplier, our measure of collateral re-use, for U.S. Treasury collateral. The collateral multiplier is the ratio of outgoing collateral to non-rehypothecated outgoing collateral.



Source: Federal Reserve Board, Form FR 2052a, Complex Institution Liquidity Monitoring Report.

Figure 7: Log Changes in Treasury Supply

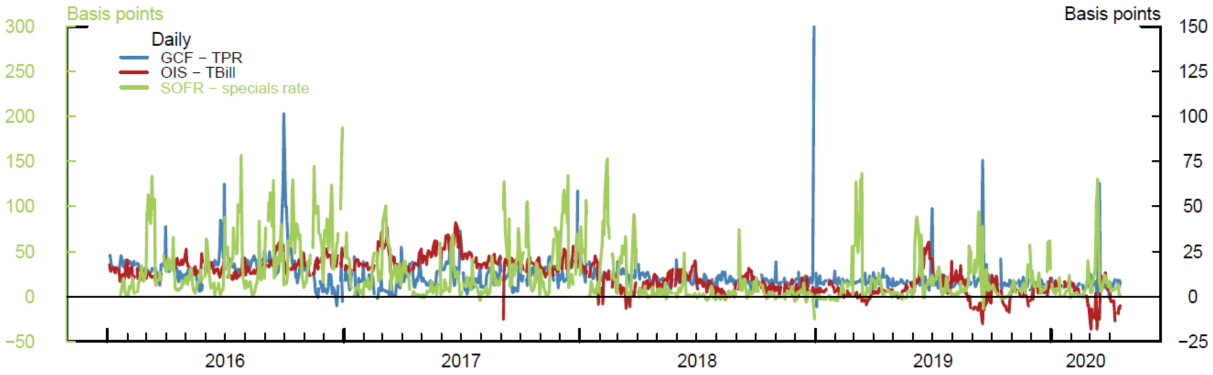
This figure depicts the log changes in the total outstanding of U.S. Treasury marketable securities. The series is a proxy of U.S. Treasury issuance.



Source:Staff calculations based on treasury data from FRBNY and Treasury Direct.

Figure 8: Repo Cash Intermediation, Repo Specialness, and the Treasury Convenience Yield

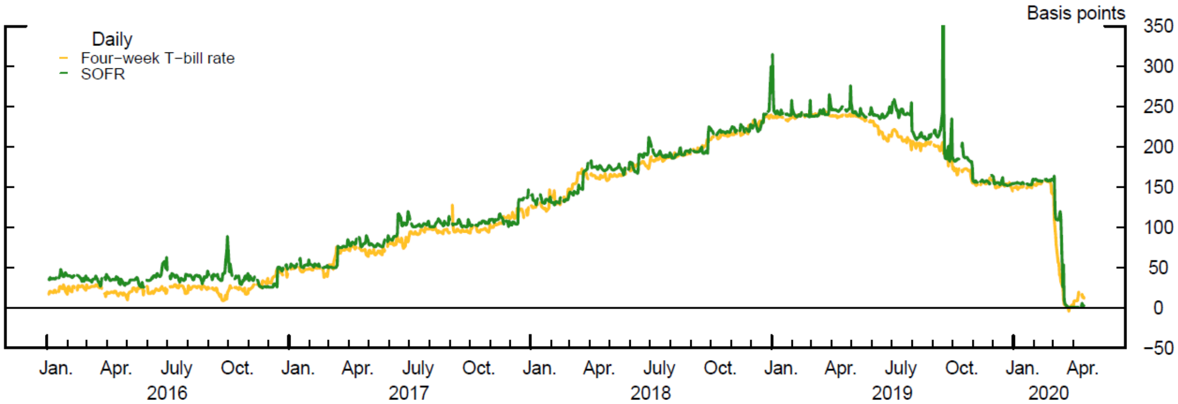
This figure depicts our measure of repo cash intermediation, which is the spread between the GCF rate and the TPR rate; repo specialness, which is the spread between the SOFR rate and the on-the-run Treasury repo rate; and the the convenience yield, which is the spread between the one-month OIS rate and the four-week T-bill.



Source: DTCC, Repo Interdealer Broker Community. Federal Reserve Bank of New York, SOFR Rate, https://apps.newyorkfed.org/markets/autorates/SOFR. Bank of New York Mellon, TPR rate, https://repoindex.bnymellon.com/repoindex. Federal Reserve, H.15 Statistical Release.

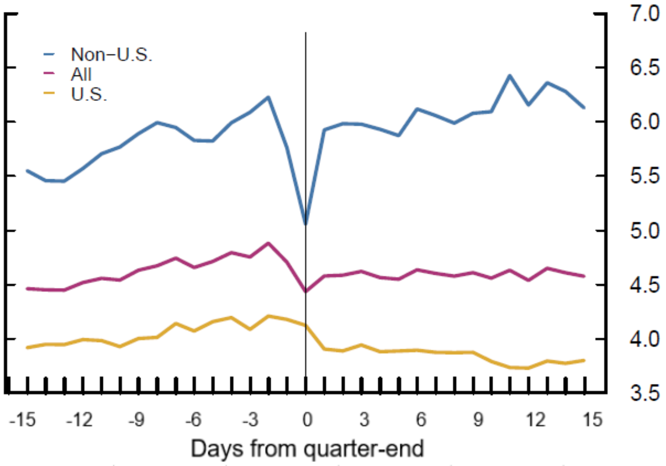
Figure 9: Four-week T-bill Rate and SOFR

This figure shows that the four-week T-bill rate is generally lower than SOFR, the overnight Treasury repo rate. Instances where the T-bill rate is lower coincide with periods of downward policy rate expectations prior to FOMC meetings.



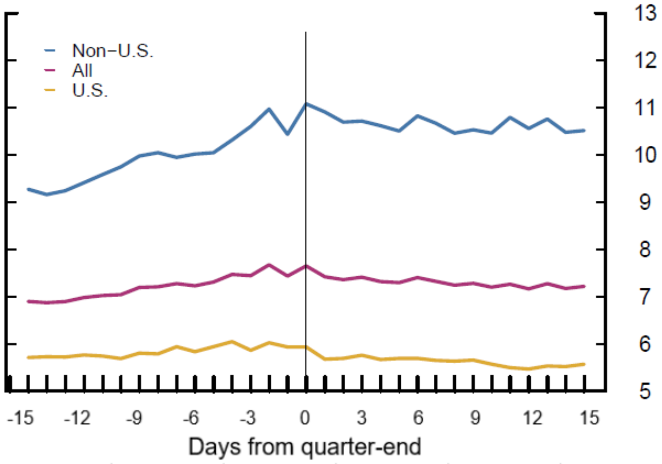
Source: Federal Reserve Bank of New York, SOFR Rate, https://apps.newyorkfed.org/markets/autorates/SOFR. Federal Reserve H.15 Statistical Release.

Figure 10: Average Repo Collateral Multiplier Around Quarter-End
This figure shows the repo collateral multiplier for the 30 days around quarter-end, averaged across the 16 quarter-ends in our sample. Non-U.S. dealers' repo collateral multiplier tends to decline sharply on quarter-end dates, consistent with well-documented window dressing activity.



Source: Federal Reserve Board, Form FR 2052a, Complex Institution Liquidity Monitoring Report.

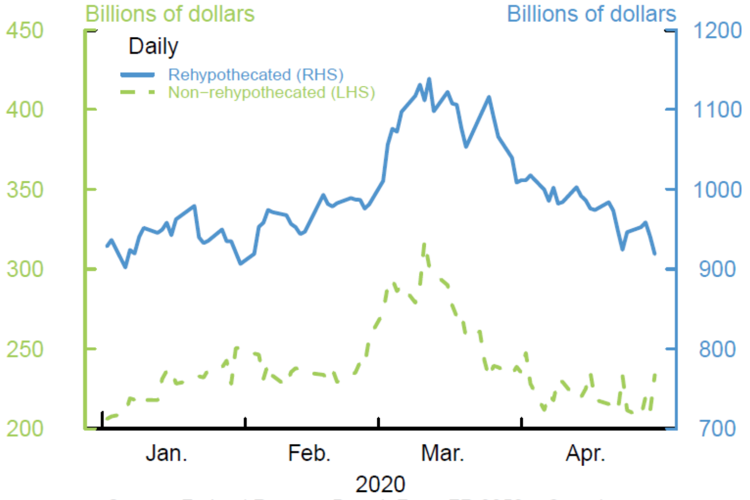
Figure 11: Average Aggregate Collateral Multiplier Around Quarter-End
This figure shows the aggregate collateral multiplier for the 30 days around quarter-end, averaged across the 16 quarter-ends in our sample. In contrast to the repo multiplier, the aggregate multiplier remains stable around quarter-end for both U.S. and non-U.S. dealers. Non-U.S. dealers tend to substitute contracts with a smaller regulatory burden, such as collateral swaps, for repo on quarter-end.



Source: Federal Reserve Board, Form FR 2052a, Complex Institution Liquidity Monitoring Report.

Figure 12: Rehypothecated and Non-Rehypothecated Treasury SFTs Amid COVID Market Turmoil

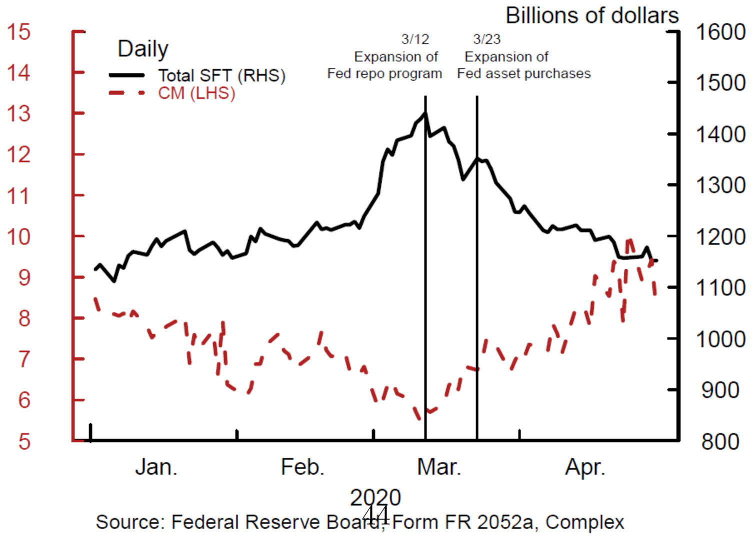
This figure shows the volume of rehypothecated and non-rehypothecated Treasury SFTs during the COVID-19 crisis. Amid deteriorating liquidity in Treasury markets, both rehypothecated and non-rehypothecated Treasury SFT volumes increased notably, as dealers financed their new positions and those of their counterparties.



Source: Federal Reserve Board, Form FR 2052a, Complex Institution Liquidity Monitoring Report.

Figure 13: Total Securities Financing Transactions and the Collateral Multiplier Amid COVID Market Turmoil

This figure shows the volume of total securities financing transactions and the movement of the aggregate collateral multiplier during the COVID-19 crisis. As securities financing volumes peaked in early March, the collateral multiplier reached its lowest historical level amid deteriorating liquidity in Treasury markets. Subsequent actions by the Fed to improve liquidity coincided with a reduction in secured funding volumes and a sharp increase in the multiplier.



Source: Federal Reserve Board, Form FR 2052a, Complex Institution Liquidity Monitoring Report.

Table 1: Summary Statistics

This table presents summary statistics for the main variables used in the paper. $\Delta\log(CM_{j,p,t})$ is the log change of the j dealer-level average collateral multiplier of contract p where $j \in \{All, US, non\text{-}US\}$ and $p \in \{AC, RP\}$. $\Delta log(ShTbillsOut_t)$ is the log change in U.S. Treasury bills outstanding with maturity less than one month, $\Delta log(TbillsOut_t)$ is the log change in U.S. Treasury bills outstanding, $\Delta log(USTnotesOut_t)$ the log change in U.S. Treasury notes outstanding, and $\Delta log(SOMA_t)$ is the log change in the Federal Reserve's U.S. Treasury holdings. $(GCF - TPR)_{t-1}$ is the spread of the GCF Treasury repo rate minus the TPR rate, $(SOFR - RPSpecial)_{t-1}$ is the spread of the SOFR rate minus the repo specials rate for on-the-run U.S. Treasury securities, and $(OIS - Tbill)_{t-1}$ is the spread of the one-month overnight index swap (OIS) rate over the four-week Treasury bill rate. The sample runs daily from the 15th of January 2016 to the 17th of April 2020. Quarter-end and "repo spike" dates are excluded.

	N	Mean	Std. Dev.	Min	Max
$\Delta\log(CM_{All,AC,t})$	972	.0003	.0520	-.1499	.1302
$\Delta\log(CM_{US,AC,t})$	972	-.0002	.0395	-.1092	.0989
$\Delta\log(CM_{nonUS,AC,t})$	972	.0011	.0916	-.2399	.2479
$\Delta\log(CM_{All,RP,t})$	972	.0004	.0519	-.1587	.1309
$\Delta\log(CM_{US,RP,t})$	972	-.00002	.0413	-.1151	.0963
$\Delta\log(CM_{nonUS,RP,t})$	972	.0009	.0961	-.2589	.2393
$\Delta\log(ShTbillsOut_t)$	1,077	.0007	.0886	-.2253	.2290
$\Delta\log(TbillsOut_t)$	1,077	.0008	.0061	-.0414	.0410
$\Delta\log(USTnotesOut_t)$	1,077	.0002	.0007	-.0004	.0047
$\Delta\log(SOMA_t)$	1,078	.0004	.0031	-.0141	.0278
$(GCF - TPR)_t$	1,072	.1138	.1010	-.0580	2.1990
$(SOFR - RPSpecial)_t$	1,061	.2384	.3052	-.2497	1.8755
$(OIS - Tbill)_t$	1,073	.1104	.0903	-.1820	.4105

Table 2: Collateral Multiplier Correlation Matrix

This table presents the correlations between different versions of the collateral multiplier. We denote these different versions of the collateral multiplier by CM_{jpt}, which is the average collateral multiplier for j dealers, where $j \in \{All, US, non\text{-}US\}$, using p contracts, where $p \in \{AC, RP\}$, at time t. The sample runs daily from the 15th of January 2016 to the 17th of April 2020. Quarter-end, ±2 days around quarter-end, and "repo spike" dates are excluded. Collateral multipliers are winsorized at the 1% and 99%.

	$\Delta\log(CM_{All,AC,t})$	$\Delta\log(CM_{US,AC,t})$	$\Delta\log(CM_{nonUS,AC,t})$	$\Delta\log(CM_{All,RP,t})$	$\Delta\log(CM_{US,RP,t})$	$\Delta\log(CM_{nonUS,RP,t})$
$\Delta\log(CM_{All,AC,t})$	1	0.564	0.892	0.940	0.528	0.829
$\Delta\log(CM_{US,AC,t})$	0.564	1	0.160	0.575	0.947	0.153
$\Delta\log(CM_{nonUS,AC,t})$	0.892	0.160	1	0.829	0.148	0.933
$\Delta\log(CM_{All,RP,t})$	0.940	0.575	0.829	1	0.585	0.873
$\Delta\log(CM_{US,RP,t})$	0.528	0.947	0.148	0.585	1	0.138
$\Delta\log(CM_{nonUS,RP,t})$	0.829	0.153	0.933	0.873	0.138	1

Table 3: Drivers of Aggregate and Repo Collateral Multipliers

This table shows the empirical results from equation (1). CM_t is CM_{jpt} in $\Delta log(CM)$: the log change of the j dealer-level average collateral multiplier of contracts p where $j \in \{All, US, non\text{-}US\}$ and $p \in \{AC, RP\}$. $\Delta \log(Gov_t)$ are $\Delta log(TbillsOut_t)$ the log change in Treasury bills outstanding, $\Delta log(USTnotesOut_t)$ the log change in U.S. Treasury notes outstanding, and $\Delta log(SOMA_t)$ is the log change in the Federal Reserve's U.S. Treasury holdings. $Spreads_{t-1}$ are $(GCF - TPR)_{t-1}$ the spread of the GCF Treasury repo rate minus the TPR rate, $(SOFR - RPSpecial)_{t-1}$ the spread of the SOFR rate minus the repo specials rate for on-the-run U.S. Treasury securities, and $(OIS - Tbill)_{t-1}$ the spread of the one-month overnight index swap (OIS) rate over the four-week Treasury bill rate. X_{t-1} are financial data controls used in table described in section 3.2 (not shown) and $1_{\text{MidMarch2020}}$ an indicator for March 15th 2020. Four lags of $\Delta log(CM_{jpt})$ are included as controls (not shown), with p-value reported of lags equal to zero. The sample runs daily from the 15th of January 2016 to the 17th of April 2020. Quarter-end, ±2 days around quarter-end, and "repo spike" dates are excluded. Dependent variable is winsorized at the 1% and 99%. Newey-West standard errors with 21 lags are reported. *, **, ***, denote significance at the 10%, 5%, and 1% levels, respectively.

	LHS: $\Delta \log(CM_{jpt})$					
	All Contracts			Repo		
	All	US	non-US	All	US	non-US
$\Delta log(TbillsOut_t)$	-1.073***	-0.810***	-1.357***	-0.900***	-0.696***	-1.176***
	(0.258)	(0.176)	(0.477)	(0.252)	(0.209)	(0.434)
$\Delta log(USTNotesOut_t)$	-9.444***	-9.448***	-10.011***	-9.203***	-11.470***	-6.271**
	(1.736)	(1.717)	(3.010)	(1.636)	(1.864)	(3.079)
$\Delta log(SOMA_t)$	5.775***	2.789***	8.524***	5.752***	2.428***	9.845***
	(0.958)	(0.897)	(1.486)	(1.190)	(0.885)	(2.184)
$(GCF - TPR)_{t-1}$	0.034	-0.009	0.096**	0.051	-0.010	0.158***
	(0.035)	(0.028)	(0.048)	(0.034)	(0.032)	(0.047)
$(SOFR - RpSpecial)_{t-1}$	0.015***	0.015***	0.011	0.013***	0.015***	0.007
	(0.005)	(0.004)	(0.009)	(0.005)	(0.004)	(0.009)
$(OIS - Tbill)_{t-1}$	-0.042	-0.019	-0.085*	-0.040	-0.017	-0.079
	(0.027)	(0.018)	(0.050)	(0.028)	(0.022)	(0.053)
$1_{\text{MidMarch2020}}$	-0.023	0.006	-0.046	-0.042**	0.006	-0.099***
	(0.019)	(0.017)	(0.029)	(0.020)	(0.017)	(0.033)
P-value	0.000	0.000	0.000	0.000	0.000	0.000
Adj RSq	0.207	0.157	0.195	0.204	0.144	0.204
N obs	878	878	878	878	878	878

Table 4: Drivers of Aggregate Collateral Multipliers Instrumenting the Convenience Yield with Short-term T-bill Issuance

This table shows the empirical results from equation (2) and (3). CM_t is CM_{jt} in $\Delta log(CM_{jt})$: the log change of the j dealer-level average collateral multiplier for all contracts. $(OIS - Tbill)_{t-1}$ is the spread of the the one-month overnight index swap (OIS) rate over the four-week Treasury bill rate and $(\widehat{OIS - Tbill})_{t-1}$ is the fitted value of the convenience yield from the first stage. $Spreads_{t-1}$ are $(SOFR - RPSpecial)_{t-1}$ the spread of the SOFR rate minus the repo specials rate for on-the-run U.S. Treasury securities and $(GCF - TPR)_{t-1}$ the spread of the GCF Treasury repo rate minus the SOFR rate (not shown). $\Delta log(ShTbillsOut_{t-1})$ is the log change in Treasury bills outstanding with maturity less than one month. $\Delta\log(Gov_{t-1})$ are $\Delta\log(USTnotesOut_{t-1})$ the log change in U.S. Treasury notes outstanding and $\Delta log(SOMA_{t-1})$ is the log change in the Federal Reserve's U.S. Treasury holdings (not shown). X_{t-1} are financial data controls used in Table 3 and $1_{\text{MidMarch2020}}$ an indicator for March 15th 2020 (not shown). Four lags of $\Delta\log(CM_{jt})$ are included as controls (not shown), with p-value reported of lags equal to zero. F-value of first stage regressions are reported. The sample runs daily from the 15th of January 2016 to the 17th of April 2020. Quarter-end, ±2 days around quarter-end, and "repo spike" dates are excluded. Dependent variable is winsorized at the 1% and 99%. Newey-West standard errors with 21 lags are reported. *, **, ***, denote significance at the 10%, 5%, and 1% levels, respectively.

	LHS: $\Delta\log(CM_{jt})$					
	All		US		non-US	
	1st Stage	2nd Stage	1st Stage	2nd Stage	1st Stage	2nd Stage
$\Delta\log(ShTBillsOut_{t-1})$	-0.069***		-0.074***		-0.067***	
	(0.016)		(0.017)		(0.016)	
$(\widehat{OIS - TBill})_{t-1}$		0.654***		0.583***		0.656
		(0.240)		(0.188)		(0.422)
F	14.670		14.596		14.396	
P-value		0.000		0.000		0.000
Adj RSq	0.560	.	0.563	.	0.560	.
N obs	897	879	897	879	897	879

Table 5: Drivers of Repo Collateral Multiplier Instrumenting the Convenience Yield with Short-term T-bill Issuance

This table shows the empirical results from equation (2) and (3). CM_t is CM_{jt} in $\Delta log(CM_{jt})$: the log change of the j dealer-level average repo collateral multiplier where $j \in \{All, US, non\text{-}US\}$. $(OIS - Tbill)_{t-1}$ is the spread of the one-month overnight index swap (OIS) rate over the four-week Treasury bills and $(\widehat{OIS - Tbill})_{t-1}$ is the fitted value of the convenience yield from the first stage. $Spreads_{t-1}$ are $(SOFR - RPSpecial)_{t-1}$ the spread of the SOFR rate minus the repo specials rate for on-the-run U.S. Treasury securities and $(GCF - TPR)_{t-1}$ the spread of the GCF Treasury repo rate minus the SOFR rate (not shown). $\Delta log(ShTbillsOut_{t-1})$ is the log change in Treasury bills outstanding with maturity less than one month. $\Delta \log(Gov_{t-1})$ are $\Delta log(USTnotesOut_{t-1})$ is the log change in U.S. Treasury notes outstanding and $\Delta log(SOMA_{t-1})$ is the log change in the Federal Reserve's U.S. Treasury holdings. X_{t-1} are financial data controls used in Table 3 and $1_{\text{MidMarch2020}}$ an indicator for March 15th 2020 (not shown). Four lags of $\Delta log(CM_{jt})$ are included as controls (not shown), with p-value reported of lags equal to zero. F-value of first stage regressions are reported. The sample runs daily from the 15th of January 2016 to the 17th of April 2020. Quarter-end, ±2 days around quarter-end, and "repo spike" dates are excluded. Dependent variable is winsorized at the 1% and 99%. Newey-West standard errors with 21 lags are reported. *, **, ***, denote significance at the 10%, 5%, and 1% levels, respectively.

	LHS: $\Delta \log(CM_{jt})$					
	All		US		non-US	
	1st Stage	2nd Stage	1st Stage	2nd Stage	1st Stage	2nd Stage
$\Delta \log(ShTBillsOut_{t-1})$	-0.069***		-0.071***		-0.067***	
	(0.016)		(0.016)		(0.016)	
$(\widehat{OIS - TBill})_{t-1}$		0.667***		0.557***		0.806*
		(0.244)		(0.192)		(0.446)
F	14.323		13.619		14.564	
P-value		0.000		0.000		0.000
Adj RSq	0.560	.	0.563	.	0.560	.
N obs	897	879	897	879	897	879

Table 6: Simultaneous Equation Regressions of Collateral Multipliers
This table shows the two-step GMM estimation of equation (4). CM_{it} is CM_{ipt} in $\Delta log(CM_{it})$: the log change of dealer i's collateral multiplier of contracts p where $p \in \{AC, RP\}$. $\Delta \log(Gov_t)$ are $\Delta log(TbillsOut_t)$ the log change in Treasury bills outstanding, $\Delta log(USTnotesOut_t)$ the log change in U.S. Treasury notes outstanding, and $\Delta log(SOMA_{t-1})$ is the log change in the Federal Reserve's U.S. Treasury holdings. $Spreads_{t-1}$ are $(GCF - TPR)_{t-1}$ the spread of the GCF Treasury repo rate minus the TPR rate, $(SOFR - RPSpecial)_{t-1}$ the spread of the SOFR rate minus the repo specials rate for on-the-run U.S. Treasury securities, and $(OIS - Tbill)_{t-1}$ the spread of the one-month overnight index swap (OIS) rate over the four-week Treasury bill rate. For each contract type p we show results from equation (4) where all dealers have the same coefficients on $Spreads_{t-1}$ and where U.S. dealers and non-U.S. dealers have different coefficients on $Spreads_{t-1}$. Z_{t-1} are aggregate financial data controls common to all dealers, Z_{it-1} are dealer-level financial data controls described in 3.4 (not shown) and $1_{\text{MidMarch2020}}$ an indicator for March 15th 2020. Four lags of $\Delta \log(CM_{ipt})$ are included as controls (not shown). The Hansen J-statistic is reported along with its p-value. The sample runs daily from the 15th of January 2016 to the 17th of April 2020. Quarter-end, ±2 days around quarter-end, and "repo spike" dates are excluded. Dependent variable is winsorized at the 1% and 99%. Newey-West standard errors with 21 lags are reported. *, **, ***, denote significance at the 10%, 5%, and 1% levels, respectively.

	LHS: $\Delta \log(CM_{ipt})$			
	All		Repo	
$\Delta log(TbillsOut_t)$	-1.052***	-1.045***	-0.970***	-0.961***
	(0.080)	(0.080)	(0.096)	(0.096)
$\Delta log(USTnotesOut_t)$	-8.538***	-8.660***	-9.719***	-9.867***
	(0.695)	(0.699)	(0.737)	(0.737)
$\Delta \log(SOMA_t)$	4.268***	4.241***	4.377***	4.382***
	(0.349)	(0.356)	(0.417)	(0.416)
$(GCF - TPR)_{t-1}$	0.015		0.035***	
	(0.011)		(0.013)	
$(GCF - TPR)_{t-1}^{US}$		-0.003		-0.007
		(0.012)		(0.014)
$(GCF - TPR)_{t-1}^{nonUS}$		0.055***		0.122***
		(0.018)		(0.019)
$(SOFR - RpSpecial)_{t-1}$	0.014***		0.013***	
	(0.002)		(0.002)	
$(SOFR - RpSpecial)_{t-1}^{US}$		0.016***		0.015***
		(0.002)		(0.002)
$(SOFR - RpSpecial)_{t-1}^{nonUS}$		0.010***		0.010***
		(0.003)		(0.003)
$(OIS - Tbill)_{t-1}$	-0.017**		-0.014	
	(0.008)		(0.009)	
$(OIS - Tbill)_{t-1}^{US}$		-0.013		-0.005
		(0.008)		(0.010)
$(OIS - Tbill)_{t-1}^{nonUS}$		-0.029**		-0.038***
		(0.011)		(0.012)
$1_{\text{MidMarch2020}}$	-0.001	-0.001	-0.020***	-0.021***
	(0.006)	(0.006)	(0.008)	(0.008)
J-Stat	44.361	44.273	44.901	44.380
p-value	1.000	0.999	0.999	0.999
N obs	878	878	878	878

Table 7: Simultaneous Equation Regressions of Collateral Multipliers Instrumenting the Convenience Yield with Short-term T-bill Issuance

This table shows the two-step GMM estimation of equations (5). CM_{it} is CM_{ipt} in $\Delta log(CM_{it})$: the log change of dealer i's collateral multiplier of contracts p where $p \in \{AC, RP\}$. $(OIS - Tbill)_{t-1}$ is the spread of the one-month overnight index swap (OIS) rate over the four-week Treasury bills and $(\widehat{OIS - Tbill})_{t-1}$ is instrumented by $\Delta log(ShTbillsOut_{t-1})$, the log change in Treasury bills outstanding with maturity less than one month. For each contract type p we show results from equation (5) where all dealers have the same coefficients on $(\widehat{OIS - Tbill})_{t-1}$ and where U.S. dealers and non-U.S. dealers have different coefficients on $(\widehat{OIS - Tbill})_{t-1}$. $Spreads_{t-1}$ are $(SOFR - RPSpecial)_{t-1}$ the spread of the SOFR rate minus the repo specials rate for on-the-run U.S. Treasury securities and $(GCF - TPR)_{t-1}$ the spread of the GCF Treasury repo rate minus the SOFR rate (not shown). $\Delta \log(Gov_{t-1})$ are $\Delta \log(USTnotesOut_{t-1})$ the log change in U.S. Treasury notes outstanding and $\Delta \log(SOMA_{t-1})$ is the log change in the Federal Reserve's U.S. Treasury holdings (not shown). Z_{t-1} are aggregate financial data controls common to all dealers, Z_{it-1} are dealer-level financial data controls described in 3.4, and $1_{\text{MidMarch2020}}$ an indicator for March 15th 2020 (not shown). Four lags of $\Delta \log(CM_{ipt})$ are included as controls (not shown). The Hansen J-statistic is reported along with its p-value. The sample runs daily from the 15th of January 2016 to the 17th of April 2020. Quarter-end, ±2 days around quarter-end, and "repo spike" dates are excluded. Dependent variable is winsorized at the 1% and 99%. Newey-West standard errors with 21 lags are reported. *, **, ***, denote significance at the 10%, 5%, and 1% levels, respectively.

	LHS: $\Delta \log(CM_{ipt})$			
	All		Repo	
$(\widehat{OIS - Tbill})_{t-1}$	0.554***		0.743***	
	(0.084)		(0.099)	
$(\widehat{OIS - Tbill})_{t-1}^{US}$		0.550***		0.740***
		(0.086)		(0.102)
$(\widehat{OIS - Tbill})_{t-1}^{nonUS}$		0.521***		0.681***
		(0.085)		(0.100)
J-Stat	42.982	42.696	43.561	43.036
p-value	0.997	0.995	0.997	0.994
N obs	879	879	879	879

Table 8: Drivers of Aggregate and Repo Collateral Multipliers — Weekly Regressions w/ Overlapping Data

This table shows the empirical results from equation (1) at a weekly frequency with overlapping data. CM_t is CM_{jpt} in $\Delta^5 log(CM)$: the 5-day log change of the j dealer-level average collateral multiplier of contracts p where $j \in \{All, US, non\text{-}US\}$ and $p \in \{AC, RP\}$. $\Delta^5 \log(Gov_t)$ are $\Delta^5 \log(TbillsOut_t)$ the 5-day log change in Treasury bills outstanding, $\Delta^5 log(USTnotesOut_t)$ the 5-day log change in U.S. Treasury notes outstanding, and $\Delta log(SOMA_t)$ is 5-day the log change in the Federal Reserve's U.S. Treasury holdings. $Spreads_{t-5}$ are $(GCF - TPR)_{t-5}$ the spread of the GCF Treasury repo rate minus the TPR rate, $(SOFR - RPSpecial)_{t-5}$ the spread of the SOFR rate minus the repo specials rate for on-the-run U.S. Treasury securities, and $(OIS - Tbill)_{t-5}$ the spread of the one-month overnight index swap (OIS) rate over the four-week Treasury bills. X_{t-5} are financial data controls used in table 3 (not shown) and $1_{\text{MidMarch2020}}$ an indicator for March 15th 2020. Two lags of $\Delta \log(CM_{jpt})$ are included as controls (not shown), with p-value reported of lags equal to zero. The sample runs daily from the 15th of January 2016 to the 17th of April 2020. Quarter-end, ±2 days around quarter-end, and "repo spike" dates are excluded. Dependent variable is winsorized at the 1% and 99%. Newey-West standard errors with 12 lags are reported. *, **, ***, denote significance at the 10%, 5%, and 1% levels, respectively.

	LHS: $\Delta^5 \log(CM_{jpt})$					
	All Contracts			Repo		
	All	US	non-US	All	US	non-US
$\Delta^5 log(TbillsOut_t)$	-0.575**	-0.320	-0.716	-0.510*	-0.442	-0.448
	(0.292)	(0.241)	(0.524)	(0.309)	(0.301)	(0.503)
$\Delta^5 log(USTNotesOut_t)$	-2.747	-4.965**	1.759	-1.328	-5.601**	5.708
	(3.285)	(2.318)	(5.933)	(3.185)	(2.592)	(5.670)
$\Delta^5 log(SOMA_t)$	2.083***	2.096***	2.280**	1.869***	2.040***	1.544
	(0.559)	(0.329)	(0.951)	(0.556)	(0.362)	(0.993)
$(GCF - TPR)_{t-5}$	0.123*	0.058	0.187	0.141*	0.065	0.243**
	(0.072)	(0.058)	(0.116)	(0.077)	(0.068)	(0.118)
$(SOFR - RpSpecial)_{t-5}$	0.037***	0.046***	0.022	0.033***	0.049***	0.010
	(0.012)	(0.011)	(0.020)	(0.012)	(0.012)	(0.018)
$(OIS - Tbill)_{t-5}$	-0.066	-0.023	-0.135	-0.106*	-0.052	-0.164
	(0.067)	(0.048)	(0.123)	(0.064)	(0.061)	(0.112)
$1_{\text{MidMarch2020}}$	0.066	-0.024	0.123	0.055	-0.028	0.146*
	(0.072)	(0.045)	(0.118)	(0.052)	(0.046)	(0.085)
P-value	0.000	0.000	0.000	0.000	0.000	0.000
Adj RSq	0.244	0.269	0.220	0.242	0.251	0.256
N obs	714	714	714	714	714	714

Table 9: Drivers of Aggregate and Repo Collateral Multipliers with Fiscal Government Controls

This table shows the empirical results from equation (1). CM_t is CM_{jpt} in $\Delta log(CM)$: the log change of the j dealer-level average collateral multiplier of contracts p where $j \in \{All, US, non\text{-}US\}$ and $p \in \{AC, RP\}$. $\Delta \log(Gov_t)$ are $\Delta log(TbillsOut_t)$ the log change in Treasury bills outstanding and $\Delta log(USTnotesOut_t)$ the log change in U.S. Treasury notes outstanding. $Spreads_{t-1}$ are $(GCF - TPR)_{t-1}$ the spread of the GCF Treasury repo rate minus the TPR rate, $(SOFR - RPSpecial)_{t-1}$ the spread of the SOFR rate minus the repo specials rate for on-the-run U.S. Treasury securities, and $(OIS - Tbill)_{t-1}$ the spread of the one-month overnight index swap (OIS) rate over the four-week Treasury bill rate. X_{t-1} are financial data controls used in table 3 (not shown) and $1_{\text{MidMarch2020}}$ an indicator for March 15th 2020. Four lags of $\Delta log(CM_{jpt})$ are included as controls (not shown), with p-value reported of lags equal to zero. The sample runs daily from the 15th of January 2016 to the 17th of April 2020. Quarter-end, ±2 days around quarter-end, and "repo spike" dates are excluded. Dependent variable is winsorized at the 1% and 99%. Newey-West standard errors with 21 lags are reported. *, **, ***, denote significance at the 10%, 5%, and 1% levels, respectively.

	LHS: $\Delta \log(CM_{jpt})$					
	All Contracts			Repo		
	All	US	non-US	All	US	non-US
$\Delta log(TbillsOut_t)$	-1.148***	-0.851***	-1.473***	-0.976***	-0.731***	-1.310***
	(0.243)	(0.174)	(0.453)	(0.241)	(0.208)	(0.411)
$\Delta log(USTNotesOut_t)$	-11.667***	-10.523***	-13.282***	-11.402***	-12.407***	-10.059***
	(1.895)	(1.710)	(3.252)	(1.833)	(1.817)	(3.618)
$(GCF - TPR)_{t-1}$	0.029	-0.011	0.090*	0.046	-0.012	0.150***
	(0.033)	(0.027)	(0.047)	(0.033)	(0.030)	(0.048)
$(SOFR - RpSpecial)_{t-1}$	0.015***	0.015***	0.011	0.013***	0.015***	0.007
	(0.005)	(0.004)	(0.009)	(0.005)	(0.004)	(0.009)
$(OIS - Tbill)_{t-1}$	-0.026	-0.011	-0.061	-0.024	-0.011	-0.052
	(0.027)	(0.019)	(0.049)	(0.027)	(0.023)	(0.049)
$1_{\text{MidMarch2020}}$	0.064***	0.048***	0.082**	0.044**	0.042***	0.048
	(0.023)	(0.014)	(0.033)	(0.020)	(0.014)	(0.029)
P-value	0.000	0.000	0.000	0.000	0.000	0.000
Adj RSq	0.180	0.147	0.176	0.177	0.137	0.180
N obs	878	878	878	878	878	878